Description and implementation of the
"Observer Part" of a SMART Cable

by

Listening to the Earth under the Atlantic (LEA):
Instituto de Telecomunicações (IT) and Instituto Dom Luiz (IDL) and
Instituto Português do Mar e da Atmosfera (IPMA)

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Forward

Taking into account the need to promote collaboration between the various stakeholders, as well as to promote the practice of a common language to be used in an ordering and negotiation process for a SMART (Science Monitoring And Reliable Telecommunications) Cable, fundamental in the dialogue between those who order (promoters and operators) and between those who provide (manufacturers, suppliers, developers of solutions and prototypes, ...), the Portuguese telecommunications regulator Autoridade Nacional de Comunicações (ANACOM) asked LEA (IPMA+IDL+IT) to produce documentation on the methodology to be used as well as a detailed description of the Observation Part of a SMART Cable, with such documents to appear as a Portuguese contribution to the discussion between the members of the Joint Task Force (JTF) SMART Subsea Cables, with a view, on the one hand, to their improvement, and on the other hand, so they can be used as a basic proposal for work in a process of analysis and subsequent ordering of a SMART Cable, including negotiation of a supply contract.

After releasing the earlier document, "Management considerations to elaborate a Request for Tender for a SMART Cable," in December 2021, https://www.itu.int/en/ITU-T/climatechange/task-force-sc/Documents/LEA-contribution-to-JTF_RfT-for-a-SMARTCable.pdf, it is with pleasure that we see now LEA releasing the "Description and implementation of the Observer Part of a SMART Cable" as attached, having the expectation that both documents may facilitate and speed up any process of ordering a SMART Cable.

If any technical clarification is required on the delivered documentation, it may be obtained directly from Vasco Sa (IT), vascodesa@sapo.pt, on behalf of LEA.

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L · E · A
LISTENING TO THE EARTH UNDER THE ATLANTIC

Description and implementation of the

«Observer Part» of a SMART Cable

PRODUCED BY LEA (IT-IPMA-IDL)

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1. Objective of the Document

This document was created by the Portuguese entity LEA (formed by the scientific entities IT, IPMA and IDL) with the purpose of complementing the document already published in the site of ITU/WMO/UNESCO IOC Joint Task Force:

«Management considerations to elaborate a Request for Tender (RfT) for a SMART Cable

https://www.itu.int/en/ITU-T/climatechange/task-force-sc/Documents/LEA-contribution-to-JTF_RfT-for-a-SMART-Cable.pdf

Its main objective is to facilitate the promoters of SMART Cables to prepare the Technical Part of the "Observer Part" of a SMART Cable (Science Monitoring and Reliable Telecommunications), a specific Part (Appendix) of the "Technical Specification" of a common Telecom Cable forming together a SMART Cable.

At the same time, it includes in the last point fundamental integration principles with the usual "Terms and Conditions" generally used in telecom submarine cable Networks.

Using both the above mentioned, Management Considerations to elaborate a Request for Tender (RfT) for a ***SMART Cable****, defining the management procedures, and the Technical Specifications, here presented:*

Description and Implementation of the "Observer Part" of a SMART Cable»

The preparation of the RfT of a SMART Cable, once defined the geophysics and ambient control objectives for sensing the sea bottom, would be highly facilitated.

1.1 General

This Document describes the “Observer Part” of a SMART Cable. It constitutes an addition to the requirements for Submarine Telecom Cable, forming together a SMART Cable.

Additional considerations and reasons to implement a SMART Cable shall be considered for each specific situation.

The Submarine Cable System would be equipped to provide additional services, namely seismic detection, to produce alerts, environmental measurements, and transmission of data associated with undergoing or new scientific projects.”

Being the scope larger than earthquakes and tsunamis Monitoring, in general terms involving the collection of Data for Geophysics, Oceanography, and Environment, it is necessary to consider all this added instrumentation as a value-added service to be provided by the Submarine Cable System, having been considered useful the concepts of the Joint Task Force for SMART (Science Monitoring and Reliable Telecommunications) Cables with the support of UN Agencies such as ITU, UNESCO-IOC and WMO.

In order to satisfy those requirements, which integrates detection functionalities in a telecom submarine cable (SMART Cable), this Document considers the particular terms, conditions, parts, elements, functionalities and specifications associated with:

- Insertion of Sensors along the structure of a telecom part of a Submarine Cable System;

- Data communication means to allow to connect the Sensors with the Terminal Stations;

- Interconnection with an external central point for data evaluation in real-time and storage;

- Impact on the Telecom System.

1.2 Basic aspects for a SMART Submarine Cable System

The need for submarine observatories to monitor in real-time offshore tectonic sources that can generate destructive earthquakes and tsunamis and improve ambient and biological observation is widely recognized. Additionally, particular geophysics requirements should be mentioned characterising the area where the Submarine Cable System would be implemented. This is the reason to consider the requirement for additional Scientific Monitoring in this area while fully maintaining all the specified required Reliability for the Telecom Part.

The potential Suppliers must satisfy the critical mandatory requirement of having a complete and maximum separation, in terms of Reliability, cause of failures, "Observer Part", as defined below.

Any failure or degradation of the "Observer Part" must not directly or indirectly affect any conditions or circumstances, the functionalities, technical specifications, and Reliability of the Telecom Part of the Submarine Cable System.

The SMART Cable can use the suggested configurations IN LINE with the Cable included in this Document or other alternatives satisfying the required specifications.

2. Terminology and Definitions for a SMART Cable

2.1 Terminology

The following terminology is used in this Document to mention the particular aspects of the "Observer Part" of the Submarine Cable System.

- **"SMART Cable"** - It is a designation under the concept of JTF, meaning Scientific Monitor and Reliable Telecommunication. This means that no fault in the "Observer Part" in any conditions or circumstances, directly or indirectly, shall affect the "Telecommunication Part" of the Cable used for telecommunications. The "Telecom Part" plus the "Observer Part" form the SMART Cable. A SMART Cable is the designation of the Submarine Cable System linking A and B, and C etc., having a **"Telecom Part"** and an **"Observer Part"** and then constituting a SMART Cable (**S**cience **M**onitoring and **R**eliable **T**elecommunications).

- **"Telecom Part"** - It consists of the part of a "SMART Cable" that has no sensing objectives and has the usual means, functionalities, reliability and requirements of a usual telecom submarine cable System, as defined in a general a document for the whole system.

- **"Observer Part"** - It Consists of the part that is incorporated in the usual Submarine Telecom Cable System to add observer (sensing) functionalities on the sea bottom, as defined in this Document.

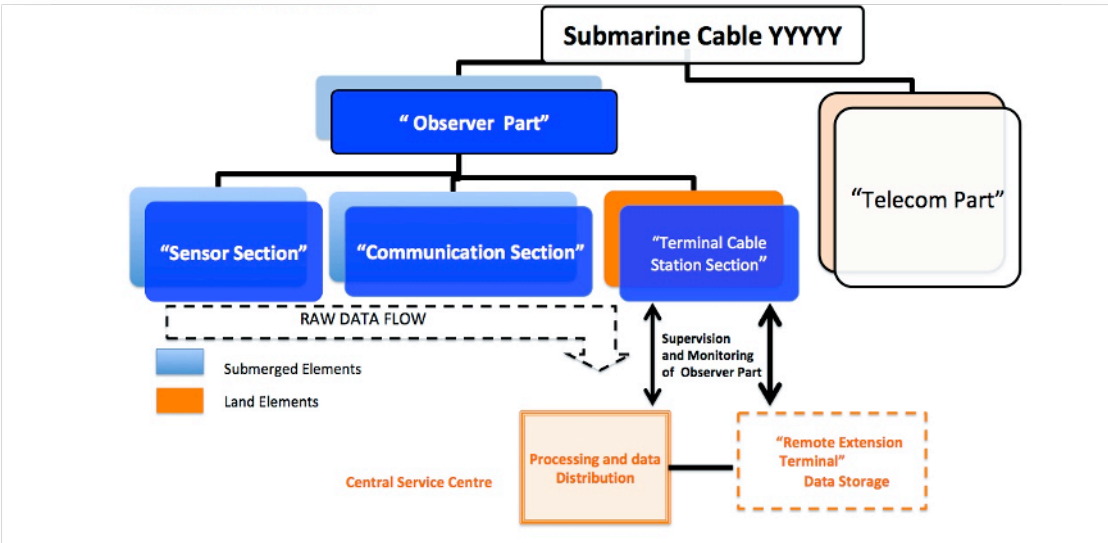

Fig. 1 - Terminology and concept for the SMART Submarine Cable System.

a) "**Package of Sensors**"- It designates the set of Sensors inserted in one particular

Telecom Repeater, “Dedicated Housing”, or a POD if it exists. Possible configurations are mentioned below.

b) **“Sensors Section” -** It is formed by the “Packages of Sensors” inserted in the SMART Cable.

c) **“Communication Section” -** It is formed by the communication means and instrumentation to promote the data communication between Sensors and the “Terminal Cable Station Section”, as detailed below.

d) **“Terminal Cable Station Section” -** It is formed by the **Terminal** located at the Cable Landing Stations to Monitor and control/interact with the Sensors and interfacing the data to the “Remote Terminal Extension” located at a “Remote Central Point”, where the raw Data is processed and stored. Equipment and instrumentation located at the Remote Central Point are not included in the “SMART Cable.”

e) **“Dedicated Fibre Pair” -** It is an additional fibre pair to be optionally considered. It may be required to fulfil the required specifications, functionalities and reliability of the “Observer part” and “Telecom Part” of the SMART Cable to establish data communications between the “Sensors Section” and the “Terminal Cable Station Section”. Additionally, it may be used for extra auxiliary, non-commercial traffic.

f) **“Submerged Elements”** of the “Observer Part” and **“Land Elements”** of the “Observer Part”.

g) We may consider the “Sensors Section” and the “Communication Section” as the **“Submerged Elements”** and, additionally, the “Terminal Cable Station Section**”** and the “Remote Terminal Extension” as the **“Land Elements”**.

h) **“Remote Terminal Extension” -** It is formed by a remote terminal located at the “Remote Central Point”. It provides monitoring and command facilities at the Remote Central Point.

i)**“Remote Central Point” -** It is a central operative point, distant from the Cable Landing Station, where the raw data is stored, processed, and distributed. Monitoring the “Observer Part” of the “SMART Cable” shall also be considered as applicable.

j)**“Sensors” -** Designates instruments to measure certain physical quantities (e.g., acceleration, pressure, temperature, ground velocity, etc.) installed at the sea bottom, IN LINE with the cable.
k) **“Package of Sensors” -** It is a set of sensors inserted in a Telecom Repeater, “Dedicated Housing”, or “POD” IN LINE with the Submarine Cable System.

l)**"WET Sensors" -** These are Sensors that require for correct operation to have contact with seawater.

m) **"Dry Sensors" -** These are Sensors that do not require correct operation to be in contact with seawater.

n) **"Sensing RPL" -** It is a RPL (Route Positioning List) as generally considered for telecom cables definition with the additional positioning of the "Packages of Sensors" in the submarine cable route.

o) **"Pattern of Failure" -** It is a structural failure, not accidental, resulting from design, deficient qualification construction, installation, or other as considered in the reference literature of reliability science, that may propagate through the other units of the system producing the same direct or indirect type of failure or be the root cause of other type of deficiency or pattern of deficiency.

2.2 Definitions

The following basic definitions are being considered in this Document:

2.2.1 "Sensors Section"

The "Sensors Section" is formed by the Sensors, inserted **"IN LINE"** with the submarine cable. The Sensors include the necessary elements to interface the recorded Data to the "Data communication Section", usually designated as Dataloggers.

Inserted **"IN LINE"** means that the sensors are inserted in the submerged part of the submarine cable system, for example, in the following ways:

a) Inside the **"Telecom Repeaters**", the standard repeaters used to install telecom communication facilities.

b) Inside, a housing designated POD is placed over the cable some meters distant from a "Telecom Repeater" and extracting Low Voltage and communications from this Repeater via an auxiliary cable with a few meters along the submarine cable (externally – for example using the support of the repeater tail). The POD may be used to insert all the Sensors or only the Sensors that require contact with the seawater, complementing the set of Sensors inserted inside the associated "Telecom Repeater". A POD can also avoid the temperature disturbance effect inside a Telecom repeater.
c) Inside a "Dedicated Housing" (similar to a repeater, housing of a Telecom Repeater, or smaller) inserted on the cable in a selected point of the Repeatered Cable

Segment (the portion of cable between two continuous Telecom Repeaters) with the purpose of having inside the Sensors and extracting energy from the High Voltage of the cable. Installing the Sensors inside the Dedicated Housings, the telecom Repeaters will remain without any modification. The full passive "Dedicated Fibre Pair" would pass simply through the unmodified Telecom Repeaters.

d) The "Sensors Section" shall provide the required clock time and Time Stamp facilities to define the real-time event of the Data obtained by Sensors.

The achievement of a minimum latency between the real-time of sensing observation and the time arrival of the Sensors Data to the "Remote Terminal Extension" and the time clock precision of the Time Stamp shall be considered critical elements for the "Observer Part."

For any type of such optional solutions, or other, to be adopted by the Suppliers, the critical point of keeping the complete separation, in terms of Reliability, from the "Telecom Part" and the "Observer Part" must be mandatorily presented and demonstrated.

2.2.2 "Communication Section"

The "Communications Section" is formed by the communications facilities necessary to transmit the raw Data from the Sensors to the "Terminal Cable Station Section" along the submarine cable.

A fundamental aspect to be considered by the potential is to create a complete physical and functional separation between telecom communications and the sensing data communication, the "Communication Section". For such purpose, a "**Dedicated Fibre Pair"** may be used to satisfy such critical purpose.

The transmission scheme to transmit the data from the sensors to the Submarine Cable Terminal Stations would be defined and selected by the Suppliers aiming to use a complete separation in terms of Reliability, functionalities and specifications from the telecom communications fibres and any other units.

The transmission scheme must have the adequate Reliability design of pathways redundancy to allow guaranteeing the required "Communication Part" Reliability and, in general, the "Observer Part" Reliability. If possible and considered practicable and cost-effective, this "Dedicated Fibre Pair" could be, in a complementary way, used for non-commercial communications.

The "Communication Section" shall provide bidirectional communications to allow the sending of control instructions from the "Central Service Centre" (Fig. 1) to the

"Sensor Section".

2.2.3 "Terminal Cable Station Section"

The equipment required in the Cable Landing Stations of the Submarine Cable System to retransmit the raw data received from the Sensors to remote points where the raw data is stored, processed, and distributed forms the "Terminal Cable Station Section".

The "Terminal Cable Station Section" allows for the implementation of alarms, Monitor facilities of the status and functionalities of the "Sensors Section" and "Communication Section" and operational commands (ex: power off and power on for the Sensors shall be considered to use in case of fault or malfunction in one particular Sensor), from the "Terminal Cable Station Section" for maintenance purposes or from any "Remote Terminal Extension", where operational and processing Data is implemented.

The flow of raw Data from the possible segments of the Submarine Cable System may be concentrated at one specific cable landing Station and extended to any "Remote Terminal Extension". Optionally, the data could be accessed at all the Cable Landing Stations and extended to any "Remote Terminal Extension".

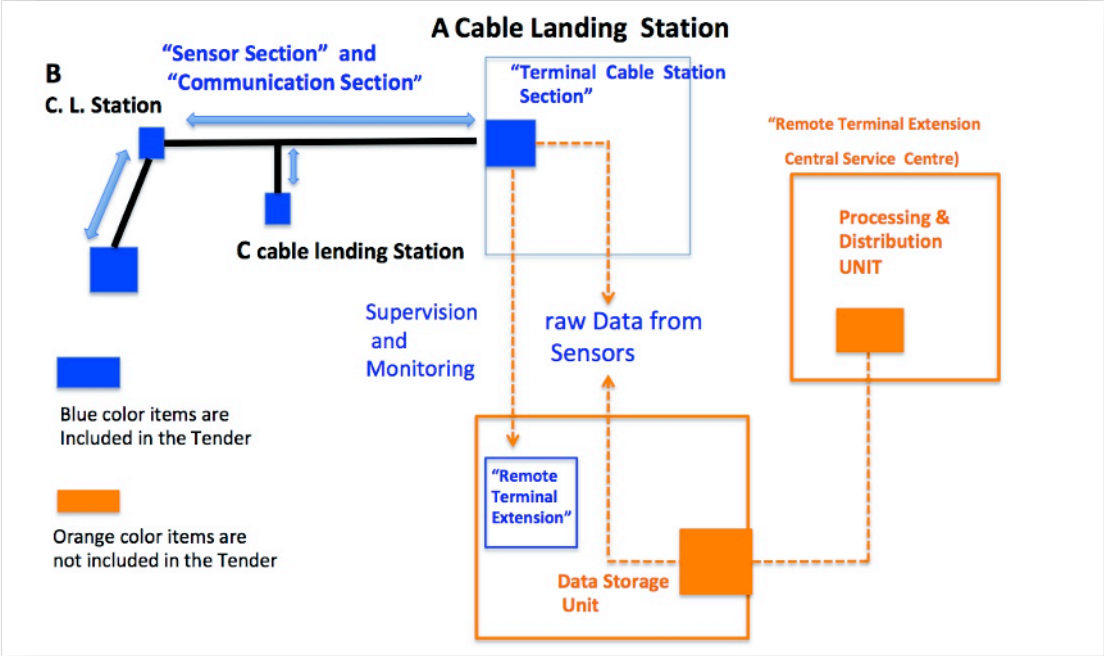

Fig. 2- Suggested schematic of data flow in the Submarine Cable

3. Particular Technical Specifications

for the “Observer Part”

3.1 Route Location of the “Packages of Sensors” IN LINE with the Submarine Cable System

Note:

The location of the cables used in these document's figures and the presumed location of Telecom Repeaters or Dedicated Housings is merely a hypothetic example to suggest a form to provide the required information in the potential Suppliers.

Support adding, comment:

For the purposes, in order to compare the presented solutions, as much as possible, as like with like, it shall be indicated an approximate location and estimative quantities of the Packages of Sensors to be used.

It is suggested to identify in each System Cable Segment (the submerged part between two Land Cable Stations of the submarine Cable System, A and B, for example, or between a BU and a Landing Station or between BUs in a Trunk Cable Segment) a specific Repeater by counting the Repeaters from Land station A to Land Station B (for example, the 25th repeater from Land Station A to Land Station B). The estimated repeater span (distance between repeaters) would estimate the location “Package of Sensors” placement.

As it will be referred to and developed ahead in this Document, two basic solutions IN LINE (inserted in the cable and not requiring special arrangements for cable laying or recovery) are referred to:

a) A Package of Sensors is placed inside the Telecom Repeaters.

b) A Package of Sensors is placed inside the Telecom Repeaters and/or PODs.

c) A Package of Sensors is placed inside Dedicated Housings in a total or mixed solution. If the solution of Dedicated Housings is adopted, a suggestion for location is to mention the System Segment, the Repeatered Section, and the position inside the Repeatered Section (for example, counted in meters from the closest Terminal Cable landing Station).

Support adding, comment:

At this stage, it's essential to give the Suppliers the information about ***where the Purchasers have to place approximately the "Package of Sensors" along the cable*** *route (based on one estimative cable route).*

In addition, the information related to the total number of "Packages of Sensors" in each area and the total count in the Submarine System must also be given. You may also refer to a minimum and a maximum "Package of Sensors" to be inserted in the System. In such a case, the suppliers shall consider both situations.

If the "Package of Sensors" does not have the same type of Sensors, it is convenient to mention where the Purchasers estimate to locate the different types of "Packages of Sensors" (with a different composition of Sensors).

As said before, at that initial stage, it is not important to present precise locations; this will be done during the different phases of establishing the cable route to be object of a marine survey. The Contractors and the Purchaser will agree on this Survey Route, but the Contractor must assume the contractual responsibility for the decision.

A simple figure like the fig.3, may help at that stage the potential Suppliers to have significant information to evaluate the number of "Package of Sensors" and/or Dedicated Housings and obtain important information on the cable assembly of Repeaters with sensors or/and Dedicated Housings with the cable, helping the Contractor to evaluate their best and cost-effective solution.

Note that, in general, the Telecom cable will include an estimative RPL (Cable route positioning list).

Based on the information given, the potential Suppliers shall present at the usual estimative RPL (Route Positioning List) for the Submarine Cable System project, a preliminary "Sensing SLD" (straight line Diagram with the positioning of the Packages of Sensors) indicating the positioning of Repeaters with "Package of Sensors" and Dedicated Housings. This "Sensing SLD" should be considered merely for indicative purposes but will allow comparing the different solutions of the potential Suppliers.

Figure 3, and table 1, indicate the total number of Packages of Sensors", suggested for the types of insertion of the Sensors IN LINE with the Cable (point 3 of this Document) and the Sensors used in each type of "Package of Sensors" (point 4 of

this Document).

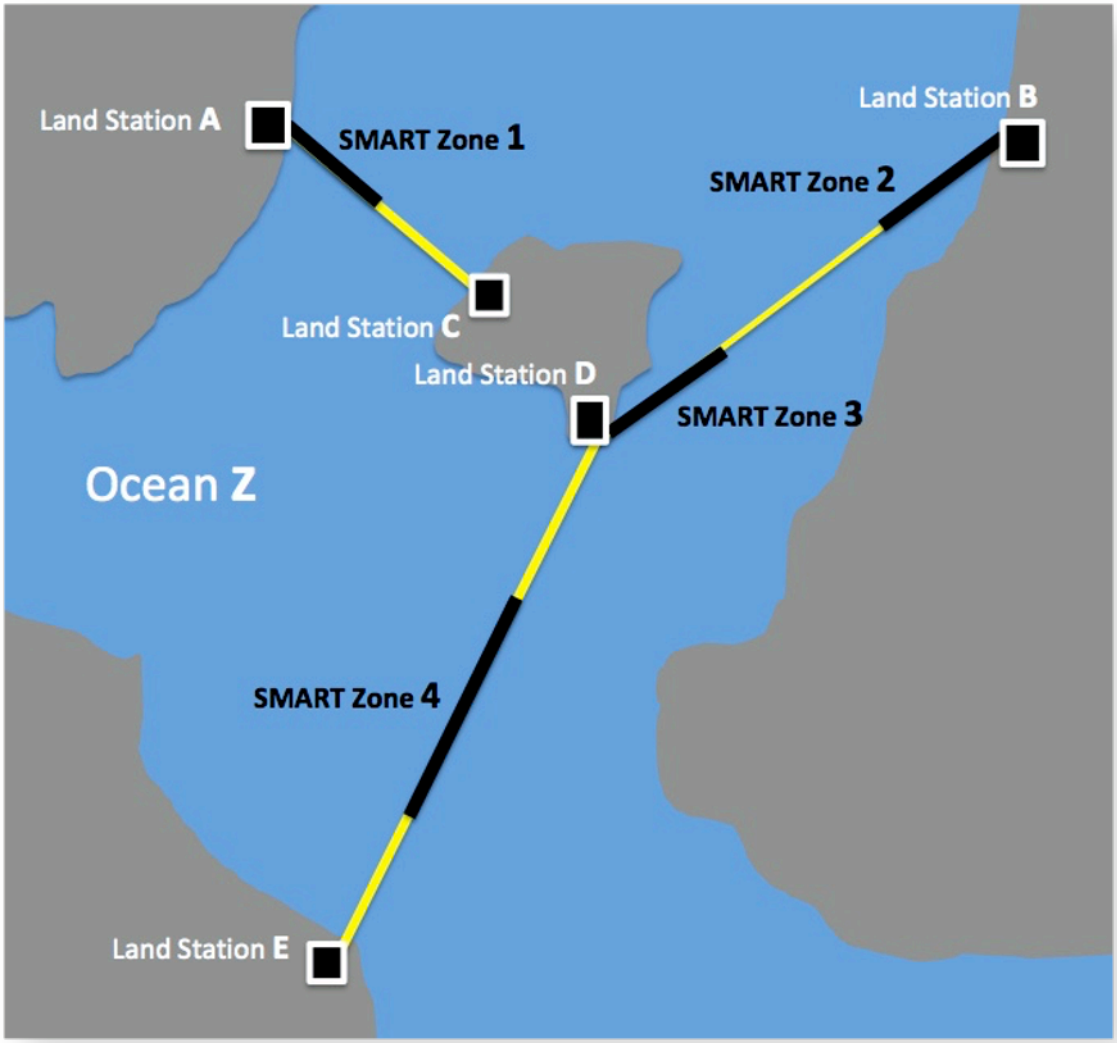

Fig. 3 - Location of the "Packages of Sensors" in the Submarine Cable Route (Sensing RPL). Note: Black Lines mean the zone of the Cable Segments with "Packages of Sensors".

Table 1 – Location of the "Packages of Sensors"

System Segment	SMART ZONE	SMART Solution	Sensors Package Positioning	Nº of packages
Station A – Station C	1	Package inside Repeaters	From Repeater 15th to 40th	25
Station B - Station D	2	Package inside Repeaters	From Repeater 20th to 45th	25
Station D - Station B	3	Packages in Dedicated Housings	From Repeater 5th to 30th, two equally spaced Dedicated Housings in each Repeater Session	50
Station D - Station E	4	Packages in Dedicated Housings	From Repeater 15th to 30th, two dedicated Housings in each Repeater Session, separated 15km from the repeaters	30

Conclusion Note:

Repeaters or Dedicated Housings for a total of 130 "Packages, of Sensors" are distributed along the 3 cable Segments. A column could be added to inform the type of Package (the exact Type of Sensors forming the specific "Package of Sensors"). The "Package of Sensors" is informed in point 4 of this Document.

Support adding, comment:

If applicable, in some or all Segments of the Submarine Cable System, in order to improve the observation in the shallow water area, one "Package of Sensors" can be placed close to the first Repeater (if a Dedicated Housing is used) or in the first repeater, in both the extremities of each Segment of the Submarine Cable System. An estimative of these areas can be indicated in Fig3.

After the laying of the cable, the Supplier shall inform with the maximum possible accuracy the location of the "Package of Sensors" and the heading of the cable for each "Package of Sensors", giving the orientation of the axis of the ground motion Sensors (accelerometer and/or seismometer) inside the Housing, without modifying the usual cable laying procedures.

3.2 Configurations with Sensors IN LINE

Based on the identified concepts for inserting the "Package of Sensors" IN LINE with the cable system, some examples of configurations are mentioned below, as indicative.

Other configurations and technical solutions can be presented; however, they shall be based on an IN LINE solution, which means that the marine laying and recovery of the cable can be undertaken using the usual laying practices without the need for additional installation of any type of branches or the need for any additional Cableship operation or instrumentation or additional time for laying or recovery. The Sensors are inserted inside the Repeaters of the telecom submarine cable system or in Dedicated Housings or a POD, in such last case, close to the Repeater, assuming that in all the options, the sensors are inserted IN LINE with the submarine cable.

3.2.1 "Package of Sensors" inside the Telecom Repeaters

In this configuration IN LINE, schematically represented in fig.4a/b, the "Package of Sensors" is inserted inside the Telecom Repeater. The Sensors from the "Package of Sensors" requiring contact with seawater, "Wet Sensors" (for example, Temperature and Pressure), are considered inserted in the "conic part "of the Telecom Repeater.
Low DC voltage could be obtained as usually is made for the units of the "Telecom Part" inside a standard Telecom Repeater.

The required solutions shall be implemented to isolate the fault or degradation of any component, unit or Section of the "Observer Part" from any possible direct or indirect fault or degradation caused in the "Telecom Part" and ensure compliance of all functional, operational and reliability specifications of the "Observer Part".

For that purpose, the Temperature, or other adverse impacts over the "Sensor Package" shall be mitigated.

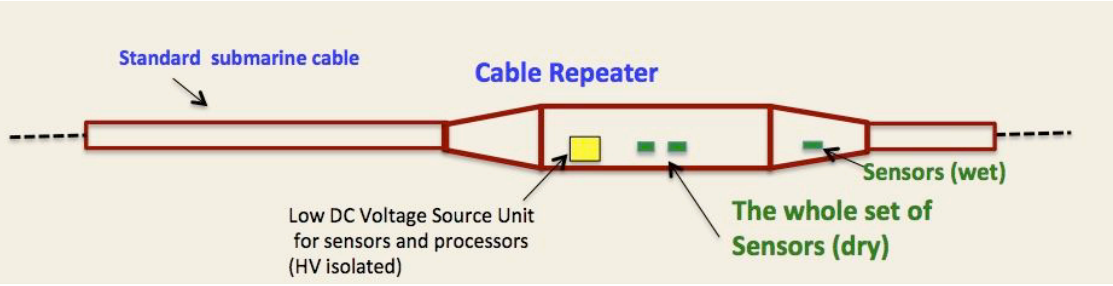

Fig.4a - Configuration scheme IN LINE, with the "Package of Sensors" inside the Telecom Repeater.

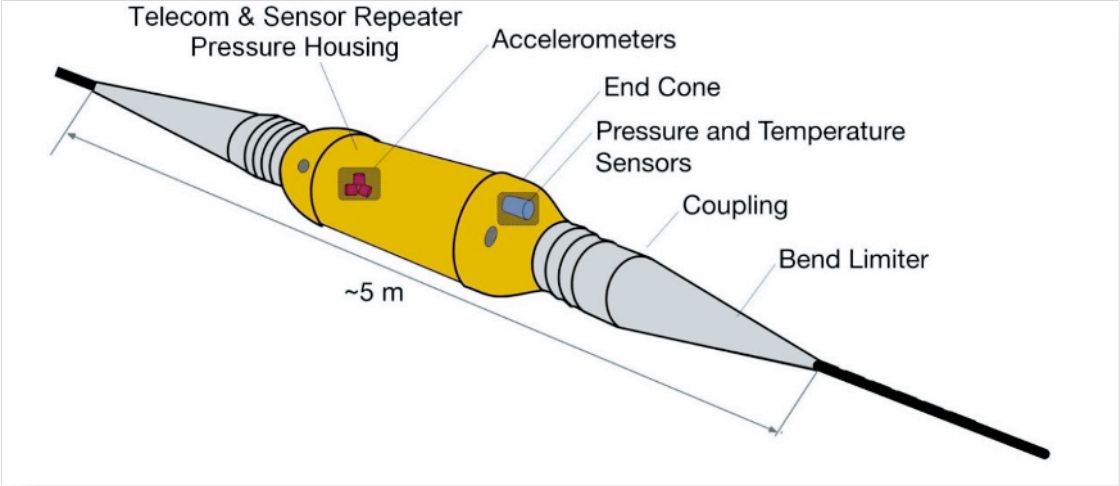

Fig. 4b - View of a configuration IN LINE with Sensors inside the Repeater. (Source: JTF)

If the potential Supplier selects this configuration, it is required to **present and demonstrate** the fundamental technical solutions to achieve the operational and functional requirements and the independence or absence of fault correlation between the Components and units of the "Observer Part" over the "Telecom Part" and ensure compliance of all specifications and reliability of the "Observer Part".

3.2.2 Sensors inside the Telecom Repeater with POD

In this IN LINE configuration, schematically represented in fig.5a, the "Package of Sensors" is inserted inside the Telecom Repeater. However, the Sensors from the "Package of Sensors" requiring contact with seawater, "Wet Sensors "(e.g., Temperature and Pressure), are considered inserted in the POD. Optionally all the Sensors may be inserted inside the POD. The POD is inserted over the cable a few meters away from the associated Telecom Repeater, on the repeater tail. The POD is linked to the associated Repeater with a low voltage and fibre mixed cable in order to allow the power feeding of Sensors and access to the "Data Communication Section" of the "Observer Part".

Low DC voltage is obtained from the associated telecom Repeater, as usually is made for the units of the "Telecom Part".

The required solutions shall be implemented to isolate the fault or degradation of any component, unit or Section of the "Observer Part" from any possible direct or indirect fault or degradation caused in the "Telecom Part" and ensure compliance with all specifications and Reliability of the "Observer Part".

For this purpose, the temperature, or other negative impacts over the "Packages of

Sensors" shall be mitigated.

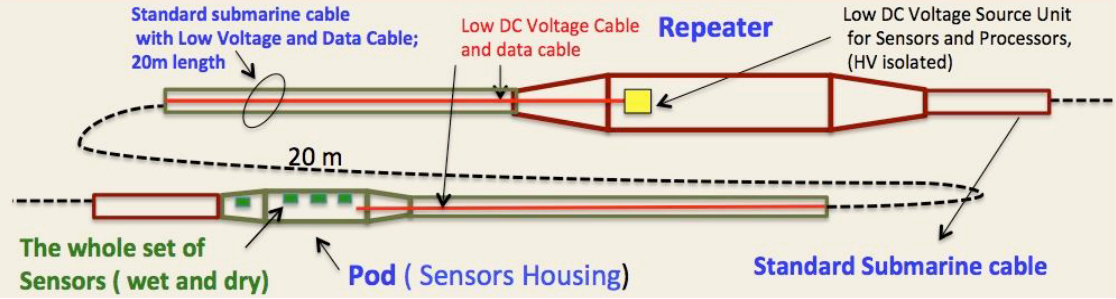

Fig.5a- Configuration scheme IN LINE with the "Packages of Sensors" inside the POD.
In this case, all Sensors were placed inside the POD.

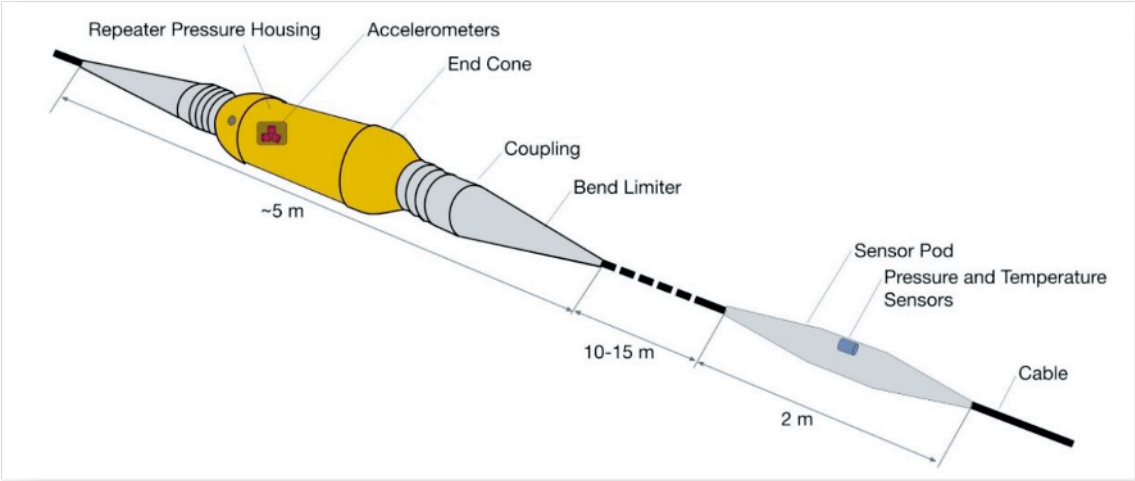

Fig. 5b - View of Telecom Repeater with POD with the wet Sensors inside the POD. (source: JTF)

For all the potential Suppliers use this configuration, it is required to present and demonstrate the fundamental Technical solutions to achieve the operational and functional requirements and the independence or absence of fault correlation between the Components and units of the "Observer Part" over the "Telecom Part" and ensure compliance of all specifications and reliability of the "Observer Part".

3.2.3 "Packages of Sensors" inside a Dedicated Housing inserted in the

Repeatered Sections (between the Repeaters)

In this IN LINE configuration, schematically represented in fig.6, the "Sensor Package" is inserted inside a Dedicated Housing included on the Telecom cable. In fig. 6c, it is schematically exemplified how a standard Telecom cable and the Dedicated Housings are integrated. Fig. 6.c explains the concept of the integration of a standard Submarine Telecom Cable and a Dedicated Submarine Cable with Sensors. This integration shows the advantage of the hybridization of the two types of submarine Cables, used for different services.

The Dedicated Housings are included in the Repeatered Sections of the submarine cable, at convenient positions. If required, more than one Dedicated Housing may be inserted in a cable Repeatered Section, subject to specific requirements to be defined by the potential Supplier.

The required power feeding for the "Packages of Sensors" is extracted from the Telecom cable in a similar way to the extraction from the Telecom Repeaters of the "Telecom Part". The fibres of the Telecom cable pass throughout the Dedicated Housing without any physical contact with the active units of the "Observer Part".

As a Dedicated Fibre Pair (not used for commercial communications) may be used for the "Data Communication Section ", the Telecom repeaters will not have any modification from the standard ones, only one additional fibre pair (the "Dedicated Fibre Pair") will pass throughout the standard Telecom Repeater without any interaction.

Low DC voltage for the DEDICATED HOUSING is obtained from the High voltage of the telecom cable as usually is made for the units of the repeaters of the "Telecom Part".

The required solutions shall be implemented to isolate a fault of any component or unit or Section of the "Observer Part" from any possible direct or indirect, consequential fault or degradation caused in the "Telecom Part" and ensures compliance with all specifications and reliability of the "Observer Part".

For this purpose, the temperature, or other negative impacts over the "Packages of Sensors" shall be mitigated.

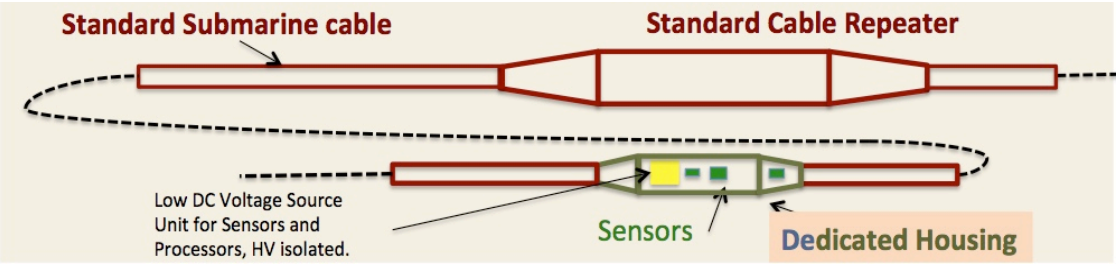

Fig. 6a - Scheme of Configuration with Dedicated Housing. (Concept: Sá, V.).

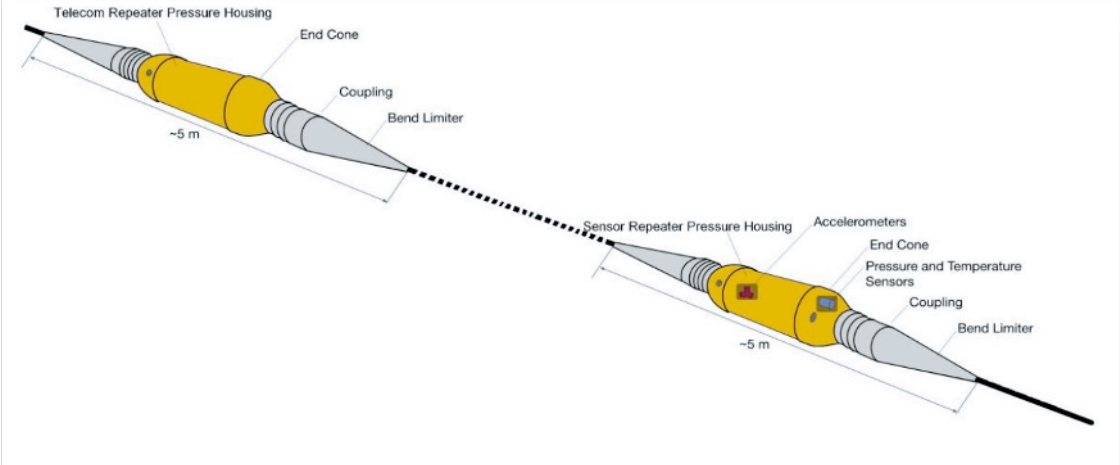

Fig. 6b - View of **Telecom Repeater** with Dedicated Housing having Sensors IN LINE. (source: JTF)

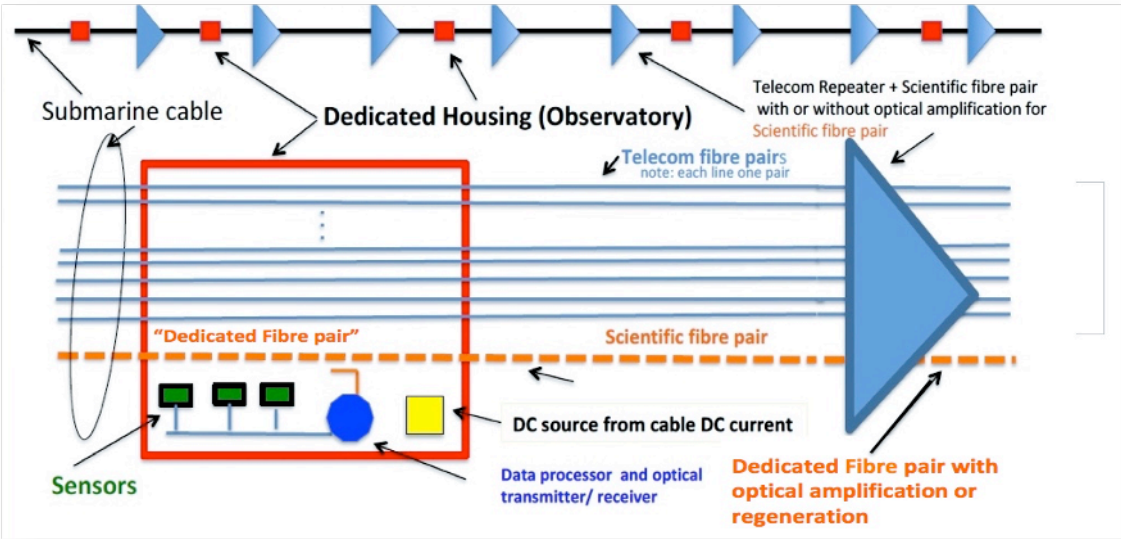

Fig.6c – Diagram of having Sensors IN LINE, inside a Dedicated Housing. (Concept: Sá, V.).

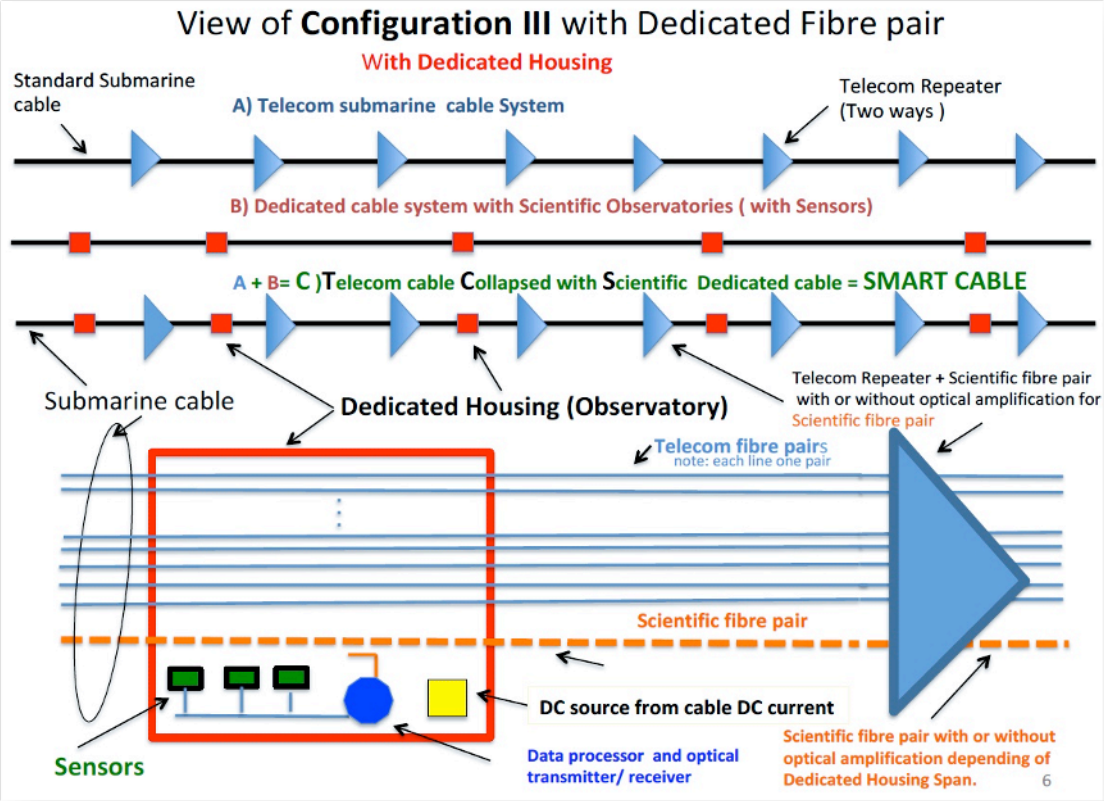

Fig. 6d - Schematic figure showing the addition of a conventional Submarine Telecom System with a standard Dedicated Sensing Submarine Cable, having Dedicated Housings. (Concept: Sá, V.).

If the potential Suppliers select this configuration, it is required to present and demonstrate the fundamental technical solutions to achieve the operational and functional requirements and the independence or absence of fault correlation between the Components and units of the "Observer Part" over the "Telecom Part" and the satisfaction of the contractual specifications and reliability of the "Observer Part".

3.2.4 Other configurations.

The potential Suppliers may present other configurations. However, the following aspects are strictly required and shall be confirmed and demonstrated:

a) It is required to present the fundamental technical solutions to achieve the operational and functional requirements of this Document, particularly the independence or absence of any direct or indirect, fault correlation between the components and units of the "Observer Part" over the "Telecom Part" and ensure compliance of all specifications and reliability of the "Observer Part".

b) The laying and the recovery of the Telecom submarine cable shall not be affected by the insertion of the "Observer Part" in terms of cost, requirements compliance and operational functionalities and repair procedures for the "Telecom **Part"** of the Submarine Cable System.

3.3 Parts of a SMART Cable System

3.3.1 General aspects. "Telecom Part"

This **Document, "Observer Part" of Submarine Cable System", shall** be considered an integrant part of the Submarine Cable System **and** contemplates the particularities for the **"Observer Part"** of the Submarine Cable System, formed by this part and by the "Telecom Part".

The "Observer Part" of the Submarine Cable System is formed into three Sections:

"Sensors Section": is formed by "Packages of Sensors", as defined in this Document "Observer Part."

"Communication Section": is formed by the means required to establish data communications from Sensors to the Cable Landing Station. An extension to a Central point should be considered.

"Terminal Cable Station Section": is formed by the Terminal at Cable Landing Stations required to Monitor and control the Sensors and interface the data to a Distant Processing and Storage Point. These Processing and Storage requirements are neither part of the "Observer Part" nor part of this.

The "Terminal Cable Station Section" shall allow the implementation of alarms, monitor facilities of the status of the "Sensors Section" and "Communication Section" and operational commands from the "Terminal Cable Station Section" for maintenance purposes or from the "Remote Central Point", via a remote terminal Extension, where the data is processed and distributed.

3.3.2 Sensors Section" and "Packages of Sensors"

The "Sensors Section" includes the "Packages of Sensors" inserted IN LINE with the Submarine cable according to the configurations suggested in point 3.2.

The potential Suppliers shall establish with the Sensors Subcontractors the required liaisons to develop and Audit the Qualification Procedures and the analysis and correction of failure modes of the Sensors to be used, which parameters are defined in point 4 of this Document. Furthermore, the potential Suppliers shall present

evidence of such methodology and procedures in terms of Quality Assurance for Specifications and Reliability.

All the Sensors shall be Qualified to allow the total satisfaction during the Design Lifetime considered for the Submarine Cable and referred to in this Document "Observer Part "of the "Submarine Cable".

The Sensors of the "Observer Part" must not cause, under any conditions or circumstances, any direct or indirect fault or degradation in the "Telecom Part" of the "Submarine Cable System" nor jeopardise the satisfaction of its Technical Specifications, during the 25 years of Design Lifetime.

In case of failure or degradation of a particular Sensor or a "Package of Sensors", it would not be repaired except in specific situations of opportunity. For example, a situation of opportunity could happen if a marine repair for the "Telecom Part" is required, and it is considered an opportunity to repair the "Observer Part".

3.3.3 "Communication Section"

The potential Suppliers shall develop and present reliable and cost-effective solutions to establish a data communication network throughout the submarine cable in order to allow the transference (real-time/near real-time) of data from the sensors to the "Terminal Cable Stations Section".

In order to increase the separation between the "Telecom Part" and the "Observer Part", a "Dedicated Fibre Pair" may be considered to establish bidirectional Data communications along the cable between the sensors and the "Terminal Cable Station Section" in the Land cable Stations.

The following basic specifications shall be considered:

a) Data flow
Data provided by the sensors to the "Terminal Cable Station Section" **must** be according to FIFO (first in, first out) principle, which guarantees streamed sequential data.

b) Data format
In general, at least 32bit encoding should be used. Standard formats common for the seismology community are welcome, in particular ***miniseed***, a sub-format of the standard for the exchange of earthquake data.
(SEED - https://ds.iris.edu/ds/nodes/dmc/data/formats/seed/)

c) Time Stamp and Data latency

NOTE: *values presented are provided as an example. The Purchaser should define the values on the tables. Basic support could be given.*

For ground motion sensors (accelerometer and seismometer), the samples must necessarily be available at the "Remote Terminal Extension" at "Remote Central Point" in less than 0.5 (objective 0.2 seconds) seconds after the respective occurrence. For the other sensors, the criticality of data latency is different, and for the corresponding sensors (thermometer, APG and the remaining additional ones), it should be lower than 10 seconds.

The "Packages of Sensors" shall be capable of recording the UTC at which data is collected with minimum accuracy better than 1 μs, when synchronization is provided from land.

A summary of presentation for the parameters and their required performance is presented in Table 2.

TABLE 2 - Time Stamp and Data latency

Parameter	Mandatory	Minimum	Expected	
Local clock with accuracy				
Accuracy				
If synchronization from land fails, the local clock shall maintain the time stamp accuracy.				
NOTE: Cells to be filled by the Purchaser. Support may be given for each particular case.				

d) Remote Control/Interaction with sensors

Control and interaction with the Sensors must be implemented for different purposes. For example, for remote calibration, a software tool shall be provided at the "Terminal Cable Station Section" to provide such facilities from a Remote Point of Data processing.

e) Data Service

Several configurations/architectures could be envisaged. For example:

A first one **(A)** is to consider each hub/repeater hosting a local ring-buffer with a data service (Internet protocol based) responding to requests from the user Data Centre.

A second **(B)** possibility could consist in making data available at the Cable Landing Stations Station(s), where a data service (Internet protocol based) will serve requests from the user's distant Data Centre.

To facilitate the ground motion data service interfacing with the user Data Centre, it is desirable for it to be **fully compatible with Seiscomp** technology, which consists of open-source software for real-time data transmission and sharing, in practice, a standard in the seismology community (https://www.seiscomp.de/). Other solutions may be defined or required by the potential Suppliers.

In case option **(A),** each local ring-buffer and corresponding data server should be accessible by redundant paths, probably something automatically available. In case option **(B),** there should be at least two CRF under supplier responsibility.

The potential Suppliers shall present a description and a schematic of the solution adopted and be contractually responsible for the satisfaction of overall Specifications and Reliability.

f) Supervision on the "Terminal Cable Station Section" or at the "Remote Terminal Extension" located at the "Remote Central Point."

Anomalies or failures in the Sensors would be able to be monitored at the "Terminal Cable Station" and extended to a "Remote Terminal Extension" located at the "Remote Central Point", where the raw data is processed and stored.

State of health data from the "Packages of Sensors", such as power supply voltage, mass position (e.g., for broadband seismometers), time status (e.g., uncertainty), and others considered relevant for monitoring the system performance shall be provided.

In case of failure or degradation in a sensor, or in case of other convenient reasons, the power of the Sensor should be able to be safely powered off manually or automatically.

The same applies to power on a Sensor after a temporary power off.

All the anomalies in the Sensors and other parts of the "Observer Part" shall be monitored and archived with a time stamp in the "Terminal Cable Station Section" memory and extended to the Remote Processing and Distribution Centre.
The "Observer Part" shall be capable of performing data integrity checks such as

packet loss ratios and reporting this information.

3.3.4. “Terminal Cable Station Section”

The potential Suppliers shall consider for the “Terminal Cable Station Section” the required facilities and functionalities to access the raw data from all the Sensors implemented in the “Submerged Elements” of the “Observer Part”.

Additionally, the “Terminal Cable Station Section” shall allow controlling, as required, the Sensors and receiving Monitor information from the status of the sensors (state of health information).

The potential Suppliers shall evaluate with the Sensors Subcontractors the necessary controls to be sent to the Sensors and which status and alarm information applies to each sensor type.

The potential Suppliers shall consider using the control facilities to power off-on any particular sensor, in case of fault or degradation or due to operational reasons from the “Terminal Cable Station Section” or the “Remote Terminal Extension.”

The “Terminal Cable Station Section” shall observe, in a reasonable way, a physical independency from the SLTE of the “Telecom Part” of the “Submarine Cable System”. However, if convenient and cost-effective, the use of a separated shelf(s) in an adequate location of the racks of the SLTE of the Telecom Part” could be acceptable.

The “Terminal Cable Station Section” will be interfaced with a “Remote Central Point” for Storage of Data, Processing and Distribution, as well as for Monitor and Management via a Remote Terminal.

The potential Suppliers are required to inform in detail the data interfaces as specified in point (3.3.) of this Document.

4. Sensors to be included in the “Packages of Sensors”.

***Support Note**: Cells in the presented tables to be filled by the Purchaser. Support may be given for each particular case. In alternative, the Purchaser may request estimative values from the potential Suppliers*

4.1 General considerations

The following Sensors and specifications are required to be presented.

a) **Mandatory Sensors** required to be presented.

ACCELEROMETER
ABSOLUTE PRESSURE GAUGE
THERMOMETER

b) **Extra**, not mandatory Sensors, for optional consideration.
To be defined by the Purchaser.

c) **Optional Sensors,** with other functionalities, may be considered.

4.2 Specifications for the Sensors

The potential Suppliers must consider the following Specifications and Parameters.

A) Requirements for the Mandatory Sensors
A.1) Accelerometer
A.1.1) Parameters

TABLE 3 - Accelerometer

Parameter	Mandatory	Minimum	Expected
Configuration			
Frequency bandwidth (±3 dB)			
Resonance frequency			
Full-scale range			
Dynamic range			
Sensitivity			
Noise floor			
Linearity			
Cross-axis sensitivity			
Sampling rate			
Sample resolution			
Particular requirements			
Cells to be filled by the Purchaser; support can be given.			

A.1.2) Particular requirements

A.1.2.1) Levelling procedures and tilt tolerance must be provided. The sensor and its method of installation must ensure that the sensor is properly levelled or that the tilt of each component can be known using gravity as a reference.

A.1.2.2) The sensor must survive to all types of applicable stresses resulting from the cable loading, deployment, protective methods, or recovery, during the initial cable laying or in case of a marine repair.

A.1.2.3) The Reliability requirements are considered in point 6.

A.2- Absolute Pressure Gauge

A.2.1) Parameters

TABLE 4 – Absolute Pressure Gauge

Parameter	Expected
Range	
Overpressure tolerance	
Accuracy	
Drift	
Hysteresis	
Repeatability	
Sampling rate	
Sample resolution	
Noise Floor	
Operating depth	
Particular requirements	
Cells to be filled by the Contractor; support could be given.	

A.2.2) Particular requirements

A.2.2.1) Pressure measurements should be obtained with a minimum of buffer fluid between the sensor transducer and the ocean water, with the buffer fluid held in place through capillary action. The potential Suppliers shall demonstrate the efficacy and Lifetime of this or an alternative solution.

A.2.2.2) The sensor must survive to all types of applicable stresses resulting from the cable loading, deployment, protective methods or recovery, due to the initial cable laying or in case of a marine repair.

A.2.2.3) The Reliability requirements are considered in point 6.2)

A.2.3.4) The Sensor must be adequate to the operative deployed Depth. If not possible, the potential Suppliers must provide information on the limitations that result from operating the sensor at a different depth from the one it was designed for.

A.3 – Temperature

A.3.1) Parameters

TABLE 5 – Temperature

Parameter	Expected
Initial accuracy	
Stability	
Sampling rate	
Sample resolution	
Operating depth	
Cells to be filled by the Purchaser; Support can be given.	

A.3.2) Particular requirements

A.3.2.1) Water temperature measurements must be free of “heat island” contamination from the heat generated by the repeater internal optical/electronics and be independent of repeater/cable orientation. If the repeater is unburied, at least one temperature Sensor must be exposed to ocean water.

A.3.2.2) The sensor must survive to all types of applicable stresses resulting from the cable loading, deployment, protective methods, or recovery, du the initial cable laying or in case of a marine repair.

A.2.2.3) The Reliability requirements are considered in point 6.2).

A.2.3.4) The Sensor must be adequate to the operative deployed Depth.

B) Requirements for Extra, not mandatory Sensors

These Sensors may be considered as an option.

NOTE: The Purchaser should provide the list of extra sensors according to its needs. As an example, requirements for a seismometer are presented.

B.1- Seismometer

B.1.1) Parameters

Parameter	Mandatory	Minimum	Expected
Configuration			
Frequency bandwidth (±3 dB)			
Dynamic range			
Noise floor1			
Sensitivity			
Clip level			
Sampling rate			
Sample Resolution2			
Particular requirements			
1 Refers to the sensor; 2 Refers to the Datalogger			
Cells to be filled by the Purchaser (see initial note); Support could be given ; see next support comment.			

B.1.2) Particular mandatory requirements

B.1.2.1) Levelling procedures and tilt tolerance must be provided. The sensor and its method of installation must ensure that the sensor is properly levelled or that the tilt of each component can be known using gravity as a reference.

B.1.2.2) The sensor must survive to all types of applicable stresses resulting from the cable loading, deployment, protective methods or recovery, du the initial cable laying or in case of a marine repair.

B.1.2.3) The Reliability requirements are considered in point 6.

C) Additional Sensors for consideration

To be evaluated case by case, at a later stage. Examples of relevant parameters for ocean monitoring that may be considered are conductivity, tilt or oxygen.

Support comments: ***General basic example of Specification for Mandatory Sensors****; Lifetime Design in accordance with the Reliability considered in the present document (25 years) point 6. Of this Document.*

Reference:

JTF Engineering White Paper June 2016 " General Requirements for Smart Cables""

Summary of basic Sensors (precise sensors and specifications to be presented by the Purchasers)

- ***Basic Sensors***
- ***Accelerometer***
- ***Absolute Pressure Gauge***
- ***Thermometer***

Accelerometer

Parameter	*Mandatory*	*Minimum*	*Reference*
Configuration	*3-Axis*		
Frequency bandwidth (±3 dB)		*0.1 to 100 Hz*	*DC to 200 Hz*
Resonance frequency			*> 2,000Hz*
Full scale range	*±2g*		
Dynamic range			*155dB in 3Hz to 30Hz*
Sensitivity			*100 ng*
Noise floor		*3 ng/$\sqrt{Hz}$*	*0.5 ng/$\sqrt{Hz}$*
Linearity			*±1% of full scale*
Cross-axis sensitivity			*<1%*
Sampling rate		*100 Hz*	*250 Hz*
Sample resolution		*18 bit*	*24 bit*
Lifetime Design Specification	*25 years*		*25 year*

Absolute Pressure Gauge

Parameter			Reference
Range			0 to 73MPa
Overpressure tolerance			84MPa (8,000m)
Accuracy			±1mm relative to recent measurements; 0.01% of full range absolute
Maximum allowable drift after a settling-in period			<10⁻ / year
Hysteresis			≤ ±0.005% of full scale
Repeatability			≤ ±0.005% of full scale
Sampling rate			20 Hz
Sample resolution			32 bits
Noise Floor			0.14 Pa2/Hz
Operating depth			Appropriate to deployment depth. Maximum is 8000 m
Drift			1x10⁻/year or better, after settling
Lifetime Design Specification	25 years		25 year

Temperature

Parameter			Reference
Initial accuracy			± 0.001ºC
Stability			0.002ºC / year
Sampling rate			1 Hz
Sample resolution[2]			24 bits
Operating depth			To be defined
Lifetime Design Specification			25 year

5. Information required for the “Submerged Elements” of the “Observer Part”

5.1 Sensors

The following information shall be presented.

a) A technical description of the proposed Sensors, including the functionalities, power consumption, interface with the “Communication Section”, general aspects of the insertion in the Housing and any safety considerations.

b) The specific Reliability information requested in point 6.3.

c) The complete list of the parameters and functionalities presented by the potential Suppliers and referent to each type of proposed Sensor.

d) The manufacturer and complete reference to of each type of Sensor.

e) Any particular operational conditions associated with the safety of the Sensors must remain satisfied due to the normal operation of the SMART Cable, including cable laying and repair and Repeaters and Dedicated Housings, if applicable, storage and transport.

f) Any particular safety aspects associated with the laying and recovery operations of the cable, for installation or due to a repair.

g) Self-tests shall be able to be implemented from the “Terminal Cable Station Section” or its extension to a remote point to evaluate the performance and status and operational conditions of the Sensors. The following aspects, not limited to, shall be considered:

a) The “Packages of Sensors” shall be able to report the calibration coefficients of all sensors, as set prior to deployment or as calculated after deployment.

b) The “Packages of Sensors” shall be able to report the “State-of-Health” of each sensor, e.g., regular operation, faulty, failed, or offline.

c) The “Packages of Sensors” shall be able to report values of interest, to be collected and Stored at the “Terminal Cable Station Section” regarding each sensor, including, at a minimum, device model, serial number, manufacture date, installation date, calibration and anomalies history. This information may be collected prior to or during installation and commissioning, as well during and after the period of Warranty of the “Observer Part” of the New SMART Cable.”

5.2 Additional requirements for the Power Feeding Equipment of the Submarine Cable System (PFE, to feed the Sensors

The potential Suppliers regarding the power feeding of the Sensors by the Submarine Cable System shall present the following information associated with the "Observer Part":

a) The concept and the process to power feed the Sensors inside the Telecom Repeaters or the Dedicated Housings or POD shall not affect in any way the "Telecom Part". The potential Suppliers shall present a description of the Power Feeding arrangement and a demonstration of the safety, in all aspects, of the power feeding of the Sensors.

b) Any additional requirements of Power or HV, required in the PFE of the Cable Landing Stations.

c) Any additional functionality or safety operational precautions and other procedures or functionalities required in the PFE of the Cable Landing Stations.

d) Any required adjustment in the normal parameters of the power feeding.

e) Any additional requirements for the operation of the PFE in the Cable System associated with the safety regulations and procedures for the operation and maintenance of the equipment or due to cable repairs or reconfiguration of the System Power Feeding configuration.

f) Any specific risks associated with the insertion of Sensors in the repeaters or Dedicated Housings.

g) Any modification with the procedures used for fault location with the PFE.

5.3 "Communication Section" for communication with Sensors

The potential Suppliers shall present the following information, but not limited to, in this Tender, in order to complement a description of the "Communication Section".

a) A general description of the transmission means of the Communications Section" including the type of fibre, if applicable, and any specific arrangements to insert the fibre along the cable System.

b) The basic communication units forming the "Communication Section" and the design of the communication scheme proposed to connect the Sensors, "Sensors Section", with the "Terminal Cable Station Section".

c) The redundancies included in the “communication Section” to avoid, in case of failure or degradation in any of its units, a failure of communication with the “Cable Station Section”, satisfying the Reliability requirements of this Document.

d) Develop the schematic of the “Communication Section” to describe how a Sensor is connected to the “Communication Section”. The description shall include the presentation of the architecture and type of components of the communication network and the number of redundant communication pathways used by each Sensor to be linked with the “Terminal Cable Station Section”. In addition, the potential Suppliers shall demonstrate the effective availability of operational pathways for each particular Sensor during the “Telecom Part” Lifetime (25 years) with at least 95% probability.

e) Whenever applicable, the optical power budget of the optical links between regeneration sections shall be presented in an adequate format and taking into account any required additional ageing margins at the beginning of life and end of life, as well as, at the end of 5 and 15 years after the Initial Acceptance.

f) The potential Suppliers shall consider the possibility of using, in a cost-effective way, any additional capacity in the “Dedicated Fibre Pair” if feasible” for non–commercial traffic use.

5.4 Information required for the “Terminal Cable Station Section”

5.4.1 Data Protocol and Interfaces with an external “Remote Terminal Extension” for Storage or Processing & Distribution

The potential Suppliers shall present and describe the protocols and interfaces he intends to use to satisfy the requirements of this Document.

5.4.2 Power and Space Requirements

The potential Suppliers shall describe the required space occupancy and power supply for the “Terminal Cable Station Section”. The “Terminal Cable Station Section” may be considered physically separated from the Terminal of the “Telecom Part” if cost-effective or integrated with this Terminal.

5.4.3 Redundancy of the “Terminal Cable Station Section”. Stock of spare units.

The potential Suppliers shall provide the Reliability parameters (FIT) of the active

units or parts of the Terminal Cable Station Section": the Lifetime and the constant failure rate during the Lifetime for all the active units, the redundancy scheme implemented, and the Burn-in procedures implemented in the Factory, before installation at the Cable Landing Station. In addition, all burn-in procedures and any consequent remedial actions shall be implemented in the factory before transporting the improved or replaced equipment to the terminal stations. A detailed report shall be supplied and accepted by the Purchaser.

The potential Supplier shall present and quote a list of Spares that, taking into account the objective of 25 years of Design Lifetime, the respective Failure Rate of the units, the number of units in service, and the time to repair at the factory, could guarantee that the probability of loss of data from a Sensor due to a missing spare (for replacement) in the "Terminal Cable Station Section" is lower than 5%, during the Lifetime of 25 years of the Submarine Cable System. The stock for the "Submerged Elements of the "Observer Part" will be defined in accordance with the defined configuration IN LINE.

5.4.4 Supervision, Monitor & Controlling of the "Observer Part"

The potential Supplier shall describe all the implemented features to allow the Supervision and Monitor of the "Observer Part", as well as the Controls to be sent to the "Sensor Section" from the "Terminal Station Cable" and from a "Remote Central Point" (used for Storage or Processing & Distribution).

The facilities, means and procedures required for implementation in the "Terminal Station Cable Section" to store and manage the history of the Supervision and Monitor activities, as well as the status and alarms of the Sensors, shall be described. This Data and control & command facilities shall also be available at a "Remote Central Point" for Processing and Management.

5.4.5 Preliminary document with operational information

The potential Suppliers shall present a preliminary document with information covering the operational functionalities and procedures on the "Terminal Cable Station Section" and from a "Remote Terminal Extension" point to Manage, Monitor, and Control the "Observer Part" of the Submarine Cable System.

5.4.6 Fault location for the "Sensors Section" and "Communication Section"

The "Terminal Station Cable Section" shall be able to locate faults in the Sensors

and locate any particular fault in the Communication Section" of the "Observer Part".

The potential Suppliers shall describe how they intend to implement fault location facilities to allow from the "Terminal Station Cable Section" or from one Remote Terminal Extension" to locate and register the faults on the Submerged Elements of the "Observer Part" of the Submarine Cable System.

The potential Supplier shall present examples of fault location procedures for the different possibilities of faults on the submerged part of the "Observer Part" that may affect the functionality and performance of such Part, as well as, in general lines, the presentation format.

6. Reliability of the “Observer Part” and Reliability independence of the “Observer Part” and the “Telecom Part”

6.1 General

The potential Suppliers must undertake their best endeavours to optimise the Reliability objectives for Submarine Cable System.

The Reliability figures presented for all the Sections of the “Observer Part” shall be clearly justified and, whenever possible, demonstrated mathematically, based on the established Quality Assurance Process and the ultimate usual Reliability theory and practice.

All the Reliability parameters, particularly for the Lifetime and Failure Rate (FIT) of all types of Sensors, units and components of the “Observer Part”, shall be obtained with at least a Confidence Level of 95%.

6.2 Reliability objectives

The overall Reliability requirements for the **“Observer Part”** are the following:

6.2.1 Design Lifetime

The Design Lifetime, with a constant Failure Rate, for the “Observer Part” shall be the same as the **“Telecom Part”**, 25 years, counted from the Initial Acceptance of the Submarine Cable System. The Lifetime shall be obtained with a minimum Confidence Level of 95%.

The potential Suppliers shall present confirmation of the satisfaction of the 25 years Design Lifetime, obtained at least with a Confidence Level of 95%.

6.2.2 Maximum number of unavailable Sensors at the end of the Lifetime

a) For each type of Sensor, at the end of its committed contractual Lifetime of 25 years, the maximum number of Sensors:

i. From which the raw Data is not available, satisfying the required specifications and functional capabilities, at the “Terminal Cable Station Section” located at the Cable landing Stations, due to any type of internal fault in the “Sensors Section” or

"Communication Section" or,

ii. being faulty, degraded or not compliant with the parameters Specifications,

must not be higher than **10%** of the total number of Sensors of such type in each Segment of the Submarine Cable System, rounded down to zero decimal places.

b) It is assumed for the calculation above mentioned, in point a), that in case of failure during the Lifetime, no Sensor will be replaced at the submerged part of the Submarine Cable System.

On the contrary, it is assumed that failures in the land part, the "Land Elements" of the "Observer Part" at the "Terminal Cable Station Section" will be repaired and will not be considered if repaired in the contractual conditions (namely the point 5.4.3.), for the quantity of 10% of non-operational or degraded Sensors, mentioned in the above point **a).**

6.3 Formal contractual presentation of Reliability figures for "Observer Part", "TABLE of Committed Reliability Figures".

The Design Lifetime, with constant Failure Rate, and the Failure Rate (FIT) for each type of Sensor or other units of the **"Observer Part"** shall be presented in a Specific Table denominated, e.g., "TABLE of Committed Reliability Figures" and would necessarily be an integrant part of the Contract Document of Submarine Cable System. This Table shall include the Units of the three Sections of the **"Observer Part",** that is, the "Sensors Section", the "Communication Section", and the "Terminal Cable Station Section", susceptible to causing a failure mode or degradation in any of such sections. These figures shall be obtained with a minimum Confidence Level of 95%.

6.4 Reliability independency between the "Observer Part" and the "Telecom Part"

The **"Observer Part"** and the **"Telecom Part"** of the Submarine Cable System must be considered entirely independent in terms of Reliability and correlation of faults, caused by the **"Observer Part"** on the **"Telecom Part".** This means the following:

a) Any type of fault, degradation or malfunction of the **"Observer Part"** of the Submarine Cable System due to any internal failure must not in any circumstances, directly or indirectly, be likely to cause a fault or degradation of any unit or part of the **"Telecom Part"** of the Submarine Cable System or affect any of the technical specifications of this "Telecom Part", particularly in the submerged part and especially in the Repeaters, during the 25 years Design Lifetime of the system.

b) With the complete satisfaction of the conditions mentioned in a) above, a failure in the **"Observer Part",** with the Sensors inserted in a Telecom Repeater, or a Dedicated Housing or in a POD, will not be considered a failure of the **"Telecom Part"** of the Submarine Cable System.

c) Any type of fault event in the **"Observer Part",** including the "Sensor Section", must not, in any conditions or circumstances, affect directly or indirectly the Reliability figures committed contractually by the potential Suppliers for the **"Telecom Part",** of the Submarine Cable System, particularly for the submerged part of the **"Telecom Part ",** during the 25 years Design Lifetime of the Submarine cable System.

d) A fault or degradation in the **"Telecom Part"** or any negative impact on its Reliability, caused directly or indirectly by any internal fault or degradation in the **"Observer Part",** occurred in any conditions or circumstances, must be considered in terms of the Contract of the **"Telecom Part"** of the Submarine Cable System as a common internal fault of the Submarine Cable System, as any other fault of the submarine cable system.

e) Any internal fault or degradation in the **"Telecom Part"** of the Submarine Cable System causing a fault or degradation in the **"Observer Part"** implies that this fault in the **"Observer Part"** must be considered for all the contractual aspects of the Submarine Cable System as a fault of the **"Telecom Part".** In such circumstances, this fault in the **"Observer Part"** must be object of the same liabilities for remedial actions from the Supplier.

f) If a "pattern of failure" occurs in the **"Telecom Part"** of the Submarine Cable System, the inclusion of the **"Observer Part"** and particularly of the "Sensors Section" or "Communication Section" in the Submerged part of the system, or the "Terminal Cable Station Session", at the Cable Landing Station, must not, in any conditions or circumstances, be considered a reason for reduction of any measures, remedial actions or liabilities due by the Supplier as a result of the Contractual Terms and Conditions applicable to the **" Telecom Part "** of the Submarine Cable System and also to the **"Observer Part".**

g) All the Reliability figures and any other specifications, or POWER Budget, presented for the **"Telecom Part"** of the Submarine Cable System must, in any circumstances, be considered as having already incorporated any possible applicable impact during the Submarine Cable System Design Lifetime of 25 years, resulting from the inclusion of the **"Observer Part".**

6.5 Reliability information required for the Sensors in the "Sensors Section", including Digital/Analogic conversion

The following information is required:

6.5.1 Values for Lifetime and Failure Rate (FIT) of all the units of the "Sensors Section"

The potential Suppliers shall provide in for each type of Sensor, including the data-loggers, the Lifetime and the constant Failure Rate (FIT) during the Design Lifetime of 25 years, with a Confidence Level not lower than 95%.

These elements shall be included in the Table, mentioned in point 6.3, to be presented as a contractual integrant part.

6.5.2 Reliability interdependence between different types of Sensors

A failure in one particular Sensor included in a "Sensor Package" inserted in any kind of Housing, "Repeater", "Dedicated Housing" or "POD", shall not affect any other Sensor of the respective "Package of Sensors" or any Sensor of other "Package of Sensors".

6.5.3 Description of the redundancy design and Quality Assurance Procedures implemented for the Reliability improvement of the "Sensors Section".

The potential Suppliers shall describe the redundancy design and Qualification Procedures implemented in order to optimise the Reliability figures of the "Sensors Section", particularly in what concerns the different types of Sensors.

The potential Suppliers shall present the established general methodology and procedures and the failure modes investigation established with the subcontractors/manufacturers of Sensors in order to Qualify, Audit and optimise the "Sensor Section" Reliability and present a report with the results obtained.

6.5.4. Maximum number of failures for the Sensors, including digital /analogue conversion (Data Loggers)

Taking into consideration the Reliability figures (FIT) referred to in point 6.3, "TABLE of Committed Reliability Figures", the potential Suppliers shall present for each type of Sensor (including the DataLogger), and according to the Reliability principles, a mathematical demonstration of the maximum number of failures for every type of Sensor in each one of the Segments of the Submarine Cable System, at the end of its Design Lifetime of 25 years.

For this computation, the results shall be obtained with a probability not lower than 95%, for each Segment of the Submarine Cable System.

6.6 Reliability Information required for the "Communication Section"

The following information is required:

6.6.1 Values for Lifetime and Failure Rate (FIT) of all the active units of the "Communication Section".

The potential Suppliers shall provide the Lifetime, with constant Failure Rate and the Failure Rate (FIT) for each Unit of the "Communication Section" obtained with a Confidence Level not lower than 95%. These elements must be included in the table "TABLE of Committed Reliability Figures", mentioned in point 6.3. The potential Supplier shall provide the adequate Reliability Qualification Procedures used to obtain such values.

6.6.2 Description of the redundancy Design and Quality Assurance Procedures

The potential Suppliers shall describe and present a schematic of the "Communication Section", including the redundancy design and Qualification Procedures implemented in order to optimise the Reliability figures of the "Communication Section". Particular attention shall be taken to the Reliability of the used components and the redundancy of the access of each specific Sensor to the "Terminal Cable Station Section", which shall use an adequate redundant multipath concept.

Based on the Reliability figures presented in point 6.3, the potential Suppliers shall provide and mathematically demonstrate the maximum total number of Sensors affected and out of operation due to a failure event in the communication path of the "Communication Section" between the Sensor and the "Terminal Cable Station," at the end of the Sensors Design Lifetime, for each Submarine Cable System Segment. This maximum number of failures shall be calculated with a probability not lower than 95%.

The potential Suppliers shall present a schematic view of the established overall Reliability Design of the "Communications Section".

6.7 Quality Assurance, including Burn-in Procedures to eliminate Early Failures

The potential Suppliers shall provide in the established process to implement Burn-in procedures to eliminate the Early Failures in all the Sections of the **"Observer Part"** and particularly in the "Sensors Section". Special consideration shall be made concerning the Burn-in procedures to be established for each type of Sensor, including the Data Loggers. The process to control and audit the subcontractors shall be presented, in general lines, as detailed as possible.

The potential Suppliers shall present a Plan for the Quality Assurance and Qualification of the "Observer Part", mentioning the involvement and participation of Sensors Subcontractors, as applicable and the obtained results.

6.8 Overall Reliability for the "Observer Part", including Sensors, Communication and Terminal, during the 25 years Design Lifetime

The potential Suppliers shall provide the overall Reliability figures of the "Observer Part" of the Submarine Cable System, including, but not limited to, all the Sections of the **"Observer Part"** formed by the "Sensor Section", "Communication Section" and "Terminal Cable Station Section".

Taking into account the Lifetime and constant Failure Rate (FIT) during the Design Lifetime of the SMART CABLE, 25 years, obtained with a Confidence Level not lower than 95% for the Sensors and other components of the "Observer Part", presented as referred to in the point 6.3, "TABLE of Committed Reliability Figures", the potential Suppliers are required to present evidence and demonstrate:

a) The maximum number of Sensors from which raw data is not received correctly at the "Terminal Cable Station Section" due to Sensors being failed, degraded or not operational or due to any fault in the "Communication Section" causing that the data of such Sensors available at the "Terminal Cable Station Section" cannot comply with the specifications required for the "Sensors Section".

b) This information shall be given for 5, 10, 15, 20 and 25 years, after the date of Coming into Service of the Submarine Cable System, with an event probability not lower than 95% (Confidence Level).

7. Impact of “Telecom Part” faults on the “Observer Part” of the Submarine Cable System

The potential Suppliers shall provide any type of possible impact of the “Telecom Part” on the “Observer Part”. The following points, but not limited to, shall be considered:

a) External cable fault on the submerged cable system affecting the Power Feeding. Different fault conditions should be considered.

   The potential Suppliers shall present the possible impacts on the Reliability and functionalities of the “Sensors Section” and “Communication Section” during its Lifetime.

b) Power on/off the submarine cable PFE due to cable repairs or maintenance Power Feeding, or other operations.

   The potential Suppliers shall present the possible impacts on the operation and the Reliability and functionalities of the “Sensors Section” or “Observer Section” along the 25 years Lifetime.

c) Operational information to mitigate any type of negative impact on the “Observer Section”.

   If applicable, the potential Suppliers shall present in general lines for operational recommendations to mitigate possible impacts of the “Telecom Part” on the “Observer Part”, to be developed subsequently, if applicable, and included in the Submarine Cable System Operation Manual.

d) The potential Suppliers shall consider any other situations that could cause possible impacts on the Reliability and functionalities of the “Sensors Section” or “Communication Section” along its 25 years Lifetime.

8. Repair methodology in case of fault of the "Sensors Section" or" Communication Section" of the Submarine Cable System

In case of a fault in the "Sensors Section" of the **"Observer Part"** of the Submarine Cable System, which must not affect in any circumstances the "Telecom Part", as mandatorily required in this Document, the Purchasers will not repair the submerged part of the Submarine Cable System, except if special conditions of opportunity or circumstances are observed. Opportunity conditions may be observed if a marine repair is required for the "Telecom Part". This situation does not apply if the reliability of the "Observer Part" is not satisfied, under the responsibility or Guaranty of the potential Supplier.

9. Impact of the "Observer Part" on Marine Operations, Cable Laying, Recovery and Repair; Cable Laying positioning accuracy.

9.1 Compatibility with Marine repair Operations, Cable Laying and Recovery

The potential Suppliers shall confirm that the presented IN LINE configurations, inserting the "Packages of Sensors" inside the Repeaters, inside the Repeaters with POD or inside Dedicated Housings, or other proposed configuration IN LINE, are fully compatible with the usual methodology and practice used by the submarine cable industry for all the marine operations applicable to a common telecommunications submarine cable, not requiring any modifications of equipment or operational procedures, for the Laying, Recovery or Repair of the Submarine Cable System, formed by the **"Telecom Part"** and **" Observer Part",** particularly for the common Cableships and the technical staff skills operating on board the Maintenance Agreement Cableships.

9.2. Accuracy of the positioning of the "Package of Sensors"; after laying RPL with "Packages of Sensors" positioning

Accuracy of the positioning of the "Packages of Sensors"

The potential Suppliers shall confirm and provide acceptable evidence for each "Sensor Package"(inside its container Housing: a Repeater, a Dedicated Housing or a Repeater with POD, according to the considered configuration option, by the cable

lay calculation or using specific instrumentation available in the Sensors) of the following accuracy specifications for the respective container housing are attained *(values indicated as " XXX" to be filled by the Purchaser or as an alternative, at that stage, committed by the potential Suppliers):*

a) The accuracy of the geographic location of the container housing to within ±XXX m.

b) The accuracy of the depth of the container housing, Repeater or Dedicated Housing to within ±XXX% of the water depth.

c) The accuracy of the heading (azimuthal direction) of the container housing, Repeater or Dedicated Housing to within ±XXX°.

d) For directional sensors, like the accelerometer and seismometer, the orientation of the axis of the Sensors inside the container housing, relative to its structure, while inserting the "Packages of Sensors" inside the Container housing, must be established and confirmed to within ±XXX°.

e) The potential Suppliers shall provide acceptable evidence of the methods used to achieve these specifications.

9.2.1 Particular considerations for the RPL and SLD of the Submarine Cable System

For the Submarine Cable System, a particular Cable Route Positioning List including the "Package of Sensors" (CRPL-SP) shall be considered having for each container housing, Repeater or Dedicated Housing with the "Packages of Sensors" beyond the usual items, the geographical position, the depth and the heading respecting the above accuracy specifications.

The SLD (Straight Line Diagram) of the Submarine Cable System shall have also identified these submerged elements of the **"Observer Part".**

The RPL and the SLD for the Submarine Cable System shall have all the necessary additional identification elements required to support the marine repairs, or other operations, due to the insertion of the "**Observer Part".**

10. Impact of the observer part on Submarine Power Feeding

The potential Supplier shall provide information on any required modification of the Power Feeding Equipment (PFE) of the "Telecom Part" of the submarine cable system motivated by the consideration of a SMART Cable with "Observer Part".

The potential Supplier is required to estimate the required additional Power Voltage at the PFE of the Telecom System and the additional Power consumption.

10.1 Mechanical required modifications

The potential Suppliers shall provide information on any particular operational or constructive aspect required to interconnect the Cable Terminal Cubicle of the Power Feeding Equipment (PFE) or the fibre pairs Cubicle of the submarine Cable to the "Terminal Cable Station Section" of the **"Observer Part"**, or any other observable mechanical or construction aspect.

10.2 Other requirements for the "Observer Part"

Additional requirements for the inclusion of the **"Observer Part"** in the Telecom System in terms of installation or performance in the Cable Landing Stations or the Submarine cable System shall be mentioned, and the respective solutions presented.

11. Impact and Particularities of the "Observer Part" on the Terms and Conditions of the "Telecom Part" of Submarine Cable.

Note to the point 11. :

The part of the information of this point 11 may be integrated in the "Terms and Conditions" of the general Document "Terms and Conditions" of the Submarine Cable, a fundamental contractual Part of the general contract of the Cable system, a "SMART Cable, in the present case, that defines all the terms and conditions of the general contract including among others:

The Object of the contract; Commercial conditions of the contract; Guaranty condition; Acceptance of the system; Initial and Final; LONG Term support; Testing Procedure and conditions for the system Acceptance; Payment Conditions and Billing Schedule; Responsibilities of the Parts for the contract implementation; Calendar for the Supply, installation and testing; Liquidated damages for possible delay of the Supplier, etc.

In the Tender, the potential Suppliers are requested to satisfy, point by point, or present alternatives satisfying the same objectives, all the conditions required by the Purchaser in the Request for the Tender presentation (RfT) to be presented in a specific Document denominated "Statement of Compliance", presented in the document sent by the Purchaser "Request of Invitation for The Tender" to the Tender, that covers individually all the points of the "Terms and Conditions" (above mentioned), of the Technical Specifications presented for all parts of a telecom system.

Being a SMART Cable, the Technical Specifications include a specific Part, formed by the Document "Observer Part", here presented. As said before, the Tender is mandatorily required to include an answer, point by point, to all the questions and requirements of the "Terms and Conditions and of the "Technical Specifications"); In general terms, besides these points, the Tender includes a complete description of all the equipment and parts of the system (the potential Supplier "Technical Description of the System").

Support comment:

Parts of this point 11, may be integrated with the general "Terms and conditions of the contract" of the Telecom Part. This procedure should be harmonized and agreed with the team responsible for general procurement of the system. The points presented here (point 11 of this Document) refer specific points concerned with the "Observer Part" related to the general "Terms and Conditions" of the overall cable System.

In general, if otherwise is not mentioned in this Document, the document "Terms and

Conditions" of the Request for Tender of the Submarine Cable System, including already the **"Telecom Part",** is applicable to the **"Observer Part".** The **"Observer Part"** is, accordingly, considered one integrant part of the Submarine Cable System Acceptance.

The terms and conditions for the Acceptance of the **"Observer Part"** shall follow, in general, the terms and conditions presented for the "Telecom Part" of the Submarine Cable System. In addition, however, the following particular conditions will apply:

11.1 Contractual date and conditions for the Initial Acceptance of the "Observer Part".

The **"Observer Part"** should have the date of Initial Acceptance, the date considered for the Initial Acceptance of the **"Telecom Part".**

However, as should be mentioned in the Testing and Commissioning Programme for the Initial Acceptance Procedure of the **"Observer Part"** of the Submarine Cable System (in this case, a SMART Cable), a **Confidence trial of Observation Test Period** of six (6) months is considered prior to the final evaluation of the Initial Acceptance Certificate of the **"Observer Part".**

In these circumstances, a **"Preliminary Initial Acceptance Certificate"** exclusively for the **"Observer Part"** could be issued if the Preliminary Commissioning results of the **"Observer Part"** are accepted, and, if applicable, using the formal usual terms and conditions of the **"Telecom Part"** to incorporate it as part of the Initial Acceptance Certificate of the **"Telecom Part"** of the Submarine Cable System, the SMART Cable, Initial Acceptance Certificate.

Then, in such a case, the **Initial Acceptance** of the **"Observer Part"** could take place six months later, after a **Confidence Trial of Observation Period** of six months.

11.2 Conditions for a possible Initial and Commercial Acceptance Certificate

The **"Observer Part",** in case of non-satisfaction with the conditions for the Initial Acceptance, would follow the conditions considered for a possible Initial and **Commercial Acceptance** of the **"Telecom Part"** and globally the whole Submarine Cable, the SMART Cable.

However, in all the conditions, the Initial Acceptance of the **"Telecom Part"** shall condition the Initial Acceptance of the **"Observer Part".**

11.3 Conditions for Final Acceptance of the "Observer Part"

The **"Observer Part"** shall follow the provisions considered for the Final Acceptance of the **"Telecom Part"** of the Submarine Cable System.

The observed failures in the **"Observer Part"** during the scheduled Warranty period, five years, would be determinant for the evaluation of the Final Acceptance of the **"Observer Part".**

The number and type, as well the consequences and impact of the observed failures or degradations in the functionalities and availability of the **"Observer Part",** shall be evaluated with the support and taking into account the Reliability figures, functionalities and performances committed by the Supplier in the Contract, particularly in the " Observer Part.", point 6.

The potential Suppliers shall present to the Purchasers a demonstration making evidence that the **"Observer Part"** is compliant with the contractual specifications for the "SMART Submarine Cable System" Design Lifetime of 25 years.

The Final Acceptance of the **"Observer Part"** would condition the Final Acceptance of the Submarine Cable System, including the **"Telecom Part"** and the **"Observer Part",** which means the "SMART Cable System".

As mentioned in sub-point 6.4 d), any fault in the **"Telecom Part"** caused by an internal fault of the **"Observer Part"** is considered as a common internal fault in the **"Telecom Part"** of the **Submarine Cable System.**

11.4 Considerations for the evaluation of a "Pattern of Failure" in the "Observer Part"

The following points shall be considered:

a) The potential Suppliers shall endeavour the best efforts to promote adequate Qualification of the **"Observer Part"** and avoid any failure mechanism that could be considered a **"Pattern of Failure"** in the **"Observer Part"** of the Submarine Cable System, likely to cause an extension of faults in the **"Observer Part"** beyond the Reliability expectations.

b) Before the end of the Warranty, the Supplier shall demonstrate that there is not in the **"Observer Part"** any type of fault likely to be considered as a **"Pattern of Failure",** or any other type of fault likely to cause the **"Observer Part",** directly or indirectly, failing to meet the technical or functional objecttives defined in the Contract, in general and in this Document (an Appendix of the general "Technical Specification" applicable to the "Observer Part", during the objective Design Lifetime (25 years) as defined for the **"Observer Part".**

c) Additionally, as a fundamental and critical condition for the **Final Acceptance** of the **"Telecom Part"** and the **"Observer Part"** of the Submarine Cable System, the potential Suppliers shall demonstrate that there is not any fault, particularly a **"Pattern of failure",** in the **"Observer Part",** likely to cause the **"Telecom Part"** of the Submarine Cable System, directly or indirectly, failing to meet the Technical Specifications, Reliability or functional objectives defined in the Submarine Cable System Contract, during the Design Lifetime of 25 years.

d) In case of identification of a **"Pattern of Failure"** as mentioned in above points a) or b) or in both, the Supplier shall endeavour the best efforts to study, implement and execute a remedial solution effective for the system Lifetime (25 years) of the Submarine Cable System, including a marine operation if required, at Supplier cost, before the issuance of the Final Acceptance Certificate of the Submarine Cable System; the **SMART Cable.**

11.5 Certificates of Initial and Final Acceptance

The Certificates of Initial Acceptance and Final Acceptance, as well as a possible Certificate of Initial and Commercial Acceptance, for the **"Observer Part"** will follow the general terms of the **"Telecom Part"** general "Terms and Conditions", forming whenever agreed as adequate by the Parties a single document.

Any specific conditions applicable to the **"Observer Part"** will be incorporated into these Certificates.

11.6 Testing and Commissioning for Initial Acceptance and Final Acceptance of the "Observer Part" of the Submarine Cable System

The potential Suppliers shall present a Testing and Commissioning Programme for the **"Observer Part"** of the Submarine Cable System.

As mentioned in point 11.1, a **Confidence Observation Test of six (6) months** is considered for ending the Commissioning Programme for the **"Observer Part".** During this Confidence Observation Test of six (6) months, the **"Observer Part"** will be object of control and monitoring of its functionalities and performances under procedures to be proposed by the potential Supplier, subject to the agreement of the Purchaser, that may review and incorporate additional commissioning procedures.

This Programme for the Commissioning and Testing of the **"Observer Part"** would be included in the general Programme for the Commissioning and Testing of the Sub-

marine Cable System, where the Commissioning for the **"Telecom Part"** is included.

11.7 Assistance and Contractor responsibilities during the Warranty Period

For the **"Observer Part",** the Contractor's responsibilities during the Warranty Period of the Submarine Cable System follow in general lines the terms and conditions expressed in the Contract for the Submarine Cable System, applicable to the **"Telecom Part".**

a) In particular, for the **"Observer Part"** of the Submarine Cable System the sole specific and applicable Cableship costs associated with a possible Marine repair (running costs and standby costs) should be supported by the Purchaser, subject to the demonstration by the potential Supplier that the number of observed faults in the "Observer part" in accordance with point number 6. Is under the reliability expectations, based on the committed Reliability figures supplied in this point, particularly Table 6.3, related to the Reliability required for the "Observer Part."

b) However if the number of observed faults is exceeding the Reliability expectations, at that time, namely due to an existence of a "Pattern of Failure", incorrect reliability calculation, or due to Early Failures not adequately eliminated during the required Burn-In stage, or other internal reasons imputable to the potential Supplier, likely to cause the "Observer Part", and most critical also the "Telecom Part", failing to meet the Submarine Cable System specifications and functionalities during the Lifetime (25 years), the Supplier shall implement the necessary marine repair without any marine and any other costs supported by the Purchaser.

11.8 Long Term Support

The **"Observer Part"** of the Submarine Cable System would follow the general lines of the **"Telecom Part"** of the Submarine Cable System Contract**.**

11.9 Impact on the number of fibre pairs

If a "Dedicated Fibre Pair" is used in the "Communication Section" of the "Observer Part", this particular fibre pair is not included in the specified number of fibre pairs to be used for commercial purposes in the "Telecom Part" of the Submarine Cable System.

11.10 Permitting

The Purchaser will be responsible for obtaining the required Permits in Principle from the National authorities involved in or with the "Observer Part" of the Submarine Cable System. The Supplier, if requested, will endeavour to support the Purchaser in obtaining such Permits.

In what concerns any possible specific Work Permits for the "Observer Part", based on the Permits in Principle, the Supplier shall be the sole responsible for obtaining all such required Work Permits from the appropriate National authorities involved. The Purchaser, if requested, and at its sole discretion, may support the Supplier in obtaining such Work Permits, when applicable, for the "Observer Part".

11.11 Impact of the "Observer Part" on the format of "Price Schedule" list of the Submarine Cable System

The Price Schedule of the Submarine Cable System shall allow a clear identification of the additional prices resulting from the addition of an **"Observer Part".**

Only the prices resulting from the addition of the **"Observer Part"** to the Submarine Cable System **(**necessarily already including the "Telecom Part"), shall be clearly identified as the **"Observer Part"** prices.

The **"Observer Part"** prices shall be listed and separated into: "Sensor Section", "Communication Section", and "Terminal Cable Station Section", using the same format of presentation for quantities and unit prices for equipment and services used for the **"Telecom Part".**

The **unit prices** in the three Sections of the **"Observer Part"** shall identify clearly the quantities and unit prices associated with each type of unit. The same shall be applied to the specific unit service prices related to the **"Observer Part".**

The quantities and unit prices of Sensors in the "Sensors Section" and associated services shall be indicated in the "Price Schedule" of the "Observer Part".

The following two total prices are then considered:

Total "Telecom Part" price: The total Contract price of the Submarine Cable System having only the "Telecom Part."

Total "Observer Part" price: The total Contract price of the additional items, including services, resulting from the addition of the "Observer Part" to the Submarine Cable System.
These two items shall be clearly identified in the Price Schedule of the Submarine Cable System, The SMART CABLE.

11.12 Impact of the "Observer Part" on the "Billing Schedule" of the Submarine Cable System

The Billing Schedule for the **"Observer Part"** of the Submarine Cable System shall consider the same Billing Milestones used for the "**Telecom Part**", incorporating, as adequate, the **"Observer Part"** items.

The total **"Telecom Part"** price and the total **"Observer Part"** price (as defined above, point 12.11) shall be added, and then, the Billing Schedule percentages associated with the Submarine Cable System applied.

The aggregated invoice shall indicate the price values associated with the **"Telecom Part"** and **"Observer Part".**

The Billing Schedule of the **"Observer Part"** associated with the Initial Acceptance of this **"Observer Part"** could be object of a specific consideration, due to the existence of a Confidence Observation Test of six (6) months. All the other conditions associated with the Submarine Cable System Billing Schedule would apply, in general, for the **"Observer Part".**

11.13 Bank Guarantees for the "Observer Part"

The total additional price amount of the **"Observer Part"** the **Total "Observer Part" price** would be added to the total amount of the **"Telecom Part",** the **Total "Telecom Part" price,** being the total basis for the value of the Bank Guarantees.

The other terms and conditions for the bank Guarantees would apply, in principle, with the exception that may be caused by the possible existence of different dates for the Initial Acceptance and Final Acceptance of the" Observer Part" and "Telecom Part".

11.14 Initial Acceptance date for the "Observer Part"; Liquidated damages

The Initial Acceptance date for the **"Observer Part"** of the Submarine Cable System should be considered six (6) months after the Initial Acceptance date for the **"Telecom Part"** of the Submarine Cable System"; the SMART Cable.

The terms and conditions and percentage values applied to calculate the liquidated damages payable in case of delay of the **"Observer Part"** shall be the same as for the "Telecom Part" of the Submarine Cable System.
The **total "Observer Part" price** shall be considered to form the basis for the application of the percentage to calculate the Liquidated Damages by delay for the

"Observer Part" under the same concept of the "Telecom Part" of the Submarine Cable System.

Any delay in the Initial Acceptance date caused by reasons associated with the **"Observer Part"** of the whole Submarine Cable System (the "Smart Cable) shall be considered as any other cause of delay for the **"Telecom Part"** and in any conditions can be considered as a reason to diminish the liabilities or the payment of liquidated Damages by the Supplier.

11.15 Subcontractors for the manufacturer of the Sensors and other elements of the "Observer Part."

The potential Suppliers shall indicate the Subcontractors for the manufacturing of Sensors or other elements of the **"Observer Part"** of the Submarine Cable System. The potential Suppliers would be fully responsible for the selection and qualification of such Subcontractors. However, the Purchasers may refuse to accept a particular Subcontractor at their discretion.

The potential Suppliers shall present for such Subcontractors, particularly for the Sensors Suppliers, the general lines of the process they are implementing, or intending to implement, to establish adequate procedures for the Qualification of the Sensors, the process to guarantee the control and monitoring of manufacturer and its Reliability procedures and strategy Quality assurance and other elements considered relevant to ensure the compliance with the "Technical specifications" and "General Terms and Conditions" of the contract. The potential Suppliers shall also present how they intend to establish joint procedures to improve the Reliability of such components and in which mode and the extent they intend to audit and control the planned measures and established procedures.

END