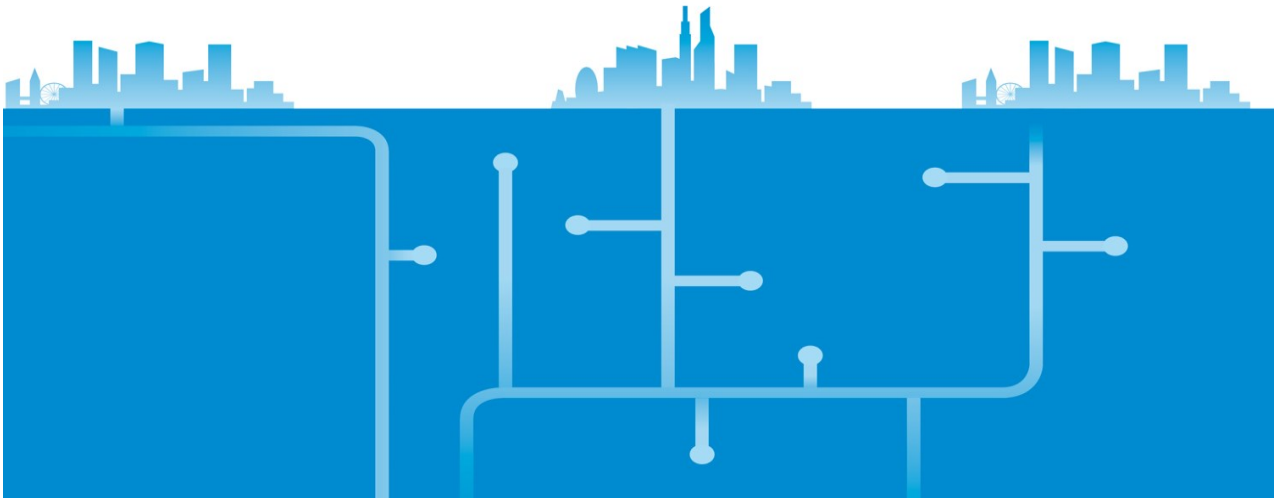
ITU-WMO-UNESCO IOC Joint Task Force

Scope document and budgetary cost estimate for a wet test to demonstrate the feasibility of installing sensors external to the repeater and to provide data from such sensors for evaluation

Joint Task Force to investigate the potential of using submarine telecommunication cables for ocean and climate monitoring and disaster warning



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Summary

A “wet test” is the first validation of the capabilities of a “green” submarine cable system, that is, a system incorporating temperature, pressure, and acceleration sensors at fixed intervals along the cable. The wet test must provide a realistic deployment and operational scenario for the sensors and must make use of representative cable, housings, sensors and other mechanical fixtures. The wet test must be installed using conventional cable laying methods. The wet test must provide power and communications for the sensors, however the power and communications need not be those intended for an actual green system. The wet test must be deployed for months or years to permit validation of the sensor performance against existing instrumentation.

Forward

Three UN specialized agencies **(International Telecommunication Union (ITU), World Meteorological Organization (WMO) and Intergovernmental Oceanographic Commission (IOC) of UNESCO)** have jointly proposed the development of mini-observatories on trans-ocean submarine cables to measure key ocean seafloor observables, with the concept and applications being developed further through the efforts of a **Joint Task Force (JTF)**. The latter was established in 2012 with a wide membership including scientists, engineers, cable owners and operators, regulators and legal experts.

The JTF initiative addresses two main needs: **a) increased reliability and integrity of the global tsunami warning network, and b) sustained climate-quality data from the sparsely observed deep oceans**. Deployment of seismic and pressure sensors is directed at the first of these. Pressure and temperature measurements support the second need. The extent and impact of damage from tsunamis and earthquakes is a major societal issue for coastal communities throughout the world. Ocean temperature is a critical variable, particularly regarding climate change, sea level rise and ecosystem stress. These aspects of the health and status of marine environments could be monitored globally in real-time through a new generation of ocean mini-observatories hosted on telecommunication cables. Measurements provided by these systems will increase our understanding of the planet and its ecosystems on decadal time scales, hence the term “green” submarine cable systems.

Purpose

The purpose of this document is to describe the scope and requirements of the wet test. The objectives of the wet test are broad, and include some goals not normally addressed by a wet test. Objectives include:

The objectives of the wet test are to:

- Demonstrate the ability of sensors to be installed as part of a submarine telecommunications system

- Demonstrate the accuracy and usefulness of the sensor data when the sensors are deployed in a realistic manner
- Prove the assumptions related to sensor orientation and direction when laid as part of a cable system
- Provide baseline requirements that will facilitate continued discussion and iteration of requirements for ocean observations utilizing optical fiber submarine telecommunications cables
- Maintain and strengthen interaction between interested parties
- Encourage system suppliers to allocate modest resources to early development stages
- Allow system suppliers to consider suitability of existing product lines
- Establish realistic goals
- Establish credibility needed to solicit more substantial resources from governments, NGOs, and industry
- Let system owners understand the functional and operational objectives of green systems
- Provide additional information for a baseline system specification
- Provide justification and/or rationale for the recommended activities to be included in this wet test

Intellectual Property Rights

ITU draws attention to the possibility that the practice or implementation of these wet test requirements may involve the use of a claimed Intellectual Property Right. ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the wet test requirements development process.

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1 Technical goals and scope

The goal of the wet test system is to satisfy interested parties of the feasibility of manufacturing, deploying, and operating sensors to measure temperature, pressure, and three axis motion when deployed as part of a submarine cable system. The wet test must show that:

- Sensors can be integrated into the cable system;
- Sensors can survive deployment stresses;
- Data can be collected and transmitted to shore;
- Data will provide value to science, and
- The system can continue to operate for months or years.

The wet test is similar in many respects to the qualification testing routinely performed by the submarine cable industry, but is not intended as a replacement for such testing. Should a participating manufacturer wish to use the wet test as a qualification test, it would need to provide its own scope, measurements, and pass-fail criteria.

Validation of sensor data is essential to justify the deployment of these instruments. Methods for comparison of data collected by the wet test to data collected from other sources, verification of sensor accuracy and repeatability, and other such validation are outside the scope of this document.

2 References

While this document describes the higher level requirements of a wet test system, the more specific functional requirements of the sensors in a "green" cable system are described in:

Functional requirements of "green" submarine cable systems, most recent edition

The following ITU-T Recommendations contain definitions and background information that apply to these wet test requirements.

ITU-T G.971 Recommendation ITU-T G.971 (07/2010), General features of optical fiber submarine cable systems.

ITU-T G.972 Recommendation ITU-T G.972 (09/2011), Definition of terms relevant to optical fiber submarine cable systems.

3 Definitions

3.1 Terms defined elsewhere

These requirements use the terms defined in ITU-T G.972.

3.2 Additional terms

client: The user of the science subsystem or a data processing system belonging to the user. The Client lies outside the scope of the submarine cable system.

green system: A fiber optic submarine cable system equipped with sensors to measure temperature, pressure, and three axis motion at regular intervals along the entire length of the cable.

science subsystem: Those components of the optical fiber submarine cable system, including both submerged plant and terminal equipment, whose sole purpose is the collection of scientific data.

sensors: Elements of the science subsystem that measure physical properties of the environment.

sensor set: A group of sensors at a single location, normally consisting of one of each type of sensor: temperature, pressure, and three-axis accelerometer.

4 Acronyms and Abbreviations

This document uses the following abbreviations and acronyms:

IOC	Intergovernmental Oceanographic Commission
ITU	International Telecommunications Union
ITU-T	International Telecommunications Union Telecommunications Standardization Sector
JTF	Joint Task Force
LS	Lump sum
LW	Lightweight
LWP	Lightweight Protected
NTTS	Nominal Transient Tensile Strength
UNESCO	United Nations Educational, Scientific and Cultural Organization
WMO	World Meteorological Organization

5 Conventions

Use of the words “shall” or “must” indicates a mandatory requirement.

Use of the word “should” indicates an optional requirement that is desirable.

Use of the word “may” indicates an option or method to be used at the suppliers’ discretion.

Use of the word “will” indicates a requirement that is assumed to be fulfilled outside the scope of these requirements.

Note that some sections include both a mandatory minimum requirement indicated with “shall” and a more stringent requirement indicated with the word “should.” In this case, the higher level of performance is advantageous, but not absolutely required.

6 Alternatives to a wet test

A wet test is the preferred method for testing the deployment and function of the equipment in uncontrolled, real life conditions. While it is not recommended that the wet test be eliminated from the program, some aspects of the wet test can be covered by testing in controlled conditions.

6.1 Stress testing

The equipment can be stress tested for vibration, resistance to shock and temperature shock in a suitable laboratory environment. These tests should be undertaken in any event prior to long term deployment. It is not uncommon for subsea telecommunications equipment manufacturers to rely on shock and vibration testing of new equipment.

6.2 Line testing

The equipment can be inserted into a model of a submarine system for long line testing. Each manufacturer of subsea telecommunications equipment has a model line established in a laboratory to demonstrate system function. Long line function is not addressed in the wet test, since the system manufacturer will undertake such testing prior to the long term deployment.

6.3 Individual deployment of instruments

The instruments could be deployed individually or in a group onto an existing subsea observatory. The instruments would be deployed by an ROV in a controlled fashion, and would not be subject to the vagaries they are likely to see in a real life deployment. However, some understanding of the data would be possible.

7 Requirements for Wet Test

7.1 Sensor performance

For sensor characteristics refer to the Functional Requirements.

7.2 Wet test system configuration

The wet test shall consist of a minimum of 10km of submarine telecom cable and a minimum of three sensor sets.

Each sensor set shall consist of one temperature sensor, one pressure sensor, and one three-axis accelerometer meeting the performance parameters provided in the Functional Requirements.

Sensors shall be housed in or placed adjacent to a cable body that matches the physical and mechanical characteristics of a repeater housing.

The submarine cable shall be a conventional 17mm, 20mm or 21mm type suitable for the expected deployment conditions such as Lightweight (LW) or Lightweight Protected (LWP), or a cable armor type that is typically used for repeater tails.

Power and communications shall be provided to the sensors. Note, however, that the power feeding and communications methods are not required to be similar to a conventional cable system and may be specific to the wet test.

[Note: It is expected that each supplier will demonstrate full integration of the sensors into their repeaters through appropriate qualification and sea trials at a later stage of development. Potential suppliers have indicated that this integration is within their normal development capability but will not be undertaken until the feasibility of the science is further validated via the wet test. The wet test should make use of power and communications that can be connected to existing ocean observatory infrastructure. Typically this means 1000Base-LX optical Ethernet and a 48V or 375V constant voltage power supply.]

The minimum distance between sensor sets shall be three times the water depth at the test location. This limit is to prevent interference between the sensor sets during installation and recovery. Note that this may increase the required cable length.

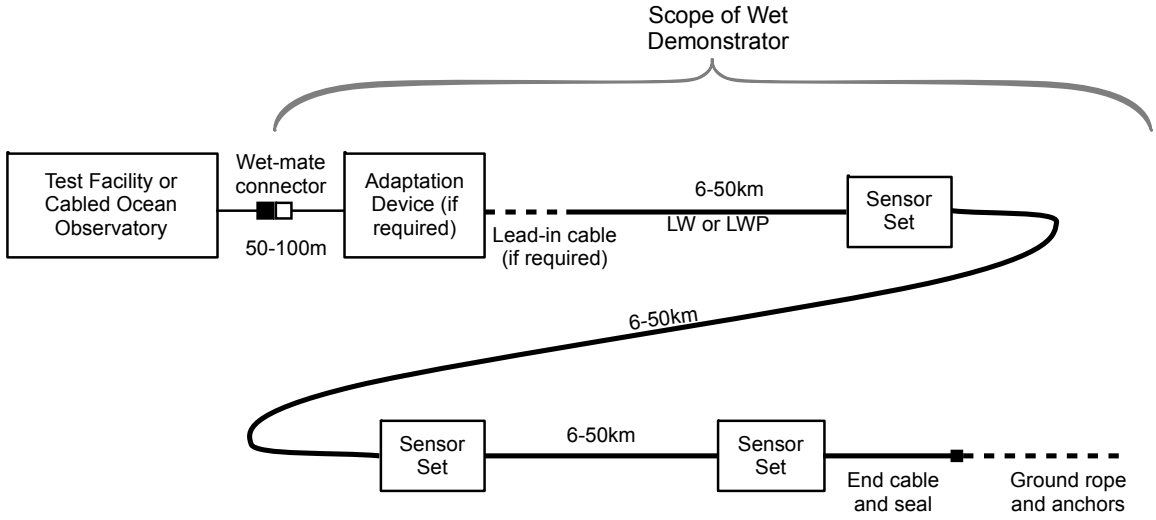

Figure 1 Conceptual wet test system

7.3 Support infrastructure and interfaces

The wet test will be laid in an area of seabed supported by a cabled observatory, Figure 1. The wet test scope will include any equipment necessary for connection to the observatory. Following installation of the wet test, an ROV and extension cable will be used to connect the wet test system to the cabled observatory.

The observatory shall agree to make the data from the wet test available to interested parties for review and verification. It shall be necessary to install verification instruments on separate platforms nearby the sensor sets for comparative data.

The wet test shall include a suitable wet-mate connector for connection to a cable observatory.

The wet test shall include any necessary adaptation to convert power received from the cabled observatory to power needed for the sensors.

The wet test shall include any necessary adaptation to connect the sensors and the wet test system to the communications interface provided by the cabled observatory.

7.4 Wet test deployment

Wet test deployment shall be conducted in accordance with written methods of procedures for safety, ship loading, stowage, ship board testing, installation, cable handling, and initial testing. Route Position Lists (RPLs) and Straight Line Diagrams (SLDs) shall be prepared and utilized during the deployment.

The wet test shall be laid using conventional cable lay equipment (preferably from a cable ship) in at least 2,000m water. 2,000m of water is recommended to provide a more realistic model of deployment from a cable ship during an ocean crossing. 2,000m is also a typical depth at the foot of a continental shelf slope, and hence a typical shallow water deployment location. Suitable cable anchors and ground ropes will be used to ensure appropriate tension is applied, and to allow recovery.

At least one sensor location shall be visually inspected by ROV after installation. This is to verify orientation and to assess the interaction between sensors and the seabed. The housing that is to be inspected shall be marked to allow the orientation to be checked visually. This is to verify that accelerometer orientation can be accurately determined.

The wet test cable will be laid at typical speed for repeater installation. No attempt will be made to reduce loads on the instrument housing.

7.5 Deployment duration

A minimum deployment period of six to eighteen months shall be required. This duration will provide a valid test of endurance without being excessive in duration. It will give an indication of possible changes over time, such as siltation and self-burial. It may also give an indication of any seasonal effects. If possible, it is suggested that the test sensors be left in place indefinitely and that monitoring continue through to failure.

7.6 Testing and Validation

7.6.1 Manufacturing and Deployment

The validity and integrity of the wet test shall be proven through a series of tests that are representative of those typically employed by the submarine cable industry.

Detailed procedures shall be developed and agreed prior to the testing.

Tests shall include:

- Sensor characterization and calibration
- Factory tests
- System assembly tests
- Shipboard tests
- Initial sensor tests upon power up
- Load and lay report
- ROV Video

7.6.2 System performance

The availability of the sensors in the wet test shall be evaluated on a continuing basis against the expectations for multi-year life. Outages due to factors outside the wet test shall be excluded from the analysis.

7.6.3 Integrity of science data

A procedure for validation of the sensor data shall be developed and carried out. Qualitative criteria for validation shall be agreed among interested parties, including the JTF, sensor supplier(s), system integrator, and installer, prior to deployment.

8 Criteria for success

The success of the wet test depends on the value and validity of the collected sensor data. The ability to manufacture and deploy a green system is a prerequisite, but not the ultimate objective.

Basic criteria for success shall include:

- All sensors operational following installation
- 99.99% availability of sensor data over test period
- No more than one sensor of each type failing over a six month period
- Successful validation of sensor data based on agreed qualitative and quantitative criteria

9 Cost estimate

Rough order of magnitude cost estimates are given here. A low estimate assuming a short cable (10 km) and a single sensor set is ~$4.6M, Table 1. A high estimate assuming a long cable (150 km) and three sensor sets is ~$13M, Table 2. Total ship days is a key cost driver, particularly for the low cost estimate. The allocated number of ship days includes time for transit from a nearby port; this could potentially be reduced if the mobilization and demobilization costs could be shared with other work such as servicing the ocean observatory or installing a submarine cable system.

Table 1. Low cost estimate

		Unit	Unit cost	Cost
LW Cable	10	km	$8,000	$80,000
Sensor sets	3	ea	$200,000	$600,000
Repeater housing	1	ea	$50,000	$50,000
System assembly	1	LS	$250,000	$250,000
Connectors	1	ea	$150,000	$150,000
Cable ship with ROV	21	days	$105,000	$2,205,000
Engineering services	1	LS	$1,000,000	$1,000,000
Contingency				$250,000
Total				**$4,560,000**

Table 2. High cost estimate

		Unit	Unit cost	Cost
LWP Cable	150	km	$12,000	$1,800,000
Sensor sets	3	ea	$300,000	$900,000
Repeater housing	3	ea	$100,000	$100,000
System assembly	1	LS	$1,500,000	$1,500,000
Connectors	1	ea	$150,000	$150,000
Cable ship	42	days	$105,000	$4,405,000
Engineering services	1	LS	$3,000,000	$3,000,000
Contingency				$1,000,000
Total				**$13,055,000**