# NEPTUNE STAGE I

# INSTRUMENTS REQUIREMENTS

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# Document Control Sheet

Contact for Revisions and Proposed Changes

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**Record of Issues**

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# 1 Introduction

1.1 This document defines the minimum functional and interface requirements ("Requirements") for undersea Instruments that are to be attached to the NEPTUNE Stage I Cabled Ocean Observatory System ("Observatory"). These requirements have been established by NEPTUNE Canada for the purposes of ensuring limited resources are used effectively to support all instruments, increasing the likelihood of a successful outcome for the instrument provider, and minimizing the potential for negative interactions between instruments and the Observatory or between instruments themselves.

1.2 Instrument Providers shall undertake all necessary work to deliver compliant Instruments, including but not limited to engineering, demonstration testing, delivery, and participation in the installation and commissioning.

1.3 This document defines the technical requirements. It identifies certain responsibilities, including responsibilities related to design and related to provision of equipment. However this document does not attempt to allocate commercial responsibility.

# 2 References

2.1 This document forms part of the Agreement between the University of Victoria (UVic) and the Instrument Provider ("Agreement").

2.2 Applicable specifications and recommendations published by the following:

2.2.1 Institute of Electrical and Electronics Engineers (IEEE) including **IEEE 802.3-2002**

2.2.2 Internet Engineering Task Force (IETF),

2.2.3 Electronic Industries Alliance / Telecommunications Industry Association (EIA/TIA).

# 3 Definitions

3.1 Definitions given in the Agreement between the Observatory and the Provider take precedence over definitions contained in this document.

3.2 "Agreement" means an agreement between the Observatory and a Provider

3.3 "Instrument" means any device, regardless of intended purpose, connected permanently or on an interim basis to the Observatory, which derives power from or uses communications bandwidth provided by the Observatory.

3.3.1 "Smart Instruments" means Instruments with fault diagnosis and isolation capabilities

3.4 "Interface" means the data communication protocol, power specification and the physical connection point and logical demarcation between the Instrument and Observatory.

3.5 Infrastructure" means the NEPTUNE Stage I Cabled Ocean Observatory including all terminal equipment, cables, primary nodes, secondary nodes, extensions, junction boxes, provided by the University of Victoria up to and including the Instrument Interfaces

3.6 “Observatory” means the sum of the “Infrastructure and the entity operating NEPTUNE Canada Stage 1.

3.7 “Provider” means the party or parties which enter into an agreement with the Observatory to provide Instruments for connection to the Observatory.

# 4 Scope

4.1 These Requirements address the following aspects of the Instruments:

4.1.1 Power and grounding

4.1.2 Communications physical, media, and network layers (Layers 1-3)

4.1.3 Communications network compatibility

4.1.4 Communications data protocols

4.1.5 Timing

4.1.6 Instrument Control and Data Transmission

4.1.7 Metadata

4.1.8 Safety

4.1.9 Engineering

4.1.10 Environmental Requirements

4.1.11 Physical Interfaces

4.1.12 Reliability

4.1.13 Maintainability

4.1.14 Embedded Software

4.1.15 Instrument testing

4.1.16 Documentation

4.1.17 Shore terminal based supporting equipment

4.2 This document defines the minimum requirements for an Instrument to be qualified for connection to the Observatory. It is expected that most, if not all, Instruments will require additional functionality beyond that given here in order to fulfill their intended purpose. Therefore, these requirements should not be seen as all-encompassing or in any way restricting additional functionality that may be desired.

4.3 The most important purpose of these Requirements is to ensure compatibility between the Instrument and the Observatory. Accordingly, Instruments must adhere closely to those aspects of the Requirements that define compatibility and interoperability.

4.4 Note that the definition of Instrument includes not only scientific instruments in the usual sense, but also equipment such as Autonomous Underwater Vehicle (AUV) docks, rovers, industrial equipment connected for testing or field trial purposes and potentially many more items that can be

connected to Stage I. The intent is that anything that can be connected to NEPTUNE Stage I meet these minimum requirements.

4.5 The Provider shall ensure that all suppliers, contractors, subcontractors, integrators or other parties providing or performing work relating to the Instrument comply with these Requirements.

# 5 Instrument Provider Primary Responsibilities

The Provider shall include the work specified in the Agreement, including its Annexes. This includes, but is not limited to:

5.1 Planning, engineering, management, quality control, quality assurance, coordination and implementation of the Instruments

5.2 Design, development, manufacture and testing of all elements of the Instruments, and spares as required

5.3 Delivery of all equipment, material, and spare items required to the installation vessel's point of loading or shore terminal, as appropriate

5.4 Provision of all materials, test equipment, labour and services as required for and specific to the installation of the Instruments, but not including marine equipment and crews or ROVs and crews.

5.5 Provision of embedded or on-shore software and its supporting equipment, where applicable

5.6 Demonstration, through engineering analysis, modeling, prototype and functional testing, installation testing and commissioning tests, that the Instrument meets the Requirements herein.

5.7 Provision of all documentation as specified in Section 13 of these Requirements

5.8 Installation and testing of all shore station based equipment

5.9 Provision of any apparatus necessary to test, qualify, or calibrate the Instrument

5.10 Testing and commissioning of the Instrument

5.11 Support for the Observatory's network and data security efforts, in particular any security requirements imposed on the Observatory for reasons of national security

5.12 Training (if and as required to manage the Instrument) for up to four persons.

# 6 Observatory Primary Responsibilities

Responsibilities of the Observatory include the following unless specified otherwise in agreements between the Observatory and the Provider:

6.1 Provision of the shore stations, including conditioned space and power for data processing and storage equipment

6.2 Provision of underwater infrastructure from shore station to node

6.3 Provision of extensions from node to junction box

6.4 Provision of an Interface to which the Instrument shall connect

6.5 Provision of power, communications bandwidth, and timing at the Interface

6.6 Provision of a connectorized cable between the Instrument and Observatory, specifications to be agreed between Observatory and Provider

6.7 Installation of the Instrument, including survey and burial

6.8 Provision of backhaul network connecting the shore station(s) to the Internet

6.9 Firewall and network security applications which isolate and protect the Observatory network from the Internet

6.10 Data Management and Archiving System (DMAS), including all forms of long term data storage and on shore buffering except that necessary for packet based communications or internal data processing.

6.11 Resource scheduling and user policy enforcement software/applications, except to the extent such functionality is available in software to be delivered as part of the Instrument

# 7 Requirements

## 7.1 General

7.1.1 The Instruments shall be designed for continuous operation. In particular, Instruments shall be capable of responding to a status inquiry from the Observatory at all times.

7.1.2 The Instrument shall automatically start up when connected to and energized by the Observatory. Interfaces provided by the Observatory are such that an Instrument may be placed in service simply by connecting the wet-mate-able connector to the interface and energizing power to the interface. This assumes that any user policies, default operating modes, network security authorizations, etc. have been previously configured.

7.1.3 The Instrument shall return to a known state upon being depowered and repowered.

7.1.4 The Instrument shall connect to the Observatory by means of a suitable connector as described in Section 8.

7.1.5 The Instrument shall support a cable length of up to 70 meters between the Observatory and Instrument for Electrical Ethernet as further described in Section 8.1 or up to 8 km for Optical Ethernet as defined in Section 8.4.

7.1.6 The Instrument shall accept power provided by the Observatory as described in Section 7.2.

7.1.7 The Instrument shall support bi-directional communications as further defined in Sections 7.3-7.6 and 8.

7.1.8 The Instrument shall be safe, reliable, and maintainable as further described in Section 10.

7.1.9 The Instrument shall comply with requirements imposed on the Observatory for the purposes of National Security.

## 7.2 Power and Grounding

7.2.1 Instruments shall operate on one of the following nominal observatory supplied voltages:

7.2.1.1 Regulated 48VDC at up to 600 watts

7.2.1.2 Regulated 12 VDC at up to 300 watts. The Provider is responsible for specifying appropriate wire gauge and the connectors for the high currents at the upper end of this power range.

7.2.1.3 400 VDC up to 5 kWatts at a level consistent with line losses from all extensions back to the node interface including losses from other power loads on the same extensions. Minimum voltage is 300 volts. Refer to section 7.2.9

7.2.1.4 The Provider shall inform the Observatory at the earliest opportunity of any instrument that may draw more than 1 kiloWatt momentarily or continuously. .

7.2.2 Power shall be supplied to the Instrument over two conductors: DC + and DC -.

7.2.3 Instruments operating from the 400V supply shall accept:

7.2.3.1 Steady state input voltages from 300 VDC to 400VDC.

7.2.3.2 Voltage surges to 420 VDC for up to 1000 ms

7.2.3.3 Voltage spikes to 500 VDC for up to 100 ms

7.2.4 Instruments shall accommodate power supply ripple of 1V for the 400V supply and 500mV for the 48 VDC and 12 VDC supplies.

7.2.5 The ripple and noise limits from the Instrument back into the power supply line shall not exceed 1V for the 400V supply.

7.2.6 Instruments shall not use the seawater, the metal chassis or pressure case as a return path for current subject to 7.2.8. Both the power and return paths (DC + and DC -) shall use the extension cable conductors and have a minimum oft 20Mohm resistance, a maximum of 10uF capacitance and 500V isolation relative to seawater/case potential.

7.2.7 The Instrument shall be capable of continuing operation with a single point in the supply to the Instrument grounded or connected to seawater by a fault. This requirement means that there shall be no low resistance connection between either side of the power supply, or any communications line, and the ground (or seawater) at or within the Instrument.

7.2.8 Notwithstanding the above requirements, in the case of instruments that require the use of a seawater ground to operate, a seawater ground may be permitted provided that such circuit is galvanically isolated from upstream components with a minimum isolation voltage of 500Vdc from seawater potential. Providers requiring such a seawater ground should apply in writing to Observatory.

7.2.9 The peak power consumption for an Instrument operating from the 400V supply shall be 5000W including associated line losses on all extensions to the instrument. 5000 W will not be available at all interfaces where long extensions and high loads from other adjacent instruments may reduce available power and lower the supply voltage

7.2.10 The max current required to any Instrument shall be agreed between Provider and Observatory and documented in the Instrument documentation.

7.2.11 The input impedance at any Instrument shall be agreed between Provider and Observatory and documented in the Instrument documentation

7.2.12 Instruments shall use efficient power supplies where possible. Providers shall get prior approval from Observatory for use of power supplies either with efficiency of less than 80% or with heat dissipation of over 100W.

7.2.13 The total power required by any Instrument and the schedule to provide that power shall be agreed between Provider and Observatory and documented in the Instrument documentation.

7.2.14 All Instruments shall be capable of being placed in a mode in which power consumption is as low as practical, but in any case less than 100W or as agreed to in writing by Observatory. (This may be the normal operating mode for low power Instruments; however high power Instruments must have a "standby" or "low power" mode.)

7.2.15 Instruments requiring greater than 100W of power in normal operations shall not draw more than 100W without receiving a valid command or acknowledgement from the Observatory control system. The Instrument may request power from the Observatory. All power commands will be screened to ensure they do not negatively impact the overall operation of the Observatory.

7.2.16 Instruments requiring greater than 100W of power in normal operations shall accept commands instructing them to reduce their load to less than 100W within an agreed time and rate without risk of damage to the instrument or disruption to the Observatory.

### 7.3 Communications Physical Layer

Subject to section 7.6 for serial instruments, the Instrument shall communicate with the junction box using one of the following standard interfaces.

7.3.1 IEEE 802.3 10BASE-T Ethernet

7.3.2 IEEE 802.3 100BASE-TX Ethernet[1]

7.3.3 IEEE 802.3 1000BASE-LX Ethernet on Single Mode Fibre (10 μm core)

### 7.4 Communications Media and Network Layers

7.4.1 The Instrument shall be compatible with the TCP/IP family of protocols as defined by the IETF, except as specified in Article 7.6.

7.4.2 Instruments shall use IPv4 or IPv6. Legacy protocols such as IPX, OSI, NetBEUI, and Appletalk will be blocked by the Observatory unless encapsulated in IP but are generally discouraged.

7.4.3 Instruments shall use only TCP and/or UDP. IP broadcast may not be used except for address resolution. IP multicast addresses (224.0.0.0 – 239.255.255.255) will be assigned provided the Provider can demonstrate a compelling need to use IP multicast.

7.4.4 Instruments shall use a unique Media Access Control (MAC) address. Instruments shall not use MAC address spoofing unless specifically agreed with the Observatory.

7.4.5 Instruments shall be capable of using the Address Resolution Protocol (ARP) to map hardware addresses to IP address.

[1] 100Base-TX defines the physical layer; 100Base-T refers to the media access layer.

7.4.6 Instruments shall be assigned an IP address by the Observatory. DHCP support is strongly encouraged as it may be the system of choice for the future.

### 7.5 Network Compatibility, Bandwidth, and Prioritization

7.5.1 Instruments shall be able to operate using less than the full physical link bandwidth. The average and peak bandwidth requirements for an Instrument shall be provided in the Instrument documentation. The Observatory may restrict or limit bandwidth available to an Instrument.

7.5.2 Instruments shall accommodate the prioritizing of communications bandwidth at the IP layer by the Observatory.

7.5.3 Instruments may use IEEE 802.1p, Class of Service (CoS) for Traffic Prioritization, to identify their traffic for prioritization. This is an option, not a requirement.

7.5.4 Instruments may use IEEE 802.1Q, Virtual Local Area Network (VLAN) Tagging and Priority, to identify their data for routing and prioritization. This is an option, not a requirement. Providers wishing to have a dedicated VLAN for their Instruments should contact the Observatory for a VLAN assignment.

7.5.5 Instruments shall tolerate a Bit Error Rate for the Underwater Interface to Shore Interface link of $1 \times 10^{-12}$ or the equivalent packet loss rate of $1.2 \times 10^{-8}$.

7.5.6 Instruments shall accommodate a round trip transmission time, including router latency, between any shore station and the Instrument of 20 msec.

### 7.6 Compatibility with Serial Interfaces

7.6.1 Observatory recognizes that some Instruments may be available only with serial data interfaces. Observatory will provide a limited number of serial interfaces on each Observatory supplied Junction box. The following requirements apply to cases where the Provider is converting from Serial to Ethernet.

7.6.2 All serial data will be encapsulated in IP for transmission to the shore station using an Ethernet Serial Server (ESS).

7.6.3 Ethernet Serial Servers must be approved by the Observatory. It is assumed the ESS will be installed in the Instrument housing although provision may be made to install ESS in junction boxes at locations where multiple serial instruments are being deployed.

7.6.4 ESS shall comply with the requirements of Sections 7.3, 7.4, and 9.1.

7.6.5 ESS shall:

Be software configurable

Control functionality remotely

Be remotely upgradeable or restore to default settings

Allow remote management of console mode

Allow Active viewing and troubleshooting of the communications status from DMAS

7.6.6 Serial Instruments shall conform to one of the following standards:

EIA standard RS-232

EIA-422 (formerly RS-422)

EIA-485 (formerly RS-485 or RS485)

7.6.7 The exact configuration of data and control leads is the responsibility of the Instrument designer. Complete testing of the selected configuration is strongly encouraged.

7.6.8 Serial Instruments shall utilize only the following serial speeds: 300 b/s, 1.2 kb/s, 4.8 kb/s, 9.6 kb/s, 19.2 kb/s, 38.4 kb/s, 57.6 kb/s or 115.2 kb/s

### 7.7 Timing

Depending on the desired accuracy, Instruments may implement one or more of the following approaches to timing:

7.7.1 Instruments shall synchronize their internal clocks to the Observatory's Network Time Protocol (NTP) server. The NTP server acquires Universal Time Coordinates (UTC) from a Global Positioning Satellite (GPS) receiver in the shore station and is locally accurate to 1. msec. NTP packets received by Instruments are uncorrected for network latency.

7.7.2 Instruments requiring the highest degree of accuracy may access the Observatory's IEEE 1588 Precision Time Protocol (PTP) system by means of suitable hardware or software drivers incorporated into the Instrument. The PTP master acquires UTC from a GPS receiver in the shore station and is locally accurate to 50 nsec. PTP frames received by the Instruments are corrected for network latency. Initial testing shows PTP signals at the Instrument will be accurate to within 2 to 5 μsec of UTC. [This value is expected to improve as additional testing is completed and experience is gained.]

7.7.3 Instrument Providers desiring a Pulse per Second (PPS) output should contact the Observatory regarding provision of a PTP client that provides PPS output for backward compatibility.

7.7.4 Data received from Instruments lacking an internal clock will be time stamped by DMAS at the shore station using time acquired from the NTP server adjusted for an estimate of the network latency. The Observatory cannot guarantee time stamp accuracy better than 100 msec.

### 7.8 Fault Isolation

7.8.1 Instruments which show evidence of unrecoverable faults or which interfere with Observatory operation will be shut down immediately. All Instruments must be designed to accommodate such shutdowns. Examples of conditions which would invoke shut down are:

7.8.1.1 Power supply short circuit

7.8.1.2 Earth leakage above a preset current.

7.8.1.3 Continuous spurious or corrupt data transmissions

7.8.2 Instruments which do not transmit data or respond to inquiries from the Observatory for a specified period will be assumed to be faulty and will be shut down.

7.8.3 Smart Instruments may remain operational following Instrument faults for diagnosis, provided that the fault does not threaten the Observatory or any other Instruments.

7.8.4 Smart Instruments shall provide a means of locating and isolating faults in internal components, including but not limited to power converters, optical transmitters and receivers, switches, routers, and other communications equipment, without underwater intervention.

7.8.5 Smart Instruments shall provide any fault, configuration, performance and security information gathered at the Instrument to DMAS.

# 8 Physical Interfaces to the Observatory

## 8.1 Underwater Mateable Connectors (UMC)

8.1.1 Where possible UMC's supplied to the Provider by the Observatory according to the Agreement.

8.1.2 UMC pin assignments will be determined by the Observatory.

8.1.3 Integration of the UMC shall be performed by qualified technicians according to the UMC manufactures specifications and procedures. The Observatory reserves the right to integrate the UMC's where the Provider cannot demonstrate technical qualifications.

## 8.2 Dry Mateable Connectors and penetrators

8.2.1 The Provider will advise the Observatory of the preferred connector type.

8.2.2 The Provider shall ensure the connector is rated for the depth and electrical loads and is appropriate for the installation including specified design life.

## 8.3 100BaseTx Ethernet

8.3.1 Connector specification and pin assignments shall be agreed between the Observatory and the Provider.

8.3.2 The maximum extension length between the Instrument and Observatory is 70 m over 100baseTx Ethernet.

8.3.3 When an Ethernet is extended by media converters or other Ethernet extenders the maximum cable length will be determined by the Observatory.

## 8.4 Optical Ethernet

8.4.1 Connector configurations for optical Ethernet Interfaces shall be specified by the Observatory .

8.4.2 The Optical Ethernet Interface has a maximum cable length of 8km on Single Mode Fibre (SMF). Only SMF may be used; although the 1000Base-LX standard allows multi-mode fibre, this requires different patch cords for launching and receiving the signal into the fibre. The Observatory nodes are equipped only for single mode fibre.

## 8.5 Adapters

8.5.1 "Adapter" means a device with two or more ports, one of which connects to an Interface and which meets these Requirements, and whose other ports connect to instruments or devices, which would not on their own meet these Requirements.

8.5.2 Providers may propose to develop an Adapter rather than undertake modification of an existing instrument. The use of Adapters to allow connection of existing instruments to the Observatory must be approved by the Observatory.

8.5.3 Providers shall inform Observatory of their intent to use an Adapter, subject to written approval from the Observatory. Providers shall submit sufficient detail design to Observatory to allow review of the suitability, feasibility and reliability of the proposed Adapter prior to obtaining such written approval.

# 9 Instrument Control and Data Management

## 9.1 Communications Data Protocols

9.1.1 Commands sent to the Instruments and the acknowledged responses shall use the TCP protocol, in a client-server mode. The Instrument shall act as the server in this mode.

9.1.2 Data streams shall use the TCP and/or UDP protocols. IP broadcast may not be used except for address resolution. IP multicast addresses (224.0.0.0 – 239.255.255.255) will not be available as we will operate within a private network with addresses in the range 10.0.0.0 to 10.255.255.255.

9.1.3 Unless specified in the Instrument documentation, IP ports 22 (Secure Shell) or 23 (Telnet) will be used for initial communication, configuration and control of the instrument. Other ports used for data transfer or other functions shall be identified in the Instrument documentation.

9.1.4 The dialog between the Data Management and Archiving System (DMAS) and the Instrument will be through socket-based communication for "simple" Instruments. Sophisticated Instruments, having local computing power attached are invited to expose their functionality through a Web Services access point.

## 9.2 Instrument Control Functions

9.2.1 The instrument shall respond to commands sent asynchronously from shore based equipment. Such commands may query the instrument's status, request data be sent, or instruct the instrument to perform some action. Command execution shall be acknowledged.

9.2.2 Other modes of communication may be permitted by the Observatory on a case-by-case basis. For example, an Instrument may wish to seek contact with its peers or may initiate contact with a server. Providers must furnish the details of the communications protocol proposed for such communications and obtain permission from the Observatory prior to implementing them.

9.2.3 Providers shall describe the means of transmitting and acknowledging commands. Providers shall furnish a description of the command and acknowledgement messages. Data structures returned, commands and their parameters shall be completely described and documented in the Instrument manuals.

9.2.4 The Instrument shall have a command that reports its brand, model and serial number.

9.2.5 The Instrument shall have a command that reports all Instrument specific metadata.

9.2.6 Instruments shall accommodate all commands to an Instrument being routed through a DMAS facility to check for command feasibility, impact on the infrastructure and prevent contention. Direct access (i.e. without checking by DMAS) to an Instrument will be considered on a case-by-case basis.

### 9.3 Data Management

9.3.1 Instruments may return raw (un-calibrated, as measured) values to DMAS

9.3.2 For Instruments returning data in engineering units, it shall be possible to request from the Instrument the calibration information that was used for the conversion from raw data.

9.3.3 Data structures returned, commands and their parameters shall be completely described and documented in the Instrument manuals.

9.3.4 Data encoding shall use the self-describing XML mark-up language with standard structures allowing every piece of information in the data stream to be tagged with semantic indications unless the Observatory agrees to another acceptable data format.

9.3.5 Instruments with local intelligence may offer their data products in the form of files to be downloaded through e.g., FTP or HTTP.

9.3.6 Instruments that are buffering data for later download shall have an internal clock and shall timetag measurements. For the timetag to be meaningful, the instrument shall have an internal clock synchronized with the Observatory's master clock through the use of the NTP or PTP time protocols.

### 9.4 Required Information

9.4.1 For DMAS integration, the Provider is expected to provide qualified answers to all of the following questions for each Instrument to be deployed.

9.4.1.1 Data types returned by the Instrument: scalar (e.g., temperature), complex (e.g., matrix, image), stream (video, acoustic) or mixed (e.g., a complex Instrument with extra scalar sensors)

9.4.1.2 Number of physical parameters measured (only for scalar Instruments)

9.4.1.3 Sample size (i.e. bytes per sample or bytes per second for streaming Instruments)

9.4.1.4 Expected regular sampling rate (number of samples per hour or number of minutes of use per hour for streaming Instruments)

9.4.1.5 Expected peak (e.g., during an event response) sampling rate.

9.4.1.6 Idle or nominal power consumption (Amps).

9.4.1.7 Expected start-up power spike (Amps).

9.4.1.8 Peak power consumption (Amps).

9.4.2 For DMAS integration, the Provider shall specify the nature of any post-processing that would have to take place at the shore station or beyond (e.g., calibration, conversions, feature extraction, etc.).

9.4.3 The Provider shall deliver Observatory with requirements/recipes for the identification of events in the real-time Instrument data flow as well as the expected reaction in case of positive detection at a time agreed with NEPTUNE Canada.

9.4.4 The Provider shall deliver recipes to be implemented in software to automatically detect deviation of the Instrument response so as to aid the data quality control as early as possible after data acquisition.

9.4.5 The Provider shall provide Observatory with the expected list of automatic/autonomous survey sequences that the Instrument is expected to perform on a regular basis as early as possible (e.g., a pan-tilt camera will take a 12-still picture panorama of its environment every 2 hours).

## 9.5 Metadata

9.5.1 Instruments shall always accompany their data with metadata, describing the circumstances of the sampling.

9.5.2 The table below is a non-exhaustive list of sample metadata keywords that should be made available by the instruments. The table is organized in various instrument categories and indicates where a particular type of information is required. Every instrument shall be accompanied with documentation describing the extent of its metadata complement for review by Observatory.

9.5.3 Instrument manufacturers and providers are strongly encouraged to specify and qualify their data and meta data using the "DFO common data dictionary" available under http://www.meds-sdmm.dfo-mpo.gc.ca/meds/About_MEDS/standards/code_search_e.asp.[2]

| ***Keyword*** | ***Description*** | ***CTD*** | ***ADCP*** | ***Still Camera*** | ***Video Camera*** | ***Sonar*** | ***Autonomous Vehicle*** | ***Vertical Profiler*** |
|---|---|---|---|---|---|---|---|---|
| TIME_START | Date and time at the start of sample taking (precisions allowed are seconds, msec, and µsec)[3] | Y | Y | Y | Y | Y | Y | Y |
| TIME_STOP | Date and time at the end of the sample. | Y | Y | Y | Y | Y | Y | Y |
| XPOS, YPOS, ZPOS | Position of sensor with respect to fixed reference point | | | | | | Y | Y |
| TILT, ROLL | Position angle of instrument with respect to level | | Y | Y | Y | Y | Y | Y |
| COMPASS | Angle of instrument with | | Y | Y | Y | Y | Y | Y |

[2] This dictionary is part of the Marine Environmental Data Services (MEDS) of the Canada Department of Fisheries and Oceans. MEDS itself is a member of the International Oceanographic Data and Information Exchange (IODE) whose mission is to enhance marine research, exploitation and development by facilitating the exchange of oceanographic data and information between participating Member States and by meeting the needs of users for data and information products.

3 Dates and times shall be expressed in UTC and will only be acceptable if they are coming from a clock that can synchronize to the observatory master clock.

| Keyword | Description | CTD | ADCP | Still Camera | Video Camera | Sonar | Autonomous Vehicle | Vertical Profiler |
|---|---|---|---|---|---|---|---|---|
| | respect to true magnetic North in degrees | | | | | | | |
| PAN, TILT | Position angle of sensor with respect to instrument | | | Y | Y | Y | | |
| ZOOM/FoV | Zoom lens extension (in mm) or better the field of view angle | | | Y | Y | Y | | |
| APERTURE | For cameras, the aperture (F) value | | | Y | Y | | | |
| LIGHTS | For optical detectors, the status of the various lights, LEDs, flashes (on/off, colour, ...) | | | Y | Y | | | |
| FOCUS | Focal distance in mm | | | Y | Y | | | |
| SPOOL | For tethered instrument: distance of instrument head with respect to its base/home station (in mm?) | | | | | | Y | Y |
| FILTER | Optional filter type in the light path, where applicable | | | Y | Y | | | |

## 9.6 Smart Instrument Functions

9.6.1 The Instrument shall provide a method for orderly shutdown which shall include notification to users and connected devices and shall minimize the risk of damage or disruption to other Instruments and the network.

9.6.2 All active components of Smart Instruments, including (where applicable) power converters, power supplies, optical transmitters and receivers, switches, and timing distribution shall be able to be monitored from DMAS. Key performance parameters to be monitored by the Instrument should include:

9.6.2.1 Status of Monitored Elements (active, failed)

9.6.2.2 Position of each switch or circuit breaker which can be remotely controlled

9.6.2.3 Precision Time Protocol status

9.6.2.4 Internal housing temperature

9.6.3 The status of all Smart Instruments shall be able to be monitored from DMAS. Status monitoring shall include the state and health of the communications links and the state and health of the power at the Instrument.

9.6.4 The list of Smart Instruments reporting capabilities is not exhaustive and Providers are invited to include such additional capabilities as may be necessary to ensure continuous operation of the Instrument.

9.6.5 The Smart Instrument shall provide a “web based interface” compliant with W3C HTML 4.01 and XHTML 1.0 for the purposes of monitoring and controlling the IP network layer, the Ethernet network layer, and power delivery to the science ports.

9.6.6 Smart Instruments shall use Simple Network Management Protocol (SNMP) or XML for the purposes of monitoring and controlling the IP and Ethernet functions within the Instrument.

9.6.7 Smart Instruments shall use Modbus or XML for the purpose of monitoring and controlling power and mechanical functions of the Instrument.

9.6.8 Smart Instruments shall be capable of monitoring the status of performance parameters and reporting this status to the Shore Terminals.

9.6.9 Smart Instruments shall accept commands from DMAS for the purpose of determining Instrument health. Providers shall describe a means of transmitting and acknowledging commands. Providers shall furnish a description of the command and acknowledgement messages. Observatory and Provider shall jointly conduct integration testing according to a mutually agreed timeline.

# 10 Instrument Design Requirements

## 10.1 Safety

The safety of personnel and the marine environment are paramount in any Instrument design. Instruments containing any uncontrolled hazards or which may result in injury to personnel on ship or on land may be immediately rejected by the Observatory.

10.1.1 Instrument design shall ensure the protection of personnel from optical, electrical, mechanical, and chemical hazards.

10.1.2 Hazardous voltages, laser sources, heat sources, mechanical and chemical hazards shall be appropriately labelled.

10.1.3 Providers shall provide Workplace Hazardous Materials Information System (WHMIS) or Material Safety Data Sheets (MSDS) for any chemicals or reagents used in the Instrument.

10.1.4 Radioactive isotopes shall not be used for any purpose without specific approval in writing from UVic.

## 10.2 Engineering

10.2.1 Instruments and instrument frames shall be designed and configured to minimize damage from or to fishing equipment- in waters up to 1800 meters depth that may reasonably be expected to be fished over the lifetime of the planned deployment.

10.2.2 Any underwater mateable connectors shall be designed and located to allow mate/demate by both academic style ROVs such as ROPOS, TIBURON and JASON II and large cable burial ROVs. The Provider will submit physical arrangement information for review by the Observatory

## 10.3 Engineering for Manned Submersibles

10.3.1 To ensure flexibility in deployment and safety of personnel in manned submersibles, underwater housings shall be designed for a depth equal to the planned deployment

depth plus 100 meters. Underwater housings shall be tested to 1.5 times such design depth. Implodable volumes shall be certified for use with manned submersibles, using an accepted test regime. A typical test regime for certification of implodable volumes normally requires a submergence pressure test to 1.5 x (max pressure (kPa) expected during deployment) for 10 cycles; held 10 minutes at greatest pressure for cycles 1 through 9, held 1 hour at greatest pressure for cycle 10. Written approval from Observatory will be required prior to deployment should the Provider be unable to meet this requirement.

## 10.4 Environmental Requirements

10.4.1 Instrument designers are encouraged to take an expansive view of the environmental requirements so that Instruments designed for one location can readily be deployed elsewhere.

10.4.2 Instruments shall be designed to meet all Requirements when operating in temperatures between -5 °C and +40 °C in order to demonstrate sufficient design margin.

10.4.3 Instruments shall tolerate temperatures of 0°C to 40°C during transport and installation. Provider shall take appropriate measures to ensure these temperature limits are not exceeded during transport. Providers shall take appropriate remedial action in the event the temperature limits are exceeded. Observatory shall take appropriate measures to ensure these temperature limits are not exceeded during installation.

10.4.4 Underwater housings shall maintain an internal environment that ensures all internal components will perform in accordance with the Requirements over the design life. Effects to be considered as examples are heat dissipation, hydrogen and water vapour exclusion.

10.4.5 Providers shall establish appropriate limits for shock and vibration tolerance during transport and installation based on commercial specifications and/or proven design practice and shall take appropriate measures to ensure such limits are not exceeded. Providers shall take appropriate remedial action in the event the established limits are exceeded.

10.4.6 Provider shall notify Observatory if the limit acoustic noise levels radiated by the Instrument into the surrounding seawater in the range from 1 Hz to 65 kHz are expected to exceed:.

50 dB re 1 µPa/Hz from 1 to 50 Hz

40 dB re 1 µPa/Hz from 50 to 500 Hz

30 dB re 1 µPa/Hz from 500 to 5000 Hz

20 dB re 1 µPa/Hz from 5 kHz to 10 kHz

10 dB re 1 µPa/Hz from 10 kHz to 65 kHz

10.4.7 Provider shall notify Observatory if the electrical fields generated by the Instrument are expected to exceed: $.x10^{-8}$ V/m (1.0 µV/cm) over the range from 0.01 to 20 Hz at a distance 30 meters from the Instrument

10.4.8 Provider shall notify Observatory if the magnetic signature of the Instrument is expected to exceed 1. nT at a distance of 30 meters from the Instrument.

10.4.9 The Instruments shall be designed so that corrosion does not affect performance over the design life.

10.4.10 Cable designs shall be designed for the intended installation including depth and expected tension and abrasion conditions. They shall employ appropriate blocking compound or jelly to limit water ingress along the cable in the event of a fault and to mitigate the affect of pressure on the conductors.

## 10.5 Reliability

10.5.1 It is understood by the Observatory that the nature of scientific experimentation allows for failures that would not be tolerated in an industrial or commercial setting. Because of the resources invested in the Observatory, Instruments must be designed with a reasonable expectation of continuous operation for a period of at least one year. The following reliability specifications are established as guidelines and Providers are strongly encouraged to meet these requirements.

10.5.1.1 Instruments designs shall include an estimate of the overall Instrument reliability based on component, sub-assembly or sub-system reliability data and using appropriate calculations or modelling. It is understood that reliability calculations cannot be relied upon to identify all risks, particularly those external to the system. Reliability calculations and modeling must make reasonable efforts to identify and quantify all internal sources of failures.

10.5.1.2 Component, sub-assembly, and sub-system reliability shall be calculated based on Telcordia, MIL-SPEC, or other recognized methodology. Actual field performance results should be used, provided at least 10,000 device hours of data are available. Providers shall clearly state the source of all Failures in Time (FIT) and Mean Time between Failure (MTBF) data.

10.5.1.3 The probability of failure during the first year of operation shall not exceed 10%. Assuming there are no duplicated or redundant components within the Instrument, this probability of failure is equivalent to total Failures in Time (FITS) for all components of 12,000 or less. [For a system with no redundant components, FITS and probability of failure over a given time period are mathematically linked as follows: MTBF(hours) = 10E9/FITS; MTBF(years) = MTBF(hours)/8760; Failure rate = 1 / MTBF; Probability of failure in t years = 1 - exp(- failure rate x t).]

## 10.6 Maintainability

10.6.1 The Provider shall submit deployment and recovery procedures including lists of special equipment including costs and physical dimensions.

10.6.2 The Provider shall inform the Observatory where instruments cannot be safely and economically installed by a vessel of opportunity such as a Canadian Coast Guard (CCG), University-National Oceanographic Laboratory (UNOLS), cable ship, or multi-function service vessel.

10.6.3 The Instrument design shall take into account lifecycle costs. Where a higher priced component will reduce or eliminate maintenance, consideration shall be given to the cost of the maintenance including recovery and re-installation.

10.6.4 Submerged plant housings, penetrations and cable terminations shall be designed to allow installation, operation, recovery and reinstallation of submersible plant in depths up to the design depth with no degradation in mechanical, electrical and optical performance.

10.6.5 The Providers shall provide delivery time and an estimated quantity of consumable spares for three years operation. This list will assist in the planning of the schedule of instrument maintenance cruises.

### 10.7 Security

10.7.1 Instrument shall not allow communication on any IP ports not specifically defined in the Instrument documentation.

10.7.2 Smart instruments are expected to provide the option of having their access password-protected.

10.7.3 Providers shall describe any security features such as an alert in the event of any attempt at unauthorized access or other tampering available in the Instruments.

10.7.4 Providers shall provide support to ensure the Instrument is compatible with the Observatory firewall and can support communication across the Internet via the firewall. Information provided shall include IP port numbers being used, lists of authorized IP address, details of security mechanisms, and, where applicable, details of higher layer protocols needed for filtering.

10.7.5 The Instruments shall accommodate the security concerns of National Governments. Where and as needed, Providers shall incorporate design changes requested to address the security concerns of National Governments.

10.7.6 Instruments containing one or more hydrophones, seismometers, electrometers and other instruments that may have national security implications shall not record their data at the Instrument level (i.e., under water), unless prior approval from Observatory has been obtained. Instruments without such approval shall transmit live acoustic stream to the shore station for further processing on shore station computers.

### 10.8 Embedded Software

10.8.1 Instruments shall use commercially proven, off-the-shelf software except where custom software development is absolutely essential for achieving the desired Instrument functionality. Software development should be focused on (a) generating messages that indicate the Instrument status and (b) accepting discrete commands from the DMAS or user provided software.

10.8.2 Embedded software should be stored in flash memory or other non-volatile storage.

10.8.3 Instruments with local intelligence shall have the ability to update both their on-board operating system and application program(s) remotely.

10.8.4 Provider shall deliver a list of all software contained in the Instrument.

## 11 Instrument Testing

11.1 Provider shall develop a test plan to be agreed with the Observatory that will demonstrate the Instrument meets these Requirements and to demonstrate any other functional capabilities. The Observatory may accept reasonable prior test data and use history as evidence of compliance with these requirements.

11.2 The Instrument test plan shall clearly state the operation to be carried out and the expected results. The test plan shall refer to documented test procedures.

11.3 Test procedures shall be submitted for review at least 60 days prior to tests and with sufficient time to prepare facilities for testing.

11.4 Testing shall include mechanical integrity, power supply integrity, and data transmission capability tests and other tests as requested by the Observatory and documented in the test plan.

11.5 Testing shall include any necessary calibration or verification of the Instrument's data collection capability.

11.6 Testing shall include a connection to the DMAS test bed in a controlled environment in sufficient time prior to deployment to permit the testing and qualification of the instrument.

11.7 Testing in shallow salt water environments prior to deployment is strongly encouraged and may be requested.

11.8 Long term "stability" testing consisting of unattended operation without failure in a grounded salt water tank for a period of 30 days or more may be required by the Observatory depending on the qualifications, use history and development cycle of the instrument.

11.9 Verification of isolation of the power and data transmission may be requested.

# 12 Shore Based Equipment

12.1 Instrument Provider shall provide details of its requirements at the Shore Stations, including where applicable space utilization, access requirements, power load schedules, HVAC load, etc. as well as any critical data processing requirements (including equipment) that will have to be hosted at the Shore Station.

12.2 Network interfaces conforming to the IEEE 802.3 family of Ethernet standards are provided at the shore terminals.

12.3 Equipment installed in the Shore Station shall be powered from standard commercial AC power sources or from -48V DC.

12.4 Providers shall provide a list of power requirements (load schedule) for the shore station.

12.5 All network equipment installed in the shore stations shall be capable of normal operation with an ambient temperature in the range from 5C to 40C.

12.6 All equipment shall conform to FCC-15 (A) and CISPR 22 for electromagnetic emissions and interference.

12.7 All equipment installed in the shore stations shall be designed for North American Earthquake Zone 4.

12.8 Compliance with Telcordia Network Equipment Building Systems (NEBS) criteria for telecommunications or enterprise equipment is strongly preferred.

# 13 Documentation

The Provider shall deliver documentation in sufficient detail to allow skilled and knowledgeable staff to integrate, operate, maintain, and troubleshoot the Instrument. It is anticipated that the Provider will

participate in all of these activities, but it is also required that a full set of instrument specific documentation be held by Observatory.

Observatory retains the right to audit the documentation to ensure that the documentation matches the hardware and software provided. Audit teams may include representatives of military or national security agencies.

Instrument documentation shall include:

13.1 An overview of the Instrument purpose and desired results, what data is to be collected, and the theory of operation of the Instrument

13.2 A functional block diagram of the instrument, including power supplies, routers, data switches, controllers and scientific apparatus

13.3 Diagrams of all internal wiring, connectors, or field maintainable components

13.4 Specific descriptions of any connections between the power supply busses and seawater/case potential

13.5 Diagrams and instructions for any routine maintenance procedures (e.g. cleaning, replacement of consumables)

13.6 Instrument initial configuration and setup (prior to deployment)

13.7 Instrument power requirements

13.8 Instrument networking capability, in particular use of CoS or VLANs

13.9 Description of serial interface converters, if used

13.10 Description of the Instrument's clock or timing system and anticipated interaction with the Observatory

13.11 Fault isolation capabilities of the Instrument

13.12 Description of Adapters, if used

13.13 Command set, including response messages

13.14 Data output format

13.15 Instrument Metadata

13.16 DMAS Required information as listed in Section 9.4

13.17 Operations procedures

13.18 Instrument Safety, including a description of any hazardous conditions and how to properly handle the Instrument

13.19 Description of the Underwater Housing - number and type of seals, material, coatings, connector types/material

13.20 Description and wiring diagrams of secondary underwater cables

13.21 Information regarding acoustic, electrical, and magnetic interference potentials

13.22 Reliability calculation

13.23 Security status – in particular are hydrophones used?

13.24 List of software used in the Instrument – operating system, programming language

13.25 Test Plan and Procedures

13.26 Description of shore based equipment

13.27 Training material, if applicable

<end>