



Requirements document

KM3Net Interconnection Links

Tender Nikhef

Version 08 July 2021

1. Requirements

This document contains the technical and operational requirements for the tender of interconnection links.



2. Scope of the project

This document covers the supply of the following items:

- The provision of “Y” type DU-interconnection links as described in section 6.2;
- The provision of “I” type DU-interconnection links as described in section 6.3.

Scientific background

The KM3NeT collaboration aims to continue the realization of an underwater infrastructure for the implementation of an underwater neutrino observatory, and instrumentation for marine and environmental sciences. It is located approximately 40 km south of Toulon at a depth of 2500 m. The observatory consists of a set of deep-sea connections for scientific instruments installed on instrumented lines (Deployment Units, or DUs), organized in a network linked to the land. The observatory near Toulon is configured for the study of neutrino properties (ORCA-Oscillation Research with Cosmics in the Abyss).

The purpose of the seabed network is to provide power and information transmission between the land and the instrumented lines via a submarine electro-optical cable to a node equipped with user ports and electro-optical links. In parallel to the power, single-mode fibre-optic links ensure the transit of scientific data from the instrumented lines, as well as command and control orders.

Underwater connectors have already been installed during the previous phases of the project, which **means that the products of this framework agreement must be fully compatible with existing ones already supplied.**

The final submarine network consists of 4 network nodes. One node allows the connection of 6 to 9 chains of 4 DUs, i.e., a maximum of 36 DUs, as well as instrumentation for the associated sciences through user ports (Figure 1).

The user ports are electro-optical (hybrid) wet-mateable connectors.

This contract concerns the supply and delivery of interconnection links between the node and the DUs.

Preliminary DUs connection scheme 2021-02-09

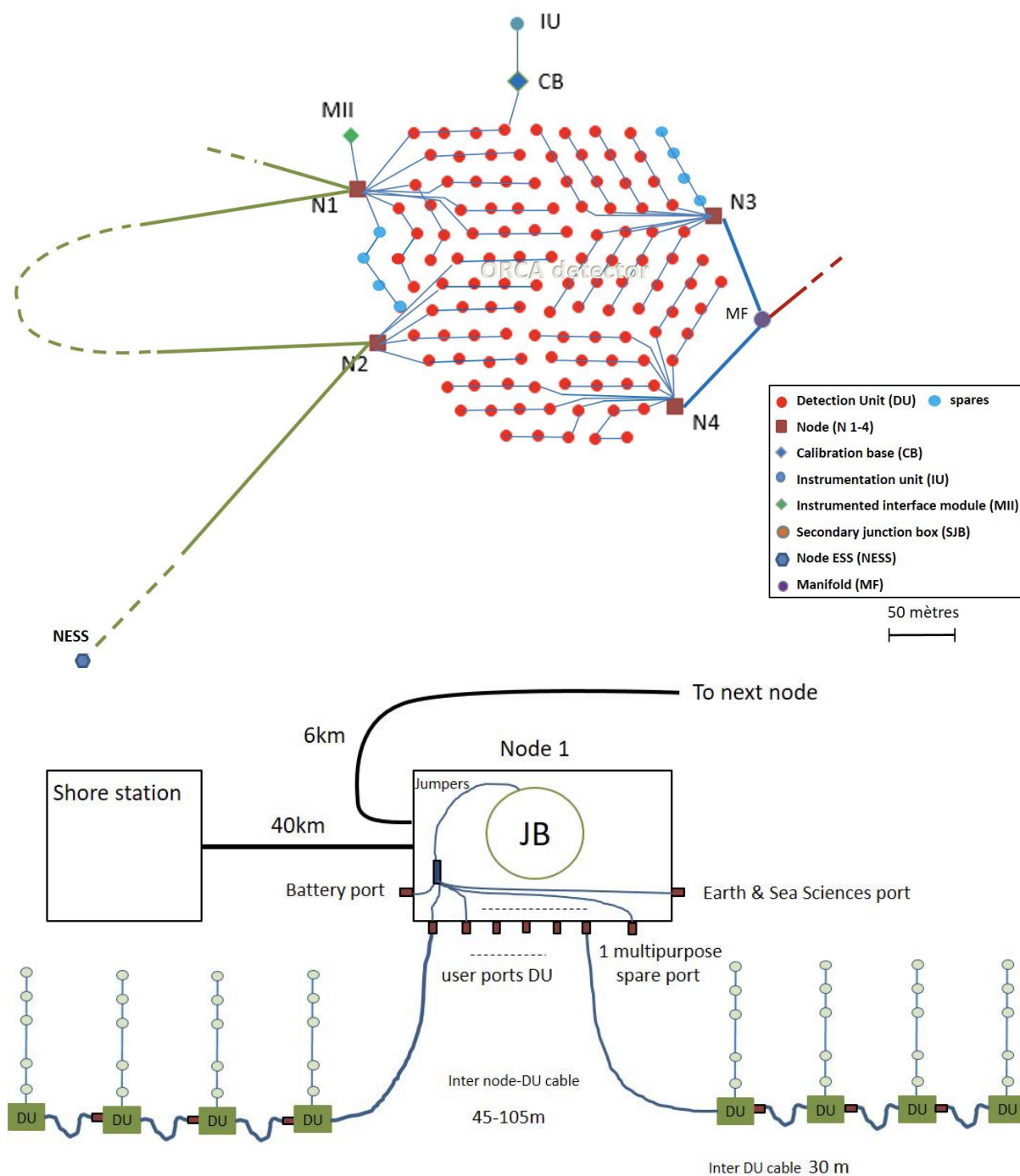


Figure 1: Diagram of the detector (top) and diagram of the DU connection (bottom)



3. Place of delivery of the equipment

Nikhef, via the company commissioned to transport and import the equipment, pays for the transport.

It shall also bear the risks until the final destination of the goods. The formalities and costs of exporting and importing, as well as the duties and taxes associated with this operation, shall also be borne by Nikhef.

Packaging

The packaging is the responsibility of the contractor and must guarantee protection against the risks associated with transport and storage operations.

Place of delivery of the material

Delivery will be made to:

CPPM - UMR 7346 (CNRS)
163 avenue de Luminy
13009 MARSEILLE
France

4. Documentation

The contractor shall provide Nikhef with the documents listed below in the form of a computer file (preferably in pdf format):

- Operating and maintenance instructions;
- Mechanical drawings, including external dimensions and interfaces, dimensions and nature of O-rings and general drawings;
- Data sheet and certificate of conformity of the optical fibre;
- Test reports and documents associated with the identified objects;
- Certificates of conformity;
- Material certificate for titanium.



5. Guarantee

The warranty period for the equipment covered by this framework agreement shall be a minimum of two (2) years.

The starting point of the guarantee period is the date of notification of the final acceptance decision for the equipment.

6. Description and general specifications of the supply

6.1 General

The operations relating to the installation of the DUs and their connection will be carried out with a light ROV (Remote Operated Vehicle) of the APACHE type (the use of a workclass ROV being envisaged only in exceptional cases for specific operations).

The user ports on the nodes and DUs already installed on the seabed or under construction are wet-mateable connectors of type NRH APC from the company Teledyne ODI. The cables shall be pressure-balanced using an oil-filled hose.

6.2 DUs "Y"-type interconnection link

The "Y" type link connects a DU to a user port of the node or 2 DUs together. It is identical in both cases.

The link consists of a penetrator with 2 hose exits, the 1st branch is ended by a ROV flying plug wet-mateable connector and the 2nd branch is ended by a bulkhead wet-mateable connector. The penetrator comprises 4 conductors with individual copper cross-sections $\geq 1.9 \text{ mm}^2$ (14 AWG) and 8 ITU-T G.652 optical fibres, it is installed on a titanium container in atmospheric pressure. The flying ROV plug has 2 conductors and 4 optical fibres, the length of the branch depends on the location of the DU and where it will be connected, the length of the pressure-balanced oil filled hose could be 30 m, 45 m, 60 m, 75 m, 90 m or 105 m. The bulkhead connector has 2 conductors and 4 optical fibres with a fixed length of the pressure balanced oil filled hose of 3 m. The diagram of this link is shown in figure 2.

The size and weight of the oil filled hose should be minimised for handling by the ROV.

Technical specifications of the penetrators, connectors and cable are described in Section 8.

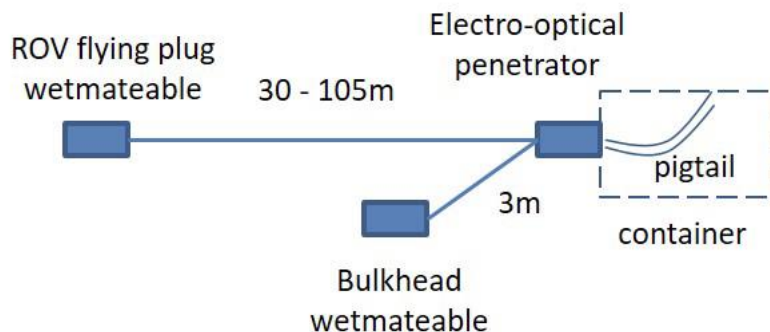


Figure 2: Diagram of the "Y" type link

6.3 DUs "I"-type interconnection link

The "I"-type link connects the 3rd DU to the 4th, the last DU in the chain of 4 DUs.

The link consists of a pressure-balanced oil filled cable with 2 conductors, each with a copper cross-section $\geq 1.9 \text{ mm}^2$ (14 AWG), and 2 ITU-T G.652 optical fibres, with a penetrator, installed on an atmospheric pressure container, at one end and a wet-mateable connector flying ROV plug type at the other end (connected to the link base described in Section 8.2). The link has a length of 30 m. The diagram of this link is in figure 3.

The size and weight of the link cable should be minimised for handling by the ROV.

Technical specifications of the penetrators, connectors and cable are described in Section 8.

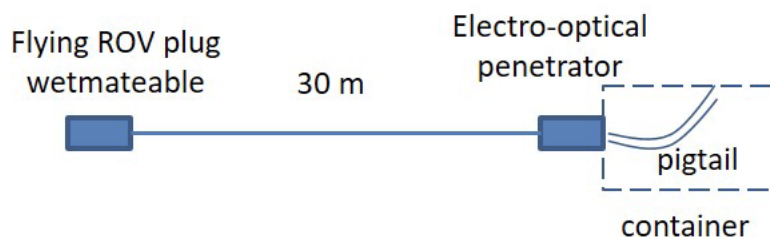


Figure 3: Schematic of the "I" type link

7. Environment

- Western Mediterranean Sea: Temperature 13°C
- Salinity: 38 g/kg water
- Maximum immersion depth: 2500m
- Lifetime: 15 years minimum
- Operating temperature: + 5°C to + 40°C
- Storage temperature: - 10°C to + 60°C



8. Technical specifications of connectors and penetrators

The cross-section of the conductors in the cables proposed by the contractor will be optimised in order to minimise the ohmic drops while maintaining a configuration (dimensions, weight) that can be handled by the ROV.

8.1 Mechanical characteristics

8.1.1 Connectors and penetrators

	Connector	Penetrator
Material:	Titanium for metal parts	
Dimensions:	NRH APC	Diameter in interface with the container < 50 mm
Mounting interface:	Bulkhead: screw flange	Screw flange
Sealing external interface:	Double O-ring seal	
Internal longitudinal sealing:	Waterblocked in both directions	
Cable output:	Plug: 45°, socket: 90°	Axial
Insertion force at operating pressure:	≤ 60 kg*	N/A
Extraction force at operating pressure:	≤ 60 kg*	N/A
Number of connections or disconnections:	> 50 without maintenance	N/A
Force on the hose:	< 30 kg axial and radial	N/A
Vibration/shock	Those induced during transport and handling	

*: The contractor shall specify the expected value at atmospheric pressure if this is different from the value at working pressure.

8.1.2 Cables

Diameter:	Preferably < 25 mm
Radius of curvature:	< 200 mm
Tensile strength:	> 150 kg
Weight in water:	Slightly heavy

8.2 NRH-APC hybrid connectors

The proposed connectors should be compatible with Teledyne ODI's NRH APC connectors.



8.2.1 Electrical part

Continuous operating voltage:	400 V rms max. (50 Hz)
Permanent operating current per contact:	3.5 Amps max.
Insulation resistance of contacts to sea water:	> 1 GOhm at 1000 V
Contact resistance:	< 30 milliOhm

8.2.2 Optical part

Fibre optic type:	ITU-T G.652
Optical attenuation at 1550 nm:	≤ 2 dB (unmatched plugs and sockets)
Optical back reflection at 1550 nm:	≤ -40 dB

8.3 Penetrators

8.3.1 Electrical part

Continuous operating voltage:	400 V rms max. (50 Hz)
Permanent operating current per contact:	3.5 Amps max. (15A peak during 100 ms induced by inrush current)
Insulation resistance of contacts to sea water:	>1 GOhm at 1000V
Contact resistance:	N/A
Pigtail:	length 2m Cross-section per wire ≥ 1.9 mm ² (14 AWG)

8.3.2 Optical part

Fibre optic type:	ITU-T G.652
Optical attenuation at 1550 nm:	≤ 0.25 dB
Optical back reflection at 1550 nm:	N/A
Pigtail:	length 2m Preferably 1mm diameter loose tube terminated with FC/PC connector



9. Marking/Identification

Each plug, base and penetrator is identified by a unique serial number.

The jumpers and interconnection links are identified by a specific marking which will be provided by Nikhef. The plugs and sockets of the connectors are not matched unless the contractor mentions it.

10. Tests

The tests requested below are only for equipment that is already qualified.

If available, the contractor shall provide with his drawings the qualification reports of the material used. If the material is not qualified, the contractor must provide the qualification test plan to be carried out prior to manufacture.

10.1 Test plan

The contractor shall state in his technical offer how he carries out the factory acceptance tests. The tests shall consist of the tests detailed in section 10.2, under pressure at 310 bars for one hour, and under atmospheric pressure. The contractor details the procedures and has them approved by Nikhef.

10.2 Factory acceptance tests

The factory tests are carried out according to the procedures and test plan presented in the tender of the contractor. The contractor shall perform at least the following measurements under and without pressure:

- Measurement of optical attenuation at 1310nm and 1550nm;
- Measurement of optical back reflection at 1550 nm;
- Linear resistance measurement;
- Measurement of insulation resistance between contacts and contacts/ground;
- Measuring the connection/disconnection force at atmospheric pressure.

The test report sheets are validated by Nikhef within a maximum of two weeks from receipt of the test report sheets. Validation of the end-of-manufacturing tests triggers the delivery process.



The contractor shall inform Nikhef of the date of the acceptance tests after manufacture, at least three weeks before they are held; the tests may be carried out in the presence of Nikhef or its representative.

10.3 Test on delivery

CPPM performs the following controls on each entity at atmospheric pressure:

- Visual inspection;
- Checking the documentation;
- Measurement of fibre attenuation at 1550 nm;
- Linear resistance measurement;
- Measurement of insulation resistance between contacts and contacts/ground;
- Measuring the force of connection and disconnection of connectors.

The purpose of these tests is to verify the continued integrity of the equipment after transport and may be carried out in the presence of the contractor or his representative.

Final acceptance is pronounced following the validation of these checks under the conditions described in Section 13 of this document.

11. Quality assurance

The contractor shall have in place a quality assurance plan in accordance with ISO 9001 or equivalent, defining the procedures implemented, and provide proof of this in his offer.

Non-conformities and anomalies during the performance of the service are dealt with and controlled in accordance with the contractor's quality assurance plan.

Major anomalies or non-conformities that could lead to a defect placing the product concerned outside the acceptance criteria are indicated in writing and sent to Nikhef as soon as possible. The corrective actions proposed by the contractor are subject to the agreement of Nikhef. All modifications in the procedures, materials, dimensions, are submitted for validation to Nikhef.

12. Delivery time

The delivery time shall be no longer than six months.



13. Final acceptance

Acceptance operations consist of verifying compliance with the technical requirements defined in this document by validating the checks and tests at the place of delivery, as specified in Section 10.3 of this document.

Final acceptance shall be pronounced within a maximum period of two weeks from the delivery and availability to the CPPM of the supplies covered by the contract and all the documentation defined in Section 4 of this document.