Instrumentation Unit of the CU
DD Review
16/04/2019

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Plan

- Global context of the IU
- Global description and main functionalities
- Environment and conditions of use
- The inductive communication system
- The instruments and inductive interfaces
- The interlink IU/CB cable
- The electronics container
- The mechanical frame
- The global IU tests
Global context of the KM3NeT calibration

In a more global context of the calibration of the KM3NeT detector,

the aim of the calibration unit is to integrate the different instruments needed to perform accurate timing and positioning calibration of the optical modules and good measurements of the environmental properties of the modules surroundings.

the minimum requirements for calibration of the detector relate to:

- time calibration of the detector which must allow to date with a precision lower than the ns the events

- the calibration in the space which must allow to know in real time the evolution of the position, moving with the marine current, of the various sensors (photomultiplicators) of the detector with a precision of about 10 cm
Global context of the IU

The IU is part of the **positioning calibration** of the KM3NeT detector.

The IU manage the **oceanographic measurements** used by the relative positioning system that evaluates the DOM and PMT positions.

**Positioning, acoustic system installed on CB:**
- Emitter acoustic transducer (fixed)
- Hydrophone acoustic receiver (fixed) to position the base of the CU and therefore the acoustic transmitter

**Positioning, oceanographic measurements, installed on IU:**
- CTD probe measuring conductivity, temperature, pressure for the calculation of sound velocity (or velocity)
- sound velocimeter allowing the direct measurement of the speed of sound in water
- currentmeter to measure the marine current
Global description and main functionalities

IB : IMM (inductive modem) + serial converter + DC/DC

Wet mateable connector

Interlink cable

Eventual buoy

Dead weight

IU releasable

IU Anchor

Figure 2 : Instrumentation Unit synoptic
The IU main composants

A recoverable part:

- the instrumented line
  - buoyancy
  - one 200m inductive cable
  - inductive interfaces for non inductive instruments
  - instruments
    - 3 currentmeters *(2 non inductive + 1 inductive)*
    - 3 sound velocimeters *(non inductive)*
    - 3 CTD (Conductivity Temperature Depth) *(2 non inductive + 1 inductive)*
  - inductive coupler
- the mechanical frame
  - acoustic beacon (only for IU positionning)
  - release Dynema system
  - electronic container
  - interlink connexion system

An non recoverable part:

- dead weight
- the interlink cable that links the IU to the CB and the CB to the DU
The IU environment and conditions of use

On the ORCA French site:

- Operating pressure: 250 bars
- Test pressure: 310 bars
- Storage temperature: -10°C / +60°C
- Seawater temperature: 13°C

- Acquisition periodicity for each parameter: 1 every 15 min
- The IU will be recovered about every 2 years for recalibration and batteries replacement

- Mechanical constraints:
  - Vibration and shocks during transport
  - Dynamic constraints generated during deployment, recovery, handling or assembly operations

- The life time of the IU must be at least 10 years
The inductive modem system (1)

On the shelf commercial SeaBird system

**IMM**: Inductive Modem Manager

**ICC**: Inductive Cable Coupler: links the inductive cable to the IMM

200m inductive cable,

\(\frac{1}{4}\) inch wire diameter, 3 strands x 19 wires, galvanized jacketed

### Mechanical specifications:

<table>
<thead>
<tr>
<th>Wire diameter</th>
<th>Jacquet diameter</th>
<th>Breaking strength</th>
<th>Weight air</th>
<th>Weight water</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.5 mm</td>
<td>8.4 mm</td>
<td>3016 kg</td>
<td>0.2 kg/m</td>
<td>0.095 kg/m</td>
</tr>
</tbody>
</table>
The inductive modem system (2)

The inductive interfaces are used to interface with the non inductive instruments.

Inductive interface Seabird RS232 ↔ inductive signal

2 types of interfaces:

UIMM: needs to be powered by the instrument
(2 to interface 2 non inductive Aquadopp currentmeters)

SBE44: has a power output to supply the instrument (with no internal batteries)
(3 to interface non inductive miniSVS sound velocimeters
2 to interface CTD non inductive instruments)

SEABIRD, has CE certification for its products

Applicable EU directives:
- Machinery directive 98/37/EC
- EMC directive 2004/108/EC
- Low voltage directive (93/68/EEC)

Applicable harmonized standards:
- EN 61326 Electrical Equipment for measurement
- EN 61010 Safety requirements for electrical Equipment for measurement
The instruments (1)

**CTD SeaBird : Conductivity Temperature Depth measurement**

1 inductive CTD
2 non inductive CTD interfaced with SBE44

**Main specifications :**

- **Weight in air:** 4.5 kg
- **Weight in sea:** 2.4 kg
- **Overall dimensions:** 564 x 138.9 x 114 mm
- **Power Consumption:**
  - Quiescent: 0.0007 Watts
  - CTD-DO Sample Acquisition: 0.3 W

**Measurement range and initial accuracy :**

- **Conductivity:** 0 to 7 S/m (± 0.0003 S/m)
- **Temperature:** -5 to 45 °C (± 0.002 from -5 to 35 °C)
- **Pressure:** 3500m (± 0.1% of full scale range)
- **Oxygen:** 120% of surface saturation (± 2% of saturation)

⇒ The Seabird CTD have a CE certification and are delivered with pressure test, conductivity, temperature calibration certificates
The instruments (2)

Aquadop Nortek currentmeter (+ other sensor)

1 inductive
2 non inductive interfaced with UIMM

Main specifications:

• Dimensions: 510 mm x 84 mm
• Weight in air: 7.6 kg
• Weight in water: 4.8 kg
• Voltage input: 9-15 VDC
• Power consumption:
  typ: 1.4 W @1 Hz, 0.2 W @0.02Hz
  Sleep consumption: 0.0013 W

Measurement range and initial accuracy:

• Sea Current: ± 3m/s
  (1% of measured value ± 0.5 cm/s)
• Temp: -4°C to 40°C (0.1°C)
• Compass: 0-360° (2°)
• Tilt: ± 30° (0.2°)
• Pressure: 6000m (0.5% of full scale)

➔ NORTEK is an ISO 9001 company in the scope of Design and Manufacture of Hydrographic and Oceanographic Measuring Equipment

➔ Each Aquadop is delivered with sensor calibration certificates
The instruments (3)

Mini SVS Valeport sound velocimeter:

3 non inductive interfaced with SBE44

Main specifications:

- **Dimensions**: 300 mm x 40 mm
- **Weight in air**: 1 kg
- **Weight in water**: < 1 kg
- **Voltage input**: 8-30 VDC
- **Power consumption**: 0.25 W

Measurement range and initial accuracy:

- **Range**: 1375-1900 m/s
- **Resolution**: 0.001 m/s
- **Accuracy**: theoretical max error ±0.017 m/s

⇒ Valeport is an ISO 9001, 14001, 18001 company

⇒ Each mini SVS is delivered with calibration certificate

⇒ The mini SVS have a CE certification
The interlink IU/CB cable (1)

The interlink cable permits to links the IU to the CB AND the CB to the DU.

Figure 4: schematics of the interlink cable

- 20 m hybrid cable (2 electric + 2 FO)
- 50 m electric cable (2 power wires + 2 twisted pairs)
Main IU electrical specifications:
- Operating voltage: 12 VDC
- Current: 1 A max.
- Conductor cross-section ≥ 1.9 mm² (14AWG)
- Twisted pairs: section ≥ 0.33mm² (22AWG), impedance 120 Ω
- Insulation resistance between conductors and conductor / ground > 1 GΩ under 1000Vdc

Main CB hybrid specifications:
- Operating voltage: 400 VAC (50 Hz) + 12 VDC
- Current: 1 A max
- Starting current: 1 A max. (12Vdc) and 32A (<10ms) max. (400 Vac)
- Conductor cross-section ≥ 1.9 mm² (14AWG)
- Twisted pairs: section ≥ 0.33mm² (22AWG), impedance 120 Ω
- Insulation resistance between conductors and conductor / ground > 1 GΩ under 1000Vdc
- 2 FO ITU-T G.652
- Optical attenuation at 1550 nm < 0.25 dB
The interlink IU/CB cable (3)

Test plans:

Pressure test (by supplier)
- At least a test under pressure for 1 hour at 310 bar and without pressure is performed

Factory Acceptance Tests (by supplier)
Carried out according to the procedures and test plan presented in the offer
- Fiber attenuation measurement at 1310 nm and 1550 nm
- Optical reflection measurement at 1550 nm
- Measurement of the linear resistance
- Measurement of the insulation resistance between contacts and contacts / ground
- Measurement of the connection / disconnection force at atmospheric pressure

Tests on delivery (by CPPM)
- Visual inspection
- Verification of documentation;
- Fiber attenuation measurement at 1550 nm
- Measurement of the linear resistance
- Measurement of the insulation resistance between contacts and contacts / ground
- Measurement of the connection effort and disconnection of the connectors.

⇒ Have been delivered in CPPM in april 2018
Specifications of the electronic board:

- **F1**: Host the IMM inductive modem
- **F2**: Conversion RS232 to RS422 (and associated line driver) to allow a serial communication on a 50 m cable
- **F3**: Adaptation of the supply voltage supplied by the CB 12V to the supply voltages
- **F4**: Connectivity towards the ICC
- **F5**: Connection to the IU / CB interlink cable

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**Figure 3: Schematics of the electronics**
The electronic container: electronics board (2)

Electric interfaces:

- To ICC via Subconn BH4F Ti:
  - 2 wires for coil+ and coil- signals

- To CB via ODI penetrator:
  - 2 wires for 12 V supply
  - 2 twisted pairs for RS422 serial communication

Power consumption: max 4W @12V

⇒ Prototype board has been tested in lab using a 50m similar submarine electric cable similar to the interlink that has been purchased

⇒ Delivered in CPPM

⇒ Need to be tested with FMC board and the final IU interlink

Need to be tested under pressure?
Test after production:
- Functional tests
- Burn-in tests, derived from the Burn-in test proposed for KM3NeT electronics, global protocol:
  - 1 first cold cycle with 10 minutes at 0°C
  - 16 hours burn-in at 70 °C
  - 10 cycles -0° to +70°C (10 minutes dwell time)
  - 5 minutes power off during the 2 before last cycle dwell time
  - If possible, the board should be ON and a minimum functional test should be performed
The electronic container: mechanics (1)

**Main functionalities:**
- Host the electronic board
- Host the ODI penetrator for the IU/CB 50m interlink cable
- Host the BH4F Ti Subconn connector for ICC

**Re-use of one Titanium ANTARES LCM:**
- Adaptation of the cylinder length
- Re-machine one endcap

**Figure 5:** schematics of the IU container
The electronic container: mechanics (2)

⇒ The length of the cylinder has been reduced according to the IU container drawings and the endcap has been re-machined to integrate the IU connectors. Global dimensions: 240 mm x 50 mm

Test after production:

The IU container has been adapted from one ANTARES LCM Titanium container.
- The LCM was fully qualified for 256 bars immersion during the ANTARES R&D phase.
- Dimensional control and visual inspection
- Pressure test: 1 pressure cycle between 0 and 310 bars (1.2 x 250 bars) ⇒ Test successfully passed (beginning of January 2019)

(For the tests, the frontal endcap equipped with the BH4F Subconn connector mated with a dummy connector and the ODI penetrator replaced by a mechanical plug)
The mechanical frame

Main specifications:

F1: Allow specific deployment and recovery sea operations
F2: Maintain the UI on the seabed
F3: Allow the specific operations of recovery of the IU for its maintenance either by dropping or by hooking.
F4: Ensuring the maintenance of the constituent elements of the IU
F5: Allow the connection and disconnection of the IU / CB interlink cable by a ROV
F6: Allow the installation of inspection and cleaning tools if necessary (camera, brush, ...)
F7: Reception function of the IB
F8: Resistance to marine corrosion
F9: The foot of the line must allow its transportation on land facilitated by a truck-type device
F10: Allow the integration of associated instruments and interfaces, ICC,..

(Mechanical maintenance of instruments on the inductive cable to be provided for all devices on the inductive line.
This integration should also allow the maintainability of the instruments during the recovery of the IU (replacement of batteries, ...)

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The mechanical frame design (1) : summary

contact Ph. Lagier for more infos

Guidelines :

- Simple shapes : straight tubes, standard dimensions, ...

- Using of validated devices from the DU : release device, insulating parts, interlink connection device, Dynema rope.

- Only 3 matters : steel, titanium, HDPE.

- Position of the acoustic release is safe, without no masking.

- Recoverable part fixed on the deadweight with Dynema rope. If a release problem occurs, the ROV can be cut the rope.
The mechanical frame design (2): summary

**IU BOTTOM LINE : main characteristics**

- **Connection device**
- **Inductive line fixation with no possible twist of the ICC**
- **Acoustic release (only for acoustic positionning)**
- **Buoyancy**
- **Electronic Container**
- **Additional mass (7 kg, up to 24)**
- **Insulating pads (galvanic corrosion)**
- **Tensionning system for the Dynema**
- **Deadweight (steel)**
- **Recoverable part (titanium)**
- **Oscillating arm support**
- **Release system (same as the acoustic release)**
- **For connector support (TBD)**

**WIA :** 597 kg 1245 kg  
**WIW :** 256 kg 818 kg  
**additional weight max nb :** 24

**Dimensions :** 2,26 (L) x 1,44 (l) x 1,39 (H) m
The mechanical frame design (2) : summary

REMINDER (1/2)

Design

- Design of the structure (oct / dec 2018)
- Two CAD models (in air / in water) for the Centre of gravity calculations
- Calculation of the behavior of the structure: in air, during the deployment and recovery phases, on the sea bed

Philippe LAGIER — october 15, 2018
The global IU tests

- The IU will undergo functional tests in air and in water once fully integrated. In this test, the CB is replaced by a PC.

The main functionalities will be tested:
- Communication test with all instruments and interfaces
- Settings tests of all instruments and interfaces
- Acquisition scenarii and data measurement transfer

- The IU will undergo functional tests with CB in air and in water (tbd)