AQUA-METRE R300-NG/R3000-NG USBL sensor

USER MANUAL

AQUA-METRE R3000-NG Base Unit

SUMMARY

<u>**Document history**</u>

Document number	Modifications and comments
0124-801-001 **0124-801-002**	Initial issue Minor corrections

1 AQUA-METRE R300-NG/R3000-NG overview

1.1 AQUA-METRE R300-NG/R3000-NG, a USBL sensor

The AQUA-METRE R300-NG/R3000-NG is a local underwater positioning system based on an acoustical interferometric scheme (mainly known as Ultra Short Base Line or USBL). It is particularly well suited to accurate local 3D locating within the range of up to 250 metres (>800 feet) from the reference point (the Base). The system may be ROV operated and managed from the surface using acoustical networking features. The AQUA-METRE R300-NG is dedicated to shallow water operation down to 300 metres like dam survey for instance, the AQUA-METRE R3000-NG has been designed for deep offshore applications like spool & jumper metrologies. The two systems are compatible as far as electrical and mechanical interface are concerned. The R3000-NG mainly differs in housing material made of aluminium instead of polymer. They also share the same set of commands (monitor commands and acoustic commands) Both may be operated using the AQUA-CAD software that allows real time interface to BricsCad range of CAD tools.

The simplest AQUA-METRE system configuration able to measure 3D coordinates underwater is made of at least two main components:

-The measurement **Base,** which constitutes the local reference Cartesian coordinate system {0,0,0}),
-At least one **Pointer** which replies to Base interrogations,
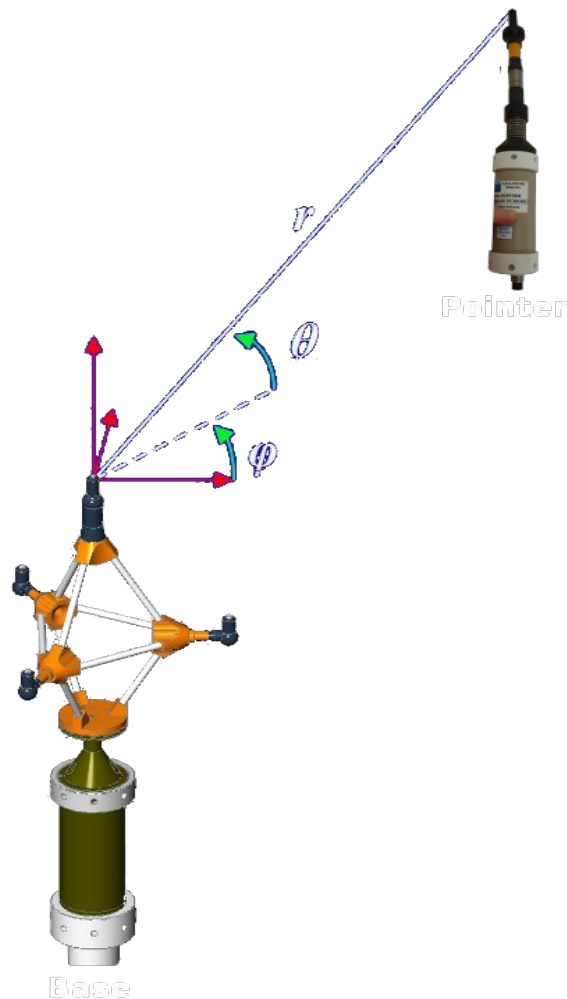
Basic system function: measurement of the Pointer's 3D location from reference Base unit

The type of Pointer differs between the R300-NG and R3000-NG systems, the MiniPointer is dedicated to shallow water operation and is easy to integrate on small ROV (survey class), the R3000-NG Pointer is bigger and dedicated to work class ROV.

The different unit types are:

R3000-NG Base Unit (with metrology interface)

R3000-NG Pointer Unit

R300-NG Base Unit

MiniPointer R300-NG Unit

1.2 AQUA-METRE R300-NG/R3000-NG system configurations

An AQUA-METRE R300-NG/R3000-NG configuration always includes one unit that acts as the Communication Master (CM) and is connected to the serial link up to the surface. The other units are addressed using acoustic network.

A typical ROV operated configuration could be as follow:
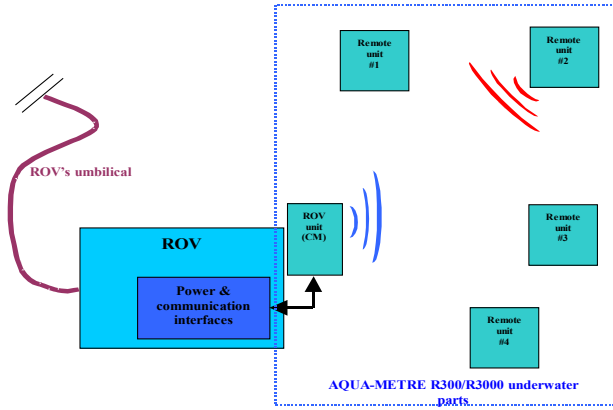
AQUA-METRE R300-NG/R3000-NG ROV operated configuration (CM through ROV umbilical)

All unit may be powered externally (electrical interface) or use their internal battery capacity. They all include a dual axis inclinometer and compass. Each Base can locate every Pointer or another Base (a Base can act as a Pointer then be located by another Base unit). It is then possible to manage the system from the surface and get measurement (3D location, inclination, heading, temperature…) of every underwater unit using a simple communication terminal. The list of commands, called Monitor Commands, are listed and described in following chapters. However, PLSM offers the AQUA-CAD software that allows system management through a friendly Graphical User Interface (GUI) and real-time interface to popular CAD software in order to get the best environment for metrology class survey. AQUA-CAD software is described in a separate document.
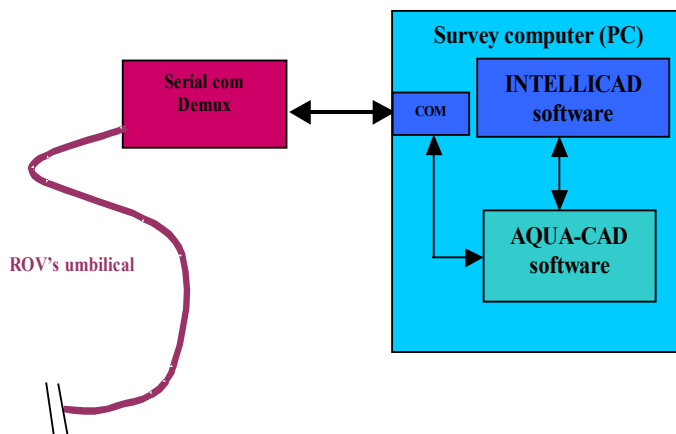
Surface system synoptic using AQUA-CAD software

1.3 The optional RTKDuo georeferencing kit

Available since 2015, the new RTKDuo kit associated with the AQUA-METRE R300-NG USBL offers a very accurate, light and hassle-free way to provide georeferenced underwater positioning. This is a powerfull option when surveyors need to measure directly geographic coordinates of underwater location (ROV, construction frame like gravel leveling system, underwater crane, …).

The typical configuration when using the system for nearshore survey (dam survey for instance) appears below :
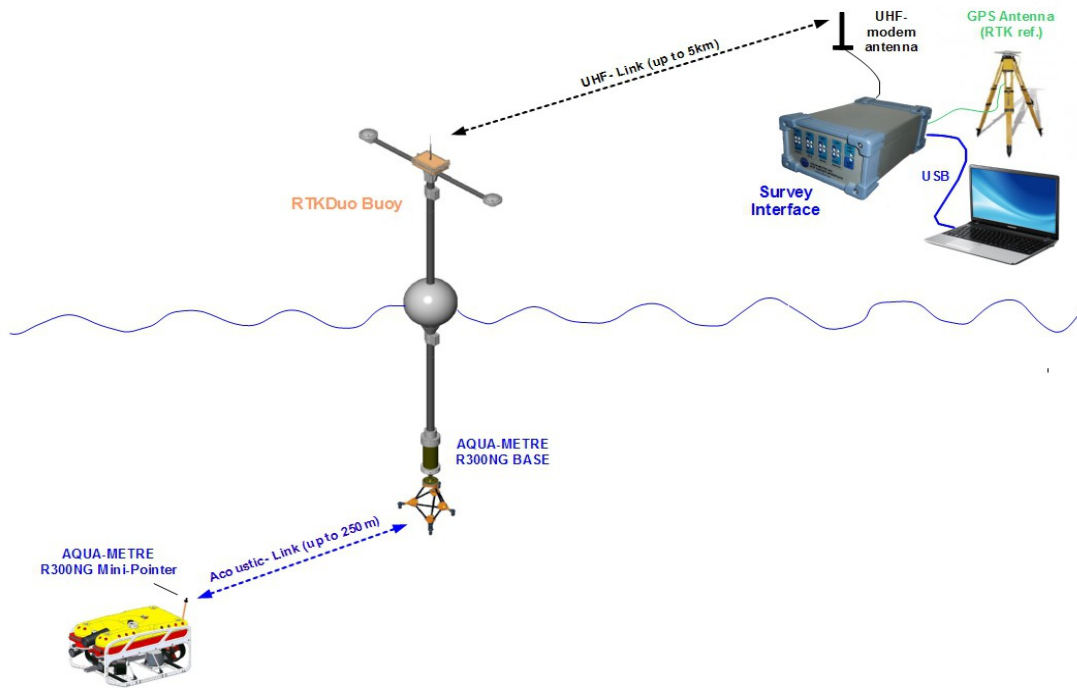
RTKDuo Buoy in typical nearshore survey configuration

The RTKDuo kit includes:

- the RTKDuo instrumented buoy (dual antenna GNSS receiver, MRU, processing unit,...),

- the Survey Interface attached to the survey PC through a USB cable,

The AQUA-METRE R300-NG Base unit is attached upside-down at the bottom of the buoy. The Survey Interface is connected to the PC and communicate with the buoy and Base unit through a radio-modem link (licence free radio), it includes a GNSS receiver dedicated to the reference RTK station.Basically, the system delivers geographic position of the MiniPointer(s) on the ROV. This system option is fully managed using AQUA-CAD software.

Note: the RTKDuo system is described in a separate document.

2 AQUA-METRE R300/R3000-NG technical characteristics

2.1 Geometry associated with measurement

The system measures the 3D coordinates of Pointer hydrophone in a local Cartesian coordinate system. This local Cartesian coordinate system being associated with the interferometric frame. The two angles are measured using a 3D interferometric scheme and distance is measured using transit time assuming a measured celerity (celerity is measured by each Base on demand and can also be set by user to a specific value).
A biaxial inclinometer measures unit inclination up to +/-20° with an accuracy better than 0.1°.
The origin of the local coordinate system of a specific Base is the top hydrophone.

The picture on the right shows the coordinate system associated with the interferometric frame:

A point **M** is given by:

-the distance **r** from the origin,

-the azimuth angle **φ** in the horizontal plane,

-the elevation angle **θ** from vertical.

(spherical coordinate system)

A locking pin allows rotation indexation when the frame is screwed on the Base housing.

This pin indexation is associated with the X axis (positive direction) and is also aligned with the bottom mechanical interface (see chapter describing Base and Pointer mechanical housing).
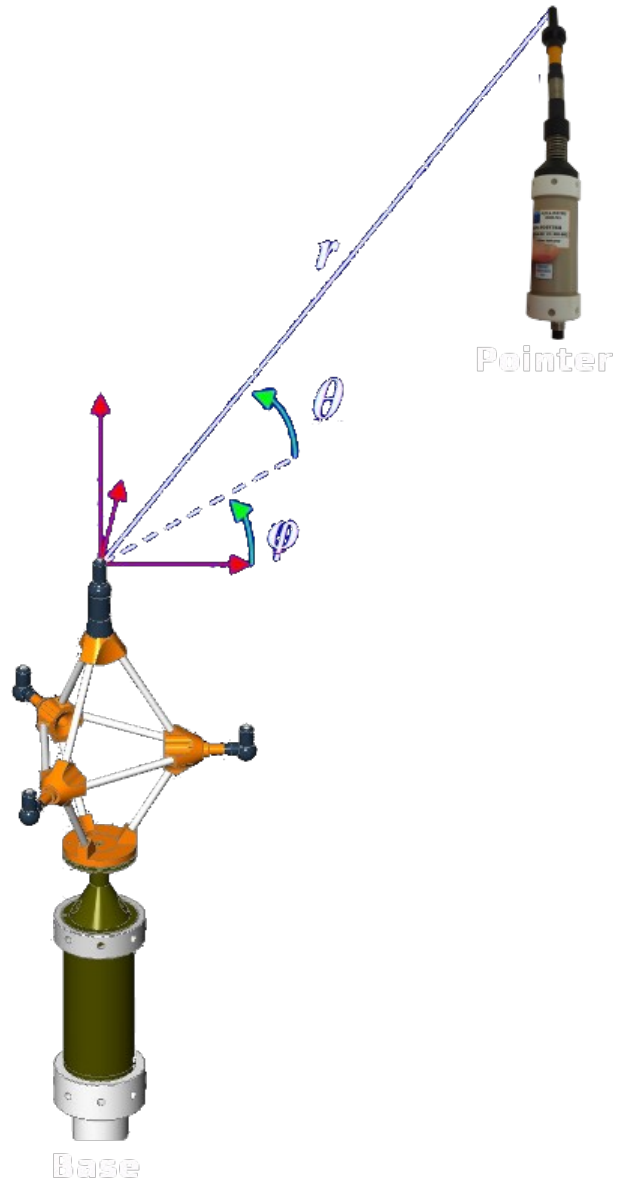
Warning:

The precise geometry of the interferometric frame guarantees the accuracy of the system. It is very important to prevent frame from being hurt. Any deformation of the frame may definitely affect the accuracy by introducing bias error.

2.2 System constrains and limitations

2.2.1 Minimum depth

The system required at least 5 meters depth to operate; in this case, the interferometric frame must be set up at mid depth (i.e. 2.5 meters).

If operated in no more than 5 meters deep, the accuracy may be affected by severe multipath environment when distance from Base to Pointer exceeds 30 meters. To operate well up to 150 meters, the system requires at least 20 meters deep.

When measuring coordinates near seafloor, make sure that the Pointer is operated with a minimum vertical offset of 1 meter.
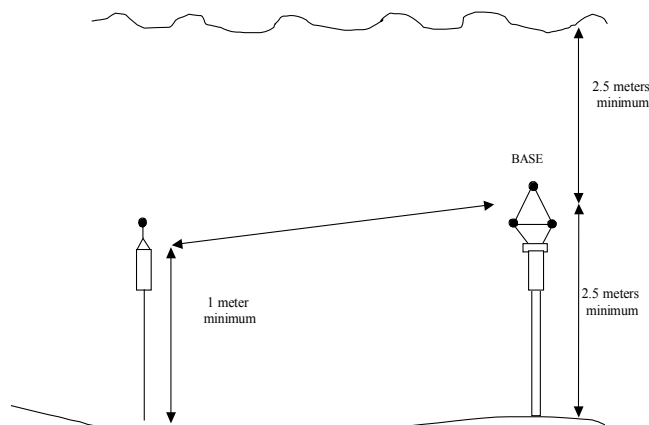
2.2.2 Maximum depth

The R300 maximum operating depth is 300 metres.

The R3000 maximum operating depth is 3000 metres (maximum hydrostatic pressure 350 bars).

2.2.3 Acoustic path

To operate, the AQUA-METRE R300/R3000 requires a direct acoustic path between the Base and the Pointer (this is an advantage compared to long baselines system which requires several free paths). A mask may affect the accuracy and/or stability of the measures, or may simply vanish the acoustic wave.

The following rule of thumb must be followed: keep at least one meter and a half clear from the direct virtual line between the Base and the Pointer as described below:
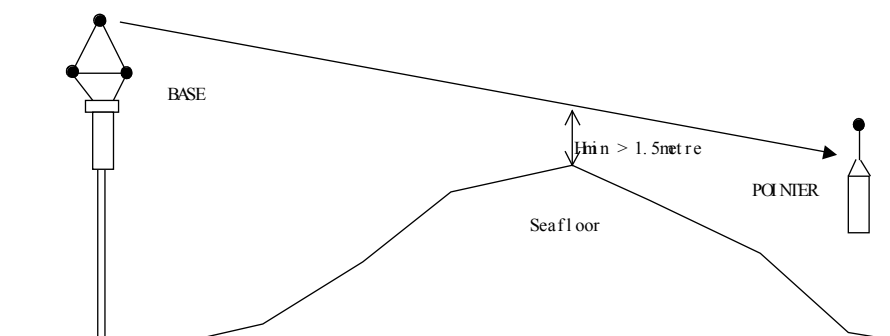
Base to Pointer acoustic path requirement

This value of the clearance is obviously Base to Pointer distance dependent.

The choice of the Base location is a critical step of the system set up.

2.2.4 Operational area

Warning: the interferometric frame does not allow proper measurement in the blind area described below:
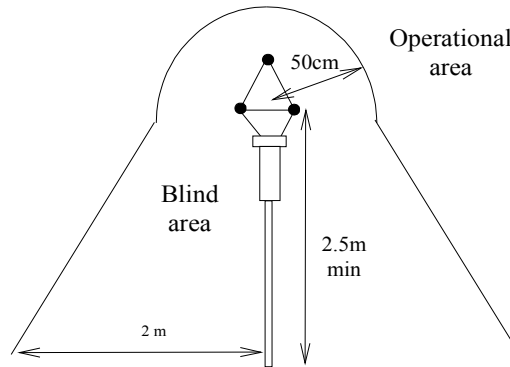
Description of the operational and blind area

The measurements taken in this area may be affected by inaccuracy.

The maximum recommended distance from the Base is 150 meters (300 metres area diameter) even if the system may still operate up to 200/250 meters in case of good acoustic propagation conditions. When using the system, make sure that the acoustic path conditions described before are met.

2.2.5 Base stability and tilt

If the measurement have to be gravity referenced (meaning that local Z axis is vertical), the initial Base tilt setting must be lower than 30° from vertical in order to allow accurate compensation by internal inclinometer.

The dynamic oscillation of the Base must be limited to +/-2 cm (peak to peak) and the maximum frequency of oscillation limited to 1 Hertz.

If it is not expected to reference the measurement to gravity and then work in pure relative mode, then there is no Base position constraint. But Base stability will directly affect the final accuracy and must be compensated.

Note: when using the Base unit with the RTKDuo georeferencing system, all movements are compensated by the internal MRU of the RTKDuo sensor.

3 AQUA-METRE R300/R3000-NG Base description

3.1 Base mechanical description

The Base is made of two main components: the electronic housing with the masthead and the interferometric frame. These two components have to be assembled before operation, the interferometric frame being simply screwed on the top of the masthead
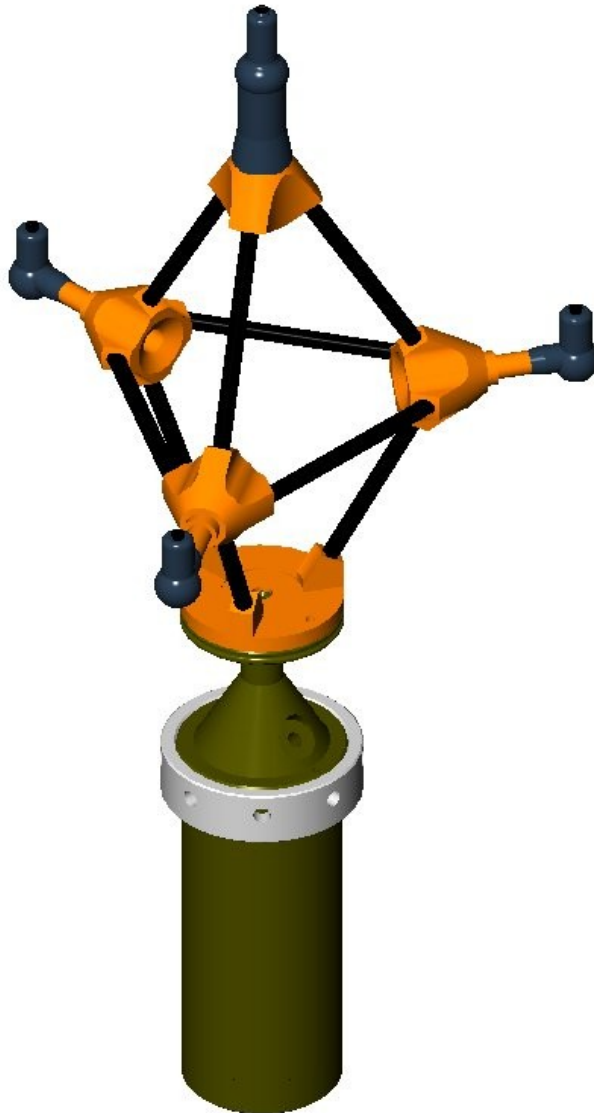
Base configuration: interferometric frame and electronic housing

This configuration is compact, giving a good acoustical environment (less affected by mechanical housing reflections).

3.1.1 Interferometric frame description
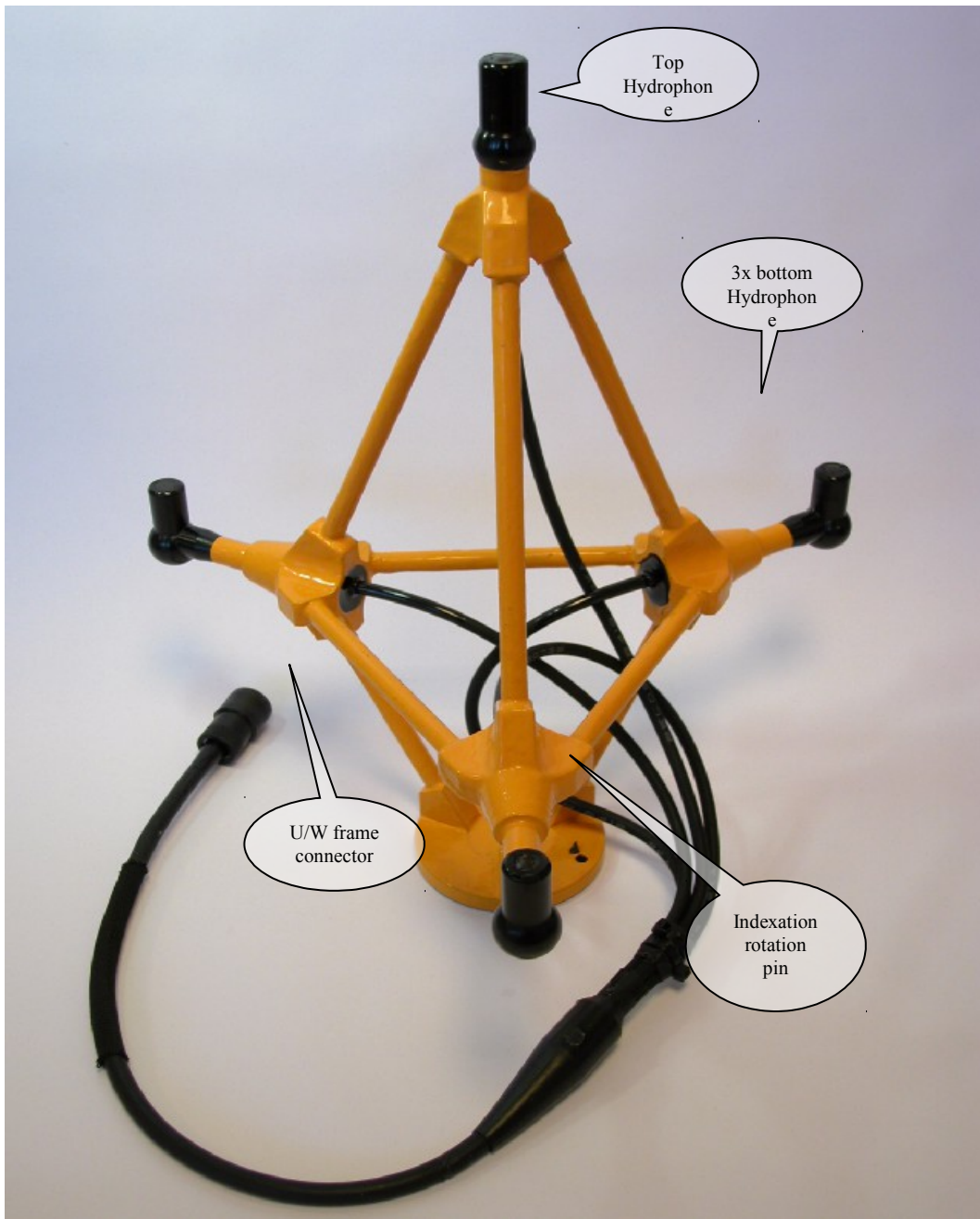
Interferometric frame, 3D CAD view (cable and connector not drawn)

This is a tetrahedral structure made of glass-epoxy junction parts and carbon-epoxy rods. These rods are cemented using epoxy resin. The four hydrophones are over moulded with polyurethane resin. The mould shape has been studied to prevent direct hurt to piezo-ceramic tube faces. The hydrophones are filled with a special liquid with special acoustic properties in order to cope with static pressure up to 350 bars (Interferometric frame for R3000 and R300 systems are identical even if R300 mechanical housings only withstand 30 bars).

Overall dimensions:
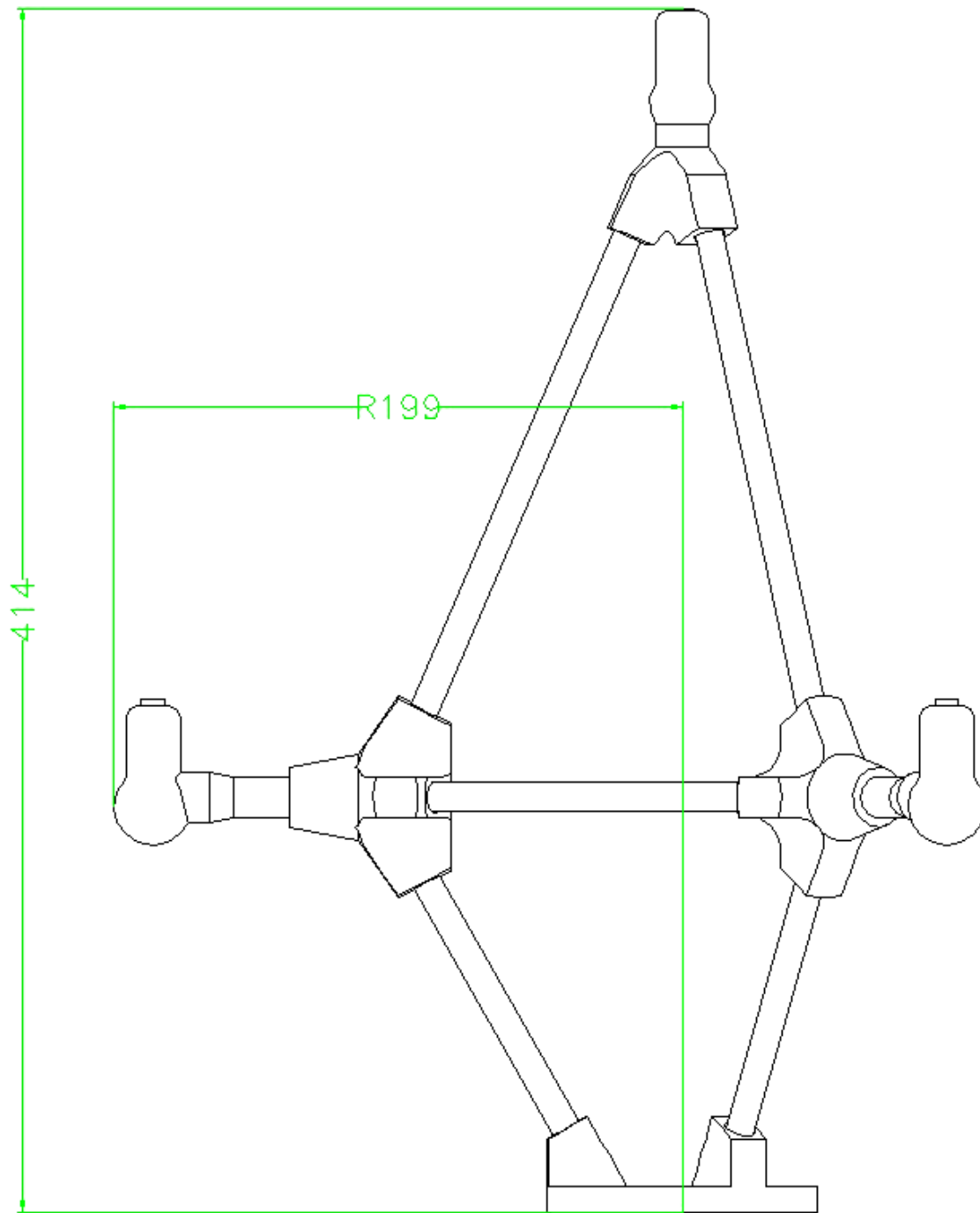
Interferometric Frame drawing

The maximum height is 414 mm and radius 199 mm.

3.1.2   AQUA-METRE R300/R3000-NG Base electronic housing description

Base R3000-NG (left) and R300-NG (right) electronic housing

The electronic housing of R300-NG and R3000-NG Base unit are very similar but made of different material to withstand different maximum operating depth (300m and 3000m respectively). They are fully mechanically and electrically compatible.

The electronic housing parts are made of polymer (R300-NG) or hard anodised 7075 T6 aluminium (R3000-NG). The top cap supports the two connectors (description hereafter), one being connected to the interferometric frame, the other to the interface, to the charger or to a dummy plug (on/off plug) in case of an acoustic remote unit.

Mechanical interface:

The bottom housing also acts as the mechanical interface for field installation. This interface is centered and an indexing hole lock the rotation allowing a perfect known offset from the interferometric frame then the local Cartesian coordinate system associated with the measurements.

727 mm

The origin of local coordinate system associated with the Base and Interferometric frame is located **727 mm** above the reference surface. In other word, the reference surface is located at z= -0.727 m according to origin of local coordinate system associated with acoustic measurements.

> 727 mm from reference surface of mechanical interface to the centre of the top hydrophone (origin of measurements)
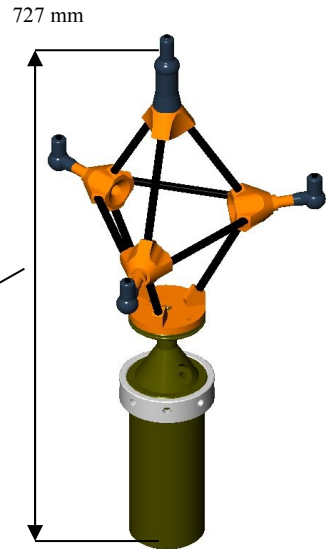
A specific sleeve is provided by PLSM to attach rapidly the Base unit to a customer mechanical interface (like the RTKDuo buoy mast, see picture).
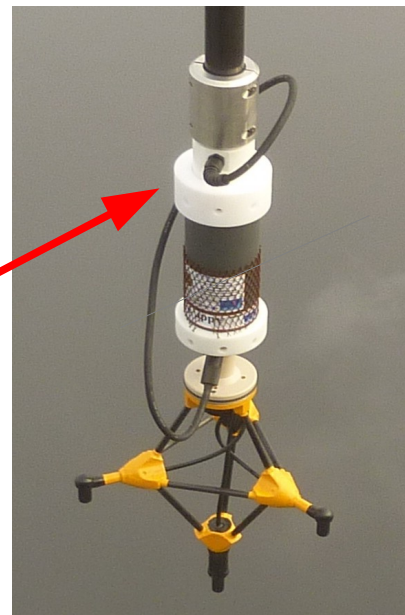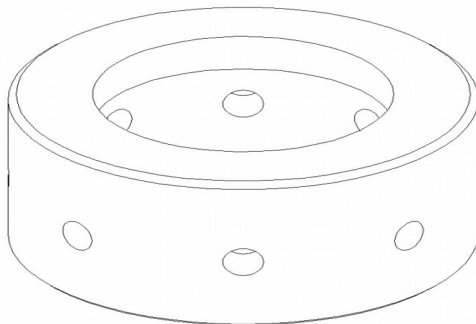
3.1.3 Interferometric frame and Base assembly (R300/R3000-NG)

Place the frame base plate over the frame rest and turn it until the locating pin is aligned with its locating hole, then lock with the main screw. Check that the frame is properly installed by looking for clearance. Any clearance in this area may be detrimental for the measurement accuracy. Then plug the electrical male connector on the female socket located on the base housing (socket with the frame pictogram).

3.2 Base electrical interfaces description (R300/R3000-NG)

The Base is equipped with two underwater connectors (IMPULSE MCBH-8 bulkhead), both located on the top cap. One is dedicated to interferometric frame interface. The other connector being used for external power/comm interface, charger and ON/OFF functions.

Interferometric frame connector (JP1) description:

Type: MCBH-8-FS type bulkhead from Impulse
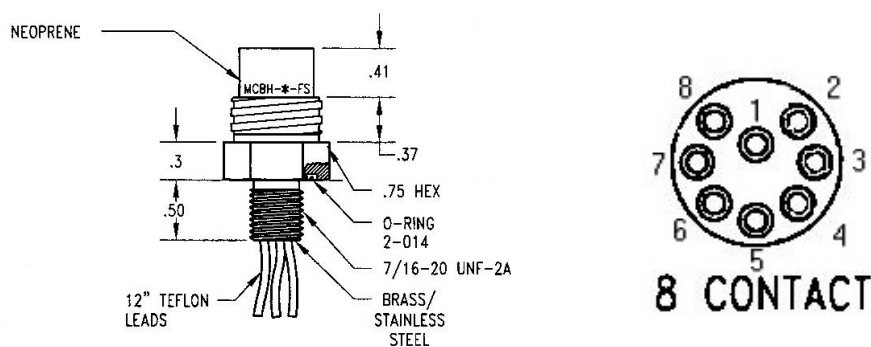
Female bulkhead

Pinout:

Pin number	Signal function	Pin number	Signal function
1	GND1	5	GND2
2	HYD1	6	HYD2
3	GND4	7	GND3
4	HYD4	8	HYD3

HYD1…4 : connection to hydrophone #1 to 4

GND1…4: return ground path for hydrophone #1 to 4

(There are separated ground path for each hydrophone in order to allow high cross channel isolation)

Use MCIL-8-MP connector from Impulse for interface cable.

Interface connector (JP2) description:

Type: MCBH-8-FS type bulkhead (see description and comment above)

Pinout:

Pin number	Signal function	Pin number	Signal function
1	GND_RS	5	GND
2	RX_RS0	6	ON/OFF
3	TX_RS0	7	TX_RS1
4	EXT_SUPPLY	8	RX_RS1

RX_RS0, TX_RS0 : RX/TX signals of main serial port (port 0), RS232 electrical level (MAX232 interface), this serial port is internally opto-coupled to ensure proper isolation,

RX_RS1, TX_RS1 : RX/TX signals of ancillary serial port (port 1), RS232 electrical level (MAX232 interface), this serial port is internally opto-coupled to ensure proper isolation,

NOTE: RX_RS0 or RX_RS1 are downlink and must be connected to TX line of the PC, and TX_RS0 or TX_RS1 as uplink to the RX line of the PC (cross Rxi/Txi between two equipment).

GND_RS: signal return path for both serial ports,

EXT_SUPPLY: external supply used to powered the Base with following characteristics:

- Voltage level between 12 and 34 Volts (24 Volts recommended),

- Maximum current: 200mA (12V input),

When external power is applied, it automatically switches the Base on.

ON/OFF: input signal used to switch the Base on or off, when floating Base is switched off, must be grounded to switch the Base on (driven by open drain, open collector or switch for instance).

I**mportant:** when external power and ON/OFF signal are active simultaneously, then the Base enters charge mode, this is done automatically using the R300/3000-NG charger interface.

Use MCIL-8-MP connector from Impulse for interface cable.

Important feature : since the connector are not mechanically differentiated, pinout of respective bulkhead have been chosen in order to avoid any damage in case of connector crossing.

Acoustic remote mode: if the unit is not connected to the ROV interface, a dummy plug will be used to switch it on before the dive (this plug simply grounds ON/OFF pin and protects all the pins from sea water). When switched on, the unit performs self-tests and emits an audible tone using the top hydrophone and enter a sleeping mode waiting for incoming acoustic "PING" wake-up message. Power consumption in sleeping mode is lowered allowing several days of autonomy.

If the Base is expected to work in acoustic remote mode:

- make sure it is well charged,

- just before survey, plug the dummy on/off connector in the interface bulkhead,

- wait until unit beeps: two short beeps means initialisation is successful and unit is then in sleeping mode, one medium (about 1 second) beep means warning encountered and a long beep means error(s) occurs.

Check the unit if warning or error occurs.

Plugging On/Off dummy plug (for remote acoustic mode)

4 AQUA-METRE R3000-NG, Pointer description

The AQUA-METRE R3000-NG Pointer is dedicated to deep offshore applications (like offshore metrologies), for shallower applications, please consider the MiniPointer AQUA-METRE R300-NG (described in the next chapter).

4.1 AQUA-METRE R3000-NG Pointer mechanical description

The AQUA-METRE R3000-NG Pointer mechanical housing is very similar to the Base. The single hydrophone just replaces the small Frame mast. A specific hydrophone mast including a spring prevents the hydrophone from being hurt. There is also a polyurethane over-molded protection to protect it.

The AQUA-METRE R3000-NG Pointer appears below:

AQUA-METRE R3000-NG Pointer

The actual point of measurement associated with the

 AQUA-METRE R3000-NG Pointer

 is located 430mm above the reference surface.

430 mm from reference surface of mechanical interface to the centre of the Pointer hydrophone (actual point of measurements)

4.2 R3000-NG Pointer electrical interface description

The Pointer is equipped with only one underwater connectors (IMPULSE MCBH-8 bulkhead), located on the top cap. This connector (8 pins connector) being used for external power/comm interface, charger or ON/OFF functions.

Interface connector description:

Identical to Base interface connector, please refer to chapter describing Base connector.

Acoustic remote mode: if the unit is not connected to the external interface, a dummy plug will be used to switch it on before the dive (this plug simply grounds ON/OFF pin and protects all the pins from sea water). When switched on, the unit performs self-tests and emit an audible tone using the top hydrophone and enter a sleeping mode waiting for incoming acoustic "PING" wake up message. Power consumption in sleeping mode is lowered allowing several weeks of autonomy.

5 MiniPointer for AQUA-METRE R300-NG

This Pointer has been designed to address a large range of shallow water applications like dam survey. Moreover, the MiniPointer includes an accurate pressure gauge that is used to counter thermocline effects on vertical coordinate when using the AQUA-METRE in fresh water (lake, river,…).

The MiniPointer, like other AQUA-METRE units, may be powered externally or using the internal batteries. An RS232 serial link is also implemented, this link is optional during work but may be useful to monitor the Pointer status and to securely report navigation message of the ROV including local static pressure and ROV heading (using the internal electronic compass included in the MiniPointer). This navigation message is send through the serial link each time the MiniPointer is interrogated by a Base and the AQUA-CAD software process it in order to compensate ROV mounting offsets and display ROV oriented in CAD software.

MiniPointer installed on a light survey class ROV

5.1   MiniPointer R300-NG electrical interfaces

The MiniPointer has two electrical bulkhead connector, one located on the top is the hydrophone(s) connector, the other, located on the bottom of the unit, is the Interface & Power Supply connector:

Mini-Pointeur R300 (hydrophone not plugged)

Do never lubricate the connector with silicon or over type of grease, always use a silicon oil instead

5.1.1   Hydrophone(s) Connector

Type: MCBH6-FS bulkhead from IMPULSE

Top Hydrophone(s) Connector:
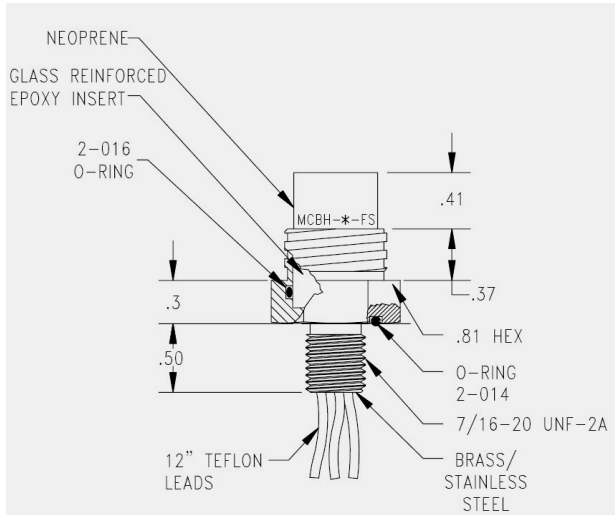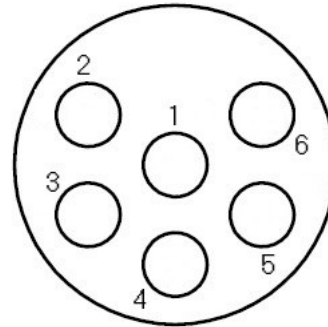
Hydrophone(s) Connector Pinout:

Pin n°	Function	Pin n°	Function
1	**HYD1-**	**5**	**HYD2-**
2	**HYD1+**	**6**	**HYD2+**
3	**Screen**	**7**	**Screen**

Hydrophone installation:

To install the top hydrophone:
- plug the hydrophone connector and gently screw the locking sleeve,
- then screw the mini-mast on the top of the MiniPointer,

Hydrophone and Mini-mast installation

5.1.2 Interface & Power Connector (compatible with other AQUA-METRE units)

Type: MCBH8-FS bulkhead from IMPULSE

Bottom Interface & Power Supply Connector
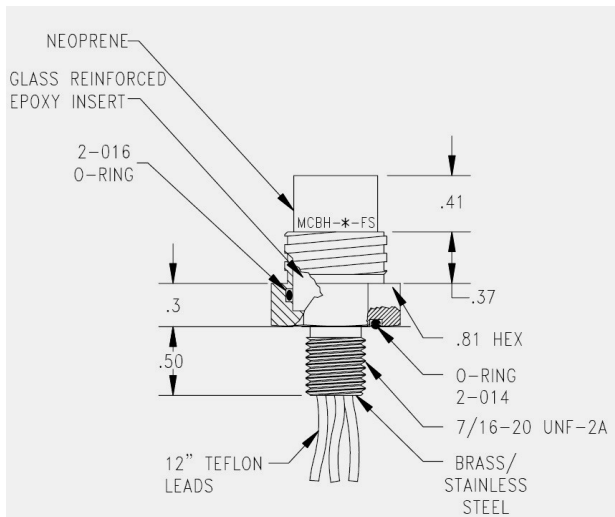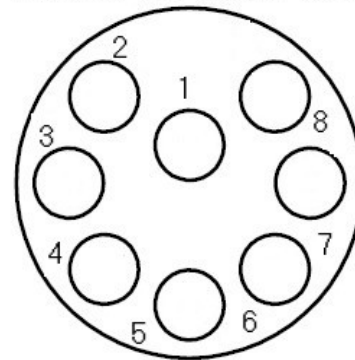
Interface & Power Connector Pinout:

Pin n°	Function	Pin n°	Function
1	GND_RS	5	GND
2	RX_RS	6	ON/OFF
3	TX_RS	7	GPI
4	EXT_SUPPLY	8	GPO

RX_RS, TX_RS : RS232 RX/TX signals (opto-isolated internally).

Nota : RX_RS is the Pointer input (downlink), TX_RS is the Pointer output (uplink).

GND_RS: return path for RX_RS and TX_RS signals,

EXT_SUPPLY, GND: external power supply input:

- voltage must be between 12 and 34 Volts (24 Volts nominal),

- Curent maximum: 300mA @ 12V (typically : 100mA @ 24V)

When the external power supply is applied, it switches the MiniPointer on (no need to use ON/OFF pin in this case).

ON/OFF: a short circuit between ON/OFF and GND pins switches the MiniPointer on using internal batteries (PLSM offers ON/OFF plug for the MiniPointer),

DO NOT short ON/OFF and GND when you want to supply the MiniPointer using an external power supply (it will put it in charge mode!**)**

GPI: opto-isolated general purpose digital input (0-5V maxi), the state of this input may be read and transmitted by acoustic. Return path is the GND_RS pin.

GPO: sortie numérique 0-5V opto-couplées (l'état de cette sortie 0 ou 1 peut être lue et/ou modifiée par commande acoustique). Le signal de retour est GND_RS (broche 1).

Recommended Connector for the Interface & Power :

Type: MCIL8-MP from IMPULSE
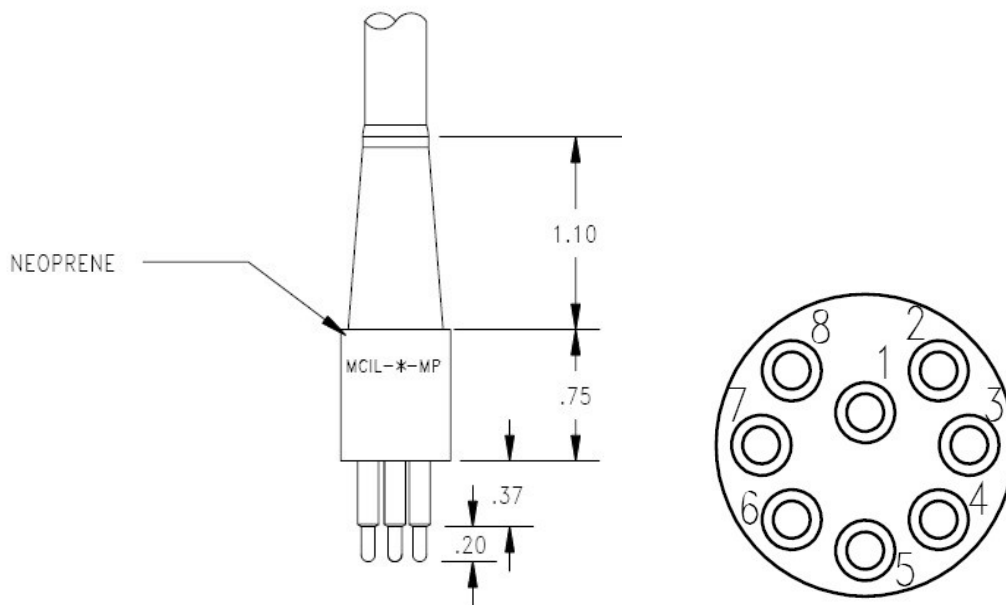
MCIL8-MP Connector (locking sleeve not shown)

5.2 MiniPointer R300-NG installation on ROV

When installed on a ROV, two main constraints must be kept in mind:

- make sure the MiniPointer hydrophone will always be in line of sight from the Base. If masked by the ROV flotation, the MiniPointer will not operate or may lead to erroneous measurements.

- in order to use the internal compass, the MiniPointer must be installed vertically (MiniPointer Z axis being vertical) with the MiniPointer X axis oriented to the forward ROV direction (see Chapter 7.2 for an explanation of Z and X MiniPointer axis).

5.3 MiniPointer R300-NG mechanical characteristics
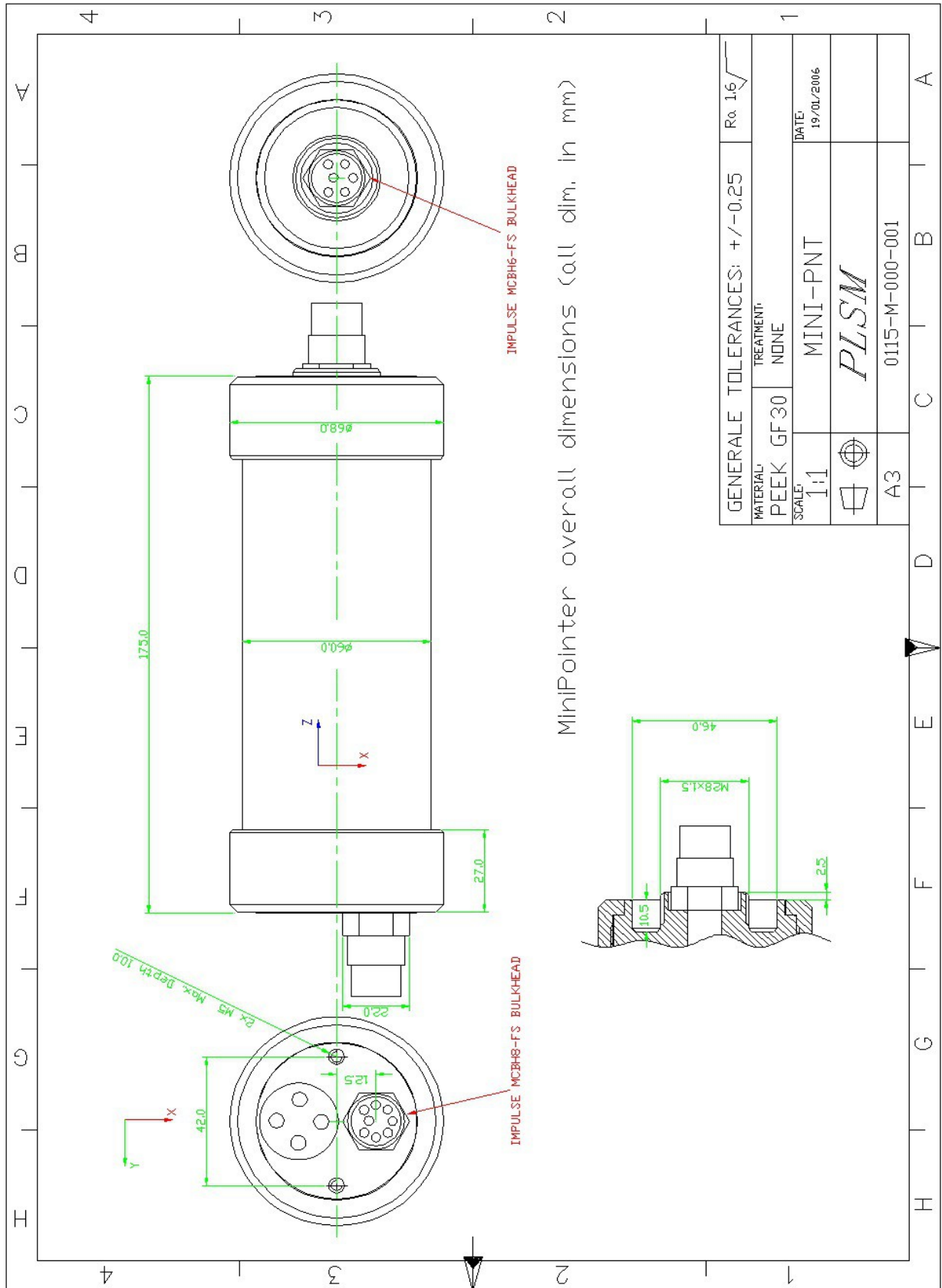
6 Specifications

Weight:
      Base R300-NG: 2.4 kg (electronic housing)
      MiniPointer R300-NG: 1.2kg
      Base R3000-NG: 3.6 kg (electronic housing)
      Pointer R3000-NG: 3.4 kg
      Interferometric frame: 1.2 kg

Dimensions:
      Base R300/R3000-NG: H 33cm x Diam 11cm
      Pointer R3000-NG: H 47cm x Diam 11cm (including hydrophone)
      MiniPointer R300-NG: H 46cm x Diam 7cm (including hydrophone)

Distance Range:
      radius up to 200m (up to 250m in good acoustical propagation conditions)

Resolution:
      radial distance: 2mm
      angle: 0.01° (both azimuth and elevation angles)
      inclination: 0.01°
      Heading: 0.1°

Accuracy (does not include celerity measurement error), rms:
      radial distance : +/- 2cm if distance<50m, +/-4cm if <100m
      Angular accuracy: +/-0.1° (both azimuth and elevation angles)
      Inclination accuracy: +/-0.1°
      Heading accuracy: +/- 1.5° (if not closed to iron structure)

Sound celerity measurement accuracy:
      error max +/- 3 m/s, (+/-1.5 m/s typical)

Standard deviation:
      radial distance <10mm if distance<50m, +/-25mm if <100m
      angle: <0,05°
      inclination: <0.05°
      Heading: <1.0°

Acoustic Bandwith:
      65 to 75 kHz (full bandwidth used by signals)

Measurement rate:
      Up to 40 points per minute

Autonomy:
      Base: min 24 hours in full active mode (one interrogation every 2 seconds),
          or at least 2 months in sleeping mode + 6 hours in full active mode
      Pointer: at least 20% higher compared to Base autonomy
      MiniPointer: min 30h in active mode

Charge adaptater:
      input 100 to 250 VAC/ 50 to 63 Hz
      charge duration: <=12 hours (managed by software)

Serial Data link:
      RS232 compliant (ESD protected)

Environment:
      Depth: down to 300 meters (salt or fresh water) for R300 version, 3000 meters for
      R3000 version
      Operating/charge temperature: 0°C to 40°C
      Storage temperature: -30°C to +70°C

7 System Maintenance

7.1 Fresh water rinsing

After use in salted or polluted water, a complete rinsing must be achieved before drying. Drying without prior rinsing would lead to salt deposit. Should it happen, dive the system in fresh water for at least one hour. Flush the water and repeat until all salt traces are dissolved (when doing so, make sure that open bulkhead connector are protected).

7.2 Batteries charge (any unit)

Plug the charger on the unit interface/charge connector, then plug the charger into the wall main AC supply (90 to 265VAC). When powered, the "ON" green led on the charger will light. After about 30 seconds of charge initialisation, the "Status" orange led will blink to confirm that the battery charge started.

Warning: The charge is automatic, provided that the battery charger is actually plugged, and the required voltage is present.

Note: The battery charger may be fitted with different plug adaptors to be used in several countries. Europe, US, UK, Australia,... Please contact PLSM (support@plsm.eu) if you don't have the right plug.

During the battery charge, the charger "Status" orange led blink every 30 seconds indicating the charge status:

1x blinking:	Charge up to 15%
2x blinking:	Charge up to 30%
3x blinking:	Charge up to 50%
4x blinking:	Charge up to 65%

5x blinking:	Charge up to 80%
6x blinking:	Charge completed

When the charge is completed, the system automatically reduce the current to a steady charge, it is recommended to unplug the battery charger.

The battery charge will not start if battery temperature is lower than 5°C or greater than 40°C.

The battery charge will stop if voltage exceed a certain limit (1.55V per cell) or last too long (maximum 12h).

7.3 Lubrication of connector and bulkhead

Before plugging any connector, make sure that no dust nor any solid particles can be entrapped inside the bulkhead or between pins. The use of lubricant is recommended for the proper contact and to ease connector insertion, PLSM recommend the following silicon oil:

Manufacturer : ELECTROLUBE, **reference** : OSL (spray),

(available at Farnell or RS Components)

other reference references from 3M may be suitable.

But silicon grease is not recommended!

(because it will accumulate in female bulkhead pin and hold dust,

it may be used however as a "better than nothing" temporary solution)

Dust protection caps are provided with the connectors, always plug them when the system is rinsed and dry.

7.4 Embedded firmware upgrade (any unit)

The firmware embedded in the Base, Pointer, or MiniPointer units can be upgraded through AQUA-CAD. The unit must be first connected to AQUA-CAD as the Communication Master unit (CM unit), the way to operate is explained here-below.

7.4.1 Connection to the unit

Connection to the unit:

PLSM provide a specific tool in order to allow connection to a Base, Pointer or MiniPointer R300-NG unit: the basic interface. This tool includes: an IMPULSE MCIL-8MP male wet pluggable connector, a small aluminium case with green led indicator, DC input, simple ON/OFF switch and RS232 DB9 female connector.
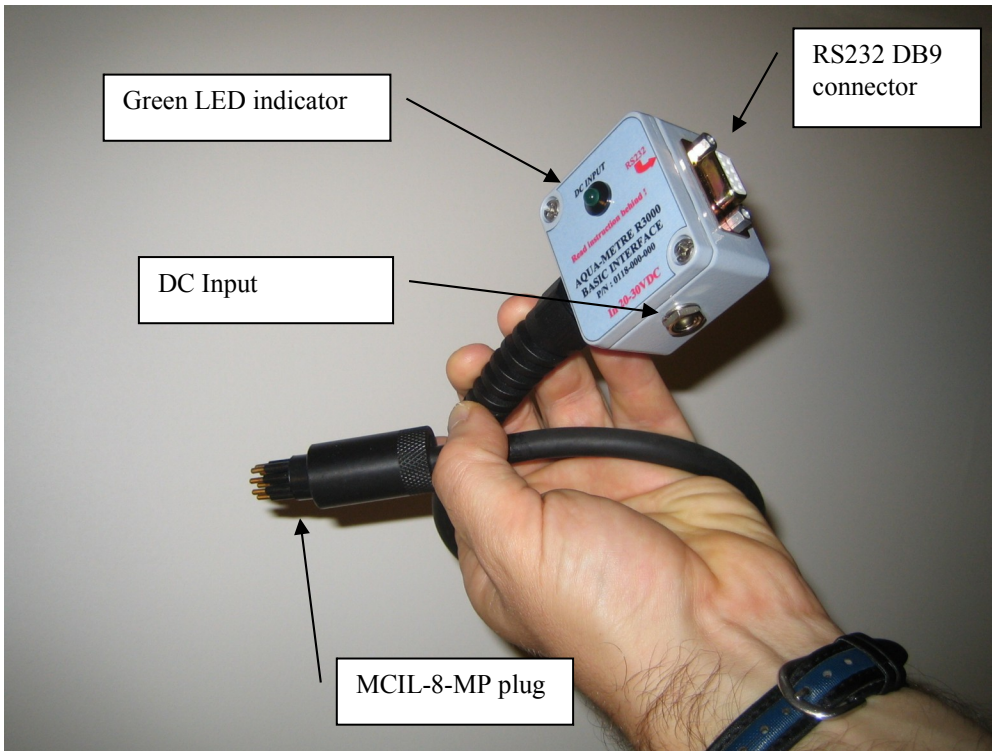
Basic Interface for R300-NG unit

To set up a connection, follow the steps:

- connect the RS232 port to a COM port available on your PC,

- plug the MCIL 8 male connector into the interface bulkhead of the unit (Base or MiniPointer),

then

- plug the AC-DC converter to the main wall supply to power and switch the unit on,

or

- use the ON/OFF switch to turn the unit on using its internal battery,

Launch AQUA-CAD and connect the CM unit using the COM port number used to connect the unit. If the unit has entered the sleeping mode, it may last up to a minute to wake up. No need to initialise the unit, the box may stay in yellow colour. User can now proceed to firmware upgrade (next chapter).

7.4.2   *Firmware upgrade*

When the unit is connected as the CM unit, just open the "CM Tools" window:
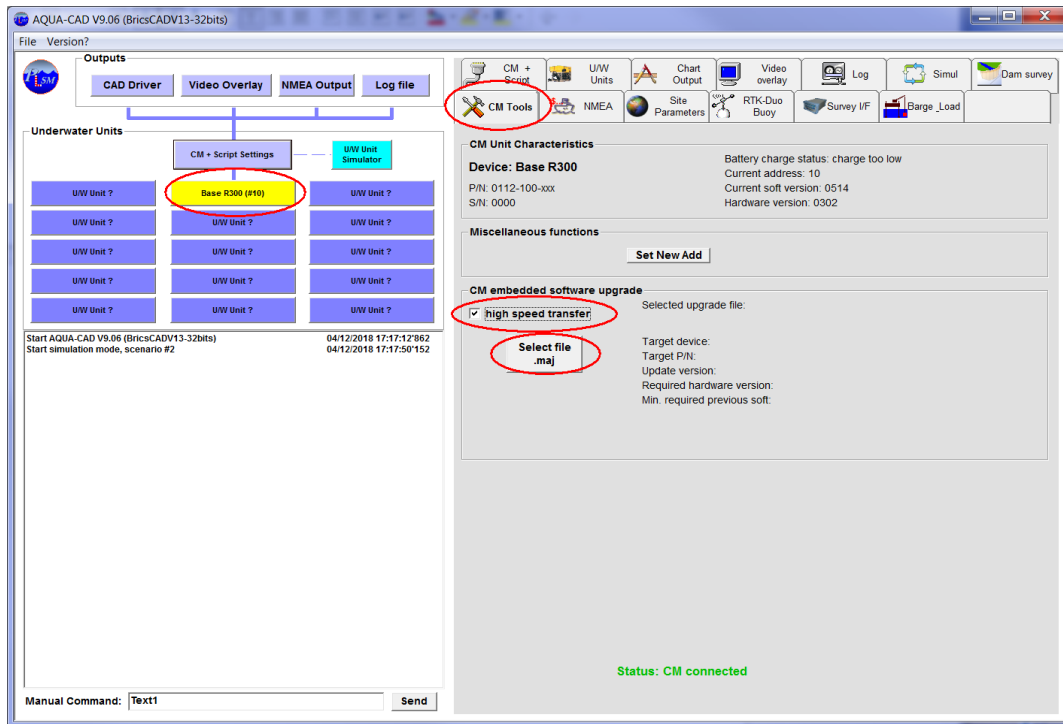
CM Tools Window for firmware upgrade

Select the "high speed transfer" option if the RS232 cable is no longer than about 10m. Then click on the "Select File .maj" button, a select folder and file floating window will be displayed. Select the firmware upgrade file transmitted by PLSM (this is a file with the extension .maj) that has been previously copied on the PC HDD. AQUA-CAD will check that the file is suited to the unit connected and prompt the user to proceed or not with the firmware upgrade.

A progress bar will show the status of the upgrade. At the end, a message will confirm or not the upgrade success.

If the upgrade is not successful, power off the unit, then on again and connect it to AQUA-CAD to check the current software version reported. Sometime an unsuccessful upgrade is reported by mistake.

Do not remove the power supply during the firmware upgrade, this may lead to a unit malfunction.

8 Carrying case

A basic system (including one Pointer and one Base) is delivered in a PELICAN 1620 case, a special custom protection foam prevents them from being hurt.

AQUA-METRE R300 in PELICAN 1620 case

This case is fitted with rollers to facilitate system maneuverability.

The overall dimensions are: 65 cm x 45 cm x 35 cm (length x width x height).

Total weight (with the case) is less than 18 kg for the R300-NG version and 20kg for R3000-NG.

9 CM serial interface protocol (R300/R3000-NG)

This chapter describes the protocol associated with Communication Master unit (CM), providing that CM unit is a R300-NG, a R3000-NG Base, R3000-NG Pointer or R300-NG MiniPointer.

This chapter is reserved to expert/developers who need to write their own software to manage an AQUA-METRE system configuration. Most of users will operate the system using AQUA-CAD software provided by PLSM (tool described in another document).

9.1 Interface description (serial port 0)

The interface is a regular RS232 serial communication line with 3 wires (TX, RX and Ground) with the following characteristics:

Baud rate: 9600 Baud

Data length: 8 bits

Parity: none

Start bit: 1 (value 1)

Stop bit: 1 (value 0)

This serial port is internally opto-coupled to ensure proper isolation (ground loop)

Handshaking: every character send to the CM unit will be echoed, no other protocol are expected due to the low average data rate (less than 50 bytes per second, modern PC have large serial COM buffer, typically 1024 bytes, allowing several seconds without missing message).

It is then possible to control every unit (Base or Pointer) using a simple terminal emulator (terminal.exe or hyperterminal.exe of windows package). This feature is especially useful when checking and/or servicing the units. A basic interface tool may be provided by PLSM to allow connection to a surface PC equipped with a serial RS232 COM port, this tool supply the unit with a DC-DC converter plugged to main VAC (100 to 240 VAC/47 to 63 Hz).

9.2 Monitor commands description

9.2.1 Monitor mode

When switched on, a unit (Base or Pointer, not ROV Pointer) enters in sleeping mode (after a self test sequence however). In this mode, the unit wait for external incoming command through acoustic or serial link. To wake up the CM unit, just type "?" (question mark) until sleeping mode exit. This is possible during a time window of about 2 seconds every 30 secondes. Thus me maximum time to unit wake up is 30 secondes.

If user switches the unit with the terminal already connected, it is possible to jump directly to monitor mode without entering sleeping mode. A message is displayed when the unit is switch on and allows user do it for 4 seconds.

Hereafter are described the **Monitor commands** send from surface through serial link. Incoming command from acoustic link are not described here because not directly accessible to user.

The CM unit also reports all incoming acoustic messages on the serial link. All **report messages** are described hereafter.

9.2.2 List of Monitor Commands

The monitor commands list appear in the next table and are detailed along the next chapters.

Command	Description	from. soft version
INIT jj	Initialisation (test and full calibration)of unit #jj	3.0
PING jj	Test the presence and/or wake up of unit #jj	3.0
CAPT jj nn	Capture of Pointer #jj using Base #nn without inclination compensation	3.0
CAPI jj nn	Capture of Pointer #jj using Base #nn with inclination compensation	3.05
INCL jj	Get the inclination angles (X and Y axis angle from horizontal) of unit #jj	3.0
HEAD jj	Heading (magnetic north) measurement of unit #jj	3.0
VBAT jj	Get the batteries voltage of unit #jj	3.0
VEMI jj	Get emitter voltage of unit #jj	3.0
TEMP jj	Get the internal temperature of unit #jj	3.0
REQC0 jj	Get the sound celerity taken into account by unit #jj	3.0
REQRT jj	Get the receiver threshold taken into account by unit #jj	3.0
REQMT jj	Get the noise level of each receiver way of unit #jj	3.0
PARAM jj	Get the parameters Heading and C0 of unit #jj	3.0
SETC0 jj	Force the sound celerity to be taken into account by unit #jj	3.0
SLEEP jj	Force the unit #jj in sleeping mode	3.0
SETRT jj	Force the receiver threshold to be taken into account by unit #jj	3.0
SETVE jj	Force the emitter voltage of unit #jj	3.0
DCAPT jj nn	Dual Capture of Pointer #jj and #(jj+16) modulo 32, using Base #nn without inclination compensation	3.06
DCAPI jj nn	Dual Capture of Pointer #jj and #(jj+16) modulo 32, using Base #nn with inclination compensation (for both Pointers)	3.06
SETMOD jj	Force the mode of operation of unit #jj	3.06
REQMOD jj	Get the mode of operation of unit #jj	3.06

9.2.2.1 INIT jj command

This command activates self-tests and calibration of unit #jj (between 1 and 31). If the unit is a Base, it also activates sound celerity measurement. In case of Pointer, default celerity of 1500 m/s is set (Pointer does normally not use the celerity, but it is expected to be used for future features like distance measurement by Pointer).

During the tests and calibration, the unit #jj sends the following report messages:

V_EMI message which gives emitter voltage actual setting,

THRESHOLD message indicating actual receiver threshold setting,

HEADING message for unit heading,

C0 message indicate the sound celerity setting for the unit,

V_BAT which gives batteries voltage,

STATUS message indicates unit reference number and warning or error status.

example:

INIT 10	*(typed by user)*
DAT: V_EMI (10)= 07.79	*(returned by unit #10)*
DAT: THRESHOLD (10)= 1.00	*(returned by unit #10)*
DAT: HEADING (10)= 265.80	*(returned by unit #10)*
DAT: C0 (10)= 1500.00	*(returned by unit #10)*
DAT: V_BAT (10)= 07.57	*(returned by unit #10)*
DAT: DISPO (10)= 0x20 WARNING= 0x000000	*(returned by unit #10)*
*	

Refer to chapter describing report message for detail of content.

9.2.2.2 PING jj command

The PING command of unit #jj (jj between 1 and 31) forces the unit #jj to send the status message. It also wake up the unit #jj if it was sleeping and was trying to wake up (for two seconds every 30 seconds). Then, if user want to wake up a specific unit, this message has to be send every 2 seconds until unit wake up.

example:

PING 10	*(typed by user)*
DAT: DISPO (10)= 0x20 WARNING= 0x000000	*(returned by unit #10)*
*	

Refer to chapter describing report message for detail of content.

9.2.2.3 CAPT jj nn command

This command forces the capture of unit #jj (jj between 1 and 31, Pointer or Base working in Pointer mode) using the unit #nn (nn between 1 and 31, must be a Base). The capture process includes: interrogation of unit #jj by unit #nn (providing that unit #nn is a Base), computation of angles and distance by unit #nn, and emission of coordinate message from the unit #nn.

The interrogation message is reported by the CM (except if the Base which interrogates is also the CM) and if capture successful, the coordinate message also. In case of capture failure, a capture error message is reported.

Example when capture successful:

CAPT 10	*(typed by user)*
INTERR: PNT (15)	*(returned by unit #10)*
COORD: PNT (15) AZ= 105.32, EL= 90.87, DIST= 167.564	*(returned by unit #10)*

*

Example when capture not successful:

CAPT 15 10   *(typed by user)*

MSG: BASE (10) CAPT. NO ANSWER   *(returned by unit #10)*

*

This last message occurs when Pointer do not answer

Example when unit #nn is not a Base, then not able to initiate a capture:

CAPT 15 10   *(typed by user)*

CM: CM UNIT (10) NOT ABLE TO CAPTURE   *(returned by unit #10)*

*

Refer to chapter describing report message for detail of content.

9.2.2.4   CAPI jj nn command

This command forces the capture of unit #jj (jj between 1 and 31, Pointer or Base working in Pointer mode) using the unit #nn (nn between 1 and 31, must be a Base), the Base inclination is compensated in order to give Z coordinates along zenith axis. The capture process includes: interrogation of unit #jj by unit #nn (providing that unit #nn is a Base), computation of angles and distance by unit #nn (with inclination measurement and compensation accordingly), and emission of coordinate message from the unit #nn.

The inclination can be compensated if and only if the absolute inclination angle is less than 15.0° from vertical. If the inclination is greater than 15.0°, an error message will be reported. When using compensated capture, make sure that the mode of the Base is properly set (see MODB command later in this chapter, or SETMOD and REQMOD commands if you are using units with embedded software version 3.06 and later).

The interrogation message is reported by the CM (except if the Base which interrogates is also the CM) and if capture successful, the coordinate message also. In case of capture failure, a capture error message is reported.

Example when capture successful:

CAPI 15 10   *(typed by user)*

INTERR: PNT (15)   *(returned by unit #10)*

COORD: PNT (15) AZ= 105.32, EL= 90.87, DIST= 167.564   *(returned by unit #10)*

This message is reported by CM when the tilt angle is out of range.
MSG: UNIT (10) TILT>15°   *(send by unit #10, the Base, when over-inclinated)*

Example when capture not successful:

CAPT 15 10   *(typed by user)*

MSG: BASE (10) CAPT. NO ANSWER *(returned by unit #10)*

This message occurs when Pointer does not answer

Example when unit #nn is not a Base, then not able to initiate a capture:

CAPT 15 10 *(typed by user)*

CM: CM UNIT (10) NOT ABLE TO CAPTURE *(returned by unit #10)*

*

Refer to chapter describing report message for detail of content.

9.2.2.5 INCL jj command

This command allows measurement of two axis inclination of the unit #jj (jj between 1 and 31). The inclination report message is send back by the unit #jj.

Example:
INCL 10 *(typed by user)*

DAT: INCLIN. (10) X= +09.45 Y= -12.01 *(returned by unit #10)*

Where:
X is the angle between the X axis of the unit and the horizontal plane, and Y the angle between the Y axis of the unit and the horizontal plane. The angles are positive when the axis goes below the horizontal plane (see illustration below).
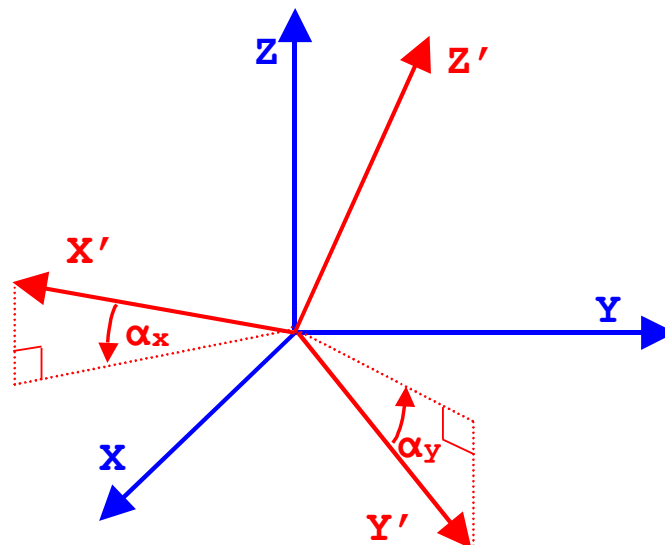
In blue: local geographic coordinate system (with Y axis North oriented and Z axis vertical)

In red: underwater unit coordinate system

Inclination angles definition, here αx is negative and αy positive

Note: these angles are not mathematically equivalent to the definition of pitch and roll angles.

9.2.2.6 HEAD jj command

This command allows measurement of magnetic north heading of the unit #jj (jj between 1 and 31). The heading is measured from the X'' axis that is defined as the axis X' after the single rotation (angle

α_z) in the space that makes the Z' axis being vertical (Z'' and Z are identical after this rotation).
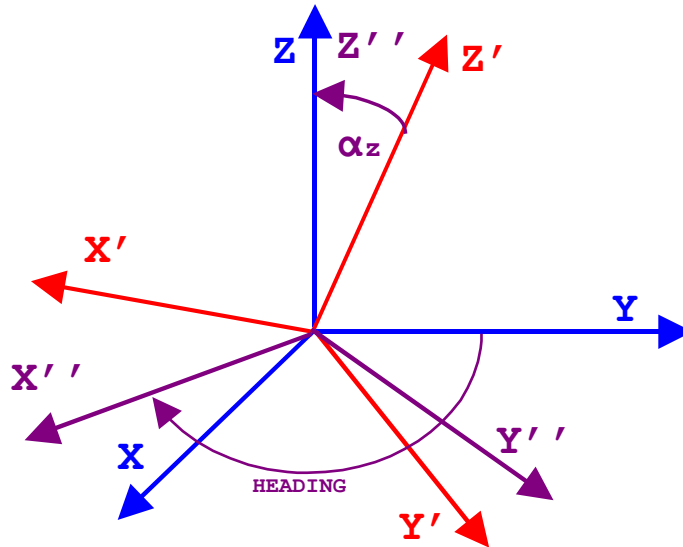
In blue: local geographic coordinate system (with Y axis North oriented and Z axis vertical)
In red: underwater unit coordinate system

HEADING definition

A heading report message is send back by unit jj.

Example:
HEAD 10   *(typed by user)*

DAT: HEADING (10)= 096.67   *(returned by unit #10)*

*

Where:
The heading is an angle between 000.00 and 359.99 degrees (always positive).
Refer to chapter describing report message for detail of content.

9.2.2.7 VBAT jj command

This command allows reading of the batteries voltage of the unit #jj (jj between 1 and 31). A batteries voltage report message is send back by unit jj.

Example:
VBAT 10   *(typed by user)*

DAT: V_BAT (10)= 08.15   *(returned by unit #10)*

*

Where:
The batteries voltage in Volts, always positive, between 00.0 and 12.00.
Refer to chapter describing report message for detail of content.

9.2.2.8   VEMI jj command

This command allows reading of the emitter voltage of the unit #jj (jj between 1 and 31). An emitter voltage report message is send back by unit jj.

Example:
VEMI 10   *(typed by user)*

DAT: V_EMI (10)= 07.50   *(returned by unit #10)*

*

Where:
The emitter voltage in Volts, always positive, between 00.0 and 12.00.
Refer to chapter describing report message for detail of content.

9.2.2.9   TEMP jj command

This command allows reading of the internal temperature of the unit #jj (jj between 1 and 31). A temperature report message is send back by unit jj.

Example:
TEMP 10   *(typed by user)*

DAT: TEMP (10)= +24.7   *(returned by unit #10)*

*

Where:
The temperature is given in degrees Celsius between –35 and +90.

9.2.2.10 REQC0 jj command

This command allows reading of celerity taken into account by unit #jj (jj between 1 and 31). A celerity report message is send back by unit jj.

Example:
REQC0 10   *(typed by user)*

DAT: C0 (10)= 1498.54   *(returned by unit #10)*

*

Where:
The sound celerity in metre per second is always positive, between 1200 and 1800.
Refer to chapter describing report message for detail of content.

9.2.2.11 REQRT jj command

This command allows reading of Receiver Threshold (RT) taken into account by unit #jj (jj between 1 and 31). A Receiver Threshold report message is send back by unit jj.

Example:
REQRT 10   *(typed by user)*

DAT: THRESHOLD (10)= 1.00   *(returned by unit #10)*

*

Where:
The receiver threshold in Volts is always positive, between 0.5 and 1.8.
Refer to chapter describing report message for detail of content.

9.2.2.12 REQMT jj command

This command allows reading of receiver Measured Threshold (MT) of unit #jj (jj between 1 and 31).
A receiver Measured Threshold report message is send back by unit jj.

Example:
REQMT 10   *(typed by user)*

DAT: MEAS. THRESHOLD (10) V1-4= 0.51 0.47 0.55 0.51   *(returned by unit #10)*

*

Where:
The receiver measured threshold in Volts is always positive, between 0.0 and 2.5.
Refer to chapter describing report message for detail of content.

9.2.2.13 PARAM jj command

This command allows reading of celerity taken into account by unit #jj as well as heading (jj between 1 and 31). A parameter report message is send back by unit jj.

Example:
PARAM 10   *(typed by user)*

PARAM: UNIT (10) C0= 1498.54 HEAD.= 274.8   *(returned by unit #10)*

*

Where:
The sound celerity in metre per second is always positive, between 1200 and 1800.
The heading is an angle between 000.00 and 359.99 degrees (always positive).
This command is equivalent to command REQ_C0 and HEAD but in a single command.
Refer to chapter describing report message for detail of content.

9.2.2.14 SETC0 jj command

This command allows setting of celerity taken into account by unit #jj (jj between 1 and 31). A celerity report message is send back by unit jj.

Example:
SETC0 10 1545.87   *(typed by user)*

DAT: C0 (10)= 1545.87   *(returned by unit #10)*

*

Where:
The sound celerity in metre per second is always positive, between 1200 and 1800.
Refer to chapter describing report message for detail of content.

9.2.2.15 SLEEP jj command

This command forces the unit #jj in sleeping mode(jj between 1 and 31). A sleeping report message is send back by unit jj.

Example:
SLEEP 10   *(typed by user)*

MSG: UNIT (10) SLEEPING   *(returned by unit #10)*

*

9.2.2.16 SETRT jj command

This command sets the Receiver Threshold (RT) taken into account by unit #jj (jj between 1 and 31). A Receiver Threshold report message is send back by unit jj.

Example:

SETRT 10 1.2   *(typed by user)*

DAT: THRESHOLD (10)= 1.18   *(returned by unit #10)*

*

Where:

The receiver threshold in Volts is always positive, between 0.5 and 1.8.
The returned value may differ from the setting because it is the actual measured value.
DO NOT SET THE RECEIVER THRESHOLD TO A TOO HIGH VALUE BECAUSE IT CAN MAKE THE UNIT BECOMING DEAF! (refer to chapter describing system set up for proper use of this command)
Refer to chapter describing report message for detail of content.

9.2.2.17 SETVE jj command

This command sets the emitter voltage of the unit #jj (jj between 1 and 31). An emitter voltage report message is send back by unit jj.

Example:

SETVE 10 6.2   *(typed by user)*

DAT: V_EMI (10)= 06.10   *(returned by unit #10)*

*

Where:

The emitter voltage in Volts is always positive, between 00.0 and 12.00. The emitter voltage returned may be different because it is the actual measured value after setting.
Refer to chapter describing report message for detail of content.

9.2.2.18 DCAPI jj nn command

This command forces the dual capture of unit #jj and #(jj+16)modulo32 (jj between 1 and 31, Pointer or Base working in Pointer mode) using the Base unit #nn (nn between 1 and 31, must be a Base), the Base inclination is compensated in order to give Z coordinates along zenith axis. The capture process includes: interrogation of unit #jj and #(jj+16)modulo32 by unit #nn (providing that unit #nn is a Base), computation of angles and distance by unit #nn (with inclination measurement and compensation accordingly), and emission of coordinate messages from the unit #nn.

The inclination can be compensated if and only if the absolute inclination angle is less than 15.0° from vertical. If the inclination is greater than 15.0°, an error message will be reported. When using compensated capture, make sure that the mode of the Base is properly set (see SETMOD and REQMOD commands later in this chapter).

The interrogation message is reported by the CM (except if the Base which interrogates is also the CM) and if capture successful, the coordinate message also. In case of capture failure, a capture error message is reported separately for each interrogated unit.

Example when capture successful:

DCAPI 05 10 *(typed by user)*

COORD: PNT (21) AZ= 105.32, EL= 090.87, DIST= 167.564 *(returned by unit #10)*

COORD: PNT (05) AZ= 023.55, EL= 110.25, DIST= 138.578 *(returned by unit #10)*

The following message is reported by CM when the tilt angle is out of range.
MSG: UNIT (10) TILT>15° *(send by unit #10, the Base, when over inclinated)*

Example when dual capture not fully successful:

DCAPI 05 10 *(typed by user)*

COORD: PNT (21) AZ= 105.32, EL= 090.87, DIST= 167.564 *(returned by unit #10)*

MSG: BASE (10) CAPT. NO ANSWER *(returned by unit #10)*

This message occurs when Pointer #05 does not answer for instance

Example when unit #nn is not a Base, then not able to initiate a capture:

CAPT 15 10 *(typed by user)*

CM: CM UNIT (10) NOT ABLE TO CAPTURE *(returned by unit #10)*

*

Refer to chapter describing report message for detail of content.

Details of dual capture versus addresses:

A dual capture does not consist of sending two times a simple interrogation message through acoustic. Only one message is sent to address #jj, the unit #jj will receive the interrogation and process to answer immediately, the unit #(jj+16)modulo32 also receives the interrogation but emits the reply after an additional delay of about 250 ms compared to unit #jj. The Base processes both replies and send the coordinates results of unit #(jj+16)modulo32 first immediately followed by coordinates of unit #jj. Note that a simple interrogation to each unit remains possible however using CAPT and CAPI commands.

DCAPI 05 10 command will perform a dual capture of addresses #05 and #21,

When **DCAPI 21 10** command will perform a dual capture of addresses #21 and #05 ((21+16)modulo32=05).

Important constrain:

Dual capture has been introduced in embedded software version 3.06 and later to address ROV heading measurement without compass, which gives better accuracy especially when working near steel structures. But for internal timing issues, Pointers distances difference must be less than 40 metres. A greater distance difference may lead to erroneous coordinates.

9.2.2.19 DCAPT jj nn command

Same command as DCAPI but without internal compensation of the Base inclination, thus the coordinates are output according interferometric frame.

Refer to previous DCAPI command description for details.

9.2.2.20 SETMOD jj nn command

This command sets the mode of operation of unit #jj (jj between 1 and 31). The mode is an 8 bits integer (mode range 0-255), in embedded software version 3.06 only the bit 0 is used and define the acoustic head up or down option. This setting is very important when using a Base and the "CAPI" or "DCAPI" command, because in this case the inclination of the Base will be compensate to always output a coordinate with X,Y axis in the local horizontal plane and Z vertical.

SETMOD #jj 0   define a unit #jj working up (typically the case when a Base is set up on the sea bed at the top of a mast for instance).

SETMOD #jj 1   define a unit working reversed (typically the case when a Base is hanged from a taut wire from the surface during dam survey for instance).

Example:
SETMOD 10 0   *(typed by user, blank between SETMOD and address)*

DAT: MODE (10)= 0   *(returned by unit #10)*

*

The setting is stored in flash memory and remains valid until next SETMOD command. User can get actual mode using the REQMOD command (see later in this chapter).

9.2.2.21 REQMOD jj command

This command query the mode of operation of unit #jj (jj between 1 and 31). The mode is an 8 bits integer (mode range 0-255), in embedded software version 3.06 only the bit 0 is used and define the acoustic head up or down option. This setting is very important when using a Base and the "CAPI" or "DCAPI" command, because in this case the inclination of the Base will be compensate to always output a coordinate with X,Y axis in the local horizontal plane and Z vertical.

Example:
REQMOD 10   *(typed by user, blank between REQMOD and address)*

DAT: MODE (10)= 0   *(returned by unit #10)*

*

The setting is stored in flash memory and remains valid until next SETMOD command.

9.2.3   List of CM command

These commands are dedicated to the CM unit only and then not addressed. They are mainly dedicated to unit configuration setting and error reporting.

Command	Description	From. embedded software version
ADDCHG jj	Set a new address #jj for the unit (CM only)	3.0
MODB j	Define the mode up or reversed (CM only)	3.0
DISPO	Get the CM unit identification (CM only)	3.0
LERR	Get the CM unit list of reported error and warning (CM only)	3.0
MODECHO j	Set the CM unit command echo mode to #j level (CM only)	3.06

9.2.3.1   ADDCHG command

This command sets the CM unit address between 1 and 31. A CM message is echoed.

Example:
ADDCHG 12   *(typed by user)*

NEW ADR= 12   *(returned by unit CM)*

*

This command is intended for system set up only. It is not recommended to use it during underwater operation. It is not possible to set a new address through acoustic link (only the CM unit through the serial electrical link).
MAKE SURE THAT THERE IS NETHER TWO UNITS WITH SAME ADDRESS, IT WILL LEAD TO DEMODULATION MESSAGE ERROR AND IMPROPER WORK.
The current configuration may be checked using the DISPO command.

9.2.3.2   MODB command

This command has been replaced by SETMOD and REQMOD commands in embedded software version 3.06 and later. These new commands allow setting of units through acoustics.

This command defines if the unit is working up or reversed, a confirmation message is echoed. This setting remains in non volatile memory and define the working mode of the unit until the next setting.

This setting is very important when using a Base and the "CAPI" command, because in this case the inclination of the Base will be compensate to always output a coordinate with X,Y axis in the local horizontal plane and Z vertical.

MODB 0   define a unit working up (typically the case when a Base is set up on the sea bed at the top of a mast for instance).

MODB 1   define a unit working reversed (typically the case when a Base is hanged from a taut wire from the surface during dam survey for instance).

Example:
MODB 0   *(typed by user, blank between MODB and address)*

Mode= 0   *(returned by unit CM)*

*

This command is intended for system set up only. It is not recommended to use it during underwater operation. It is not possible to set the mode of another Base through acoustic link (only the CM unit through the serial electrical link).
The current configuration may be checked using the DISPO command.

9.2.3.3 DISPO command

This command just return the full identification of the unit:

Example (in case of an AQUA-METRE R300 Base):
DISPO   *(typed by user)*

BASE AQUA-METRE R300 (DISPO= 17)   *(returned by unit CM)*

BASE AQUA-METRE R300 (DISPO= 17)   *(device identification returned by unit CM)*

Version Logiciel= 305   *(embedded software release returned by unit CM)*

Version Materiel= 203   *(hardware version returned by unit CM)*

Numero Serie= 101   *(serial number returned by unit CM)*

Mode= 0   *(mode defined by previous MODB command returned by unit CM)*

Adresse= 10   *(current unit address returned by unit CM)*

*

This command is information only and does not affect current setting.

9.2.3.4 LERR command

This command just return the list of reported error and warning:

Example:
LERR   *(type by user)*

NB M/A= 57   *(returned by unit)*

M/A= 00001 ERREUR=   0 ALERTE=   6008   *(returned by unit)*

M/A= 00002 ERREUR=   0 ALERTE=   6008   *(returned by unit)*

M/A= 00003 ERREUR=   0 ALERTE=   6008   *(returned by unit)*

M/A= 00004 ERREUR=   0 ALERTE=   6008   *(returned by unit)*

M/A= 00035 ERREUR=   0 ALERTE=   4008   *(returned by unit)*

This command is information only and does not affect current setting, It is detailed in the chapter dedicated to BIT functions (Build In Tests).

9.2.3.5 MODECHO command

This command sets the CM unit echo to commands mode.

The syntax is:

MODECHO j *(typed by user, blank between MODECHO and argument j)*

Where j stands for the echo mode, j= 0, 1 or 2:
0: no echo of command,
1: echo to command after the carriage return character (the full command is then echoed in a single stream),
2: full echo to every character send by user, this is the default mode when unit is switched on (the setting is not stored in flash configuration memory).
exemple:

MODECHO 1 *(typed by user, blank between MODECHO and 1)*

MODE ECHO= 1 (SINGLE ECHO) *(returned by unit CM)*

*

<u>Note:</u> the echo mode #1 (single echo) is recommended when operating the CM unit through a radio-modem link because it reduces the global time to send a command (the radio-modem do not have to switch from receiver to emitter for each character echoed, the echo is sent in a single radio packet).

9.2.4 List of Report messages

The report messages list appear in the next table and are detailed along the next chapters.

All messages that start with "REQ:" are request messages. These messages are usually send by the CM to a remote unit and are often followed by the answer that is normally a data (DAT) message. This request messages are not reported by the CM because they are send by it, but they can be reported by a passive (listen only) secondary CM unit.

All messages that start with "DAT" are data messages. These messages carry information and are generally send as an answer to request messages.

All messages that start with "SET" are setting messages. These messages set some parameters of remote units. These messages are usually send by the CM to a remote unit and are often followed by the answer that is normally a data (DAT) message. This request messages are not reported by the CM because they are send by it, but they can be reported by a passive (listen only) secondary CM unit.

All messages that start with "MSG" are information messages. These messages carry state of the unit.

Message	Description
NOISE/DEMOD ERR	Demodulation error or incoming noise on CM receiver
INTERR: PNT (jj)	Reports an interrogation of unit #jj
REQ: CAPT PNT (jj) FROM BASE (nn)	Reports a capture request of Pointer #jj using Base #nn
COORD: PNT (jj)...	Reports the coordinates measured of the Pointer jj following an interrogation
REQ: PING (jj)	Reports a request of status of unit #jj
REQ: INCLIN. (jj)	Reports a request of inclination angles of unit #jj
REQ: HEADING (jj)	Reports a request of heading angle of unit #jj
REQ: PARAM. (jj)	Reports a request of parameter of unit #jj
REQ: C0 (jj)	Reports a request of celerity of unit #jj
REQ: THRESHOLD (jj)	Reports a request of receiver threshold of unit #jj
REQ: V_EMI (jj)	Reports a request of emitter voltage of unit #jj
REQ: V_BAT (jj)	Reports a request of batteries voltage of unit #jj
REQ: TEMP (jj)	Reports a request of internal temperature of unit #jj
REQ: REC. LEVEL (jj)	Reports a request of measured receiver level of unit #jj
REQ: INIT (jj)	Reports a request of initialisation of unit #jj
SET: C0 (jj)	Reports a celerity setting for unit #jj
SET: SLEEP (jj)	Reports a sleeping mode activation for unit #jj
SET: THRESHOLD (jj)	Reports a receiver threshold setting for unit #jj
SET: V_EMI (jj)	Reports a voltage emitter setting for unit #jj

DAT: INCLIN. (jj)	Reports the inclination angles of unit #jj
DAT: HEADING (jj)	Reports the heading angle of unit #jj
DAT: C0 (jj)	Reports the celerity taken into account by unit #jj
DAT: DISPO (jj) & WARNING	Reports device code and warning status of unit #jj
DAT: DISPO (jj) & ERROR	Reports device code and error status of unit #jj
DAT: MEAS. THRESHOLD (jj)	Reports measured receiver level of unit #jj
DAT: THRESHOLD (jj)	Reports receiver threshold of unit #jj
DAT: V_EMI (jj)	Reports emitter voltage of unit #jj
DAT: V_BAT (jj)	Reports batteries voltage of unit #jj
DAT: TEMP (jj)	Reports internal temperature of unit #jj
DAT: ROVNAV (jj)	Reports navigation message of unit #jj (ROV Pointer)
DAT: MODE (jj)	Reports mode of operation of unit #jj
MSG: UNIT (jj) SLEEPING	Reports activation of sleeping mode for unit #jj
PARAM: UNIT (jj)…	Reports parameters of unit #jj
COORD: PNT (jj)…	Reports coordinates of unit #jj

9.2.4.1 NOISE/DEMOD ERR report message

This message is reported when a demodulation error occurred in the CM acoustic receiver. This may be due to the reception of a real acoustic message in very reverberant environment, which leads to demodulation error. It also may come from an incoming acoustic noise or induced electrical noise.
IMPORTANT:
When initialisation of an underwater Base unit occurs, it will induce the NOISE/DEMOD ERR message when trying to measure local celerity, it is normal and last for about one minute or less.
A NOISE/DEMOD ERR message may also be displayed after an interrogation message due to unit acoustic answer (short multi-frequencies pulse not interpreted as a message).
Except for the above reasons, if this message is displayed too often, try to increase the receiver threshold.

example:
NOISE/DEMOD ERR

9.2.4.2 INTERR: PNT (jj)report message

This message is reported by CM when an interrogation is send to the unit #jj (jj between 1 and 31 included). It is also a confirmation that the Base that interrogates has received the capture request message.
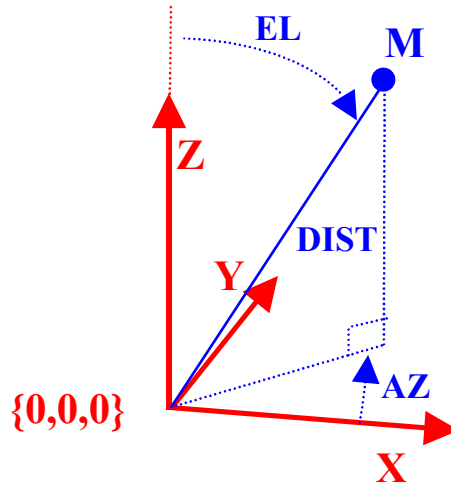
Example:
INTERR: PNT (10)

9.2.4.3   COORD: PNT (jj) report message

This message is reported by the unit that performed the capture (interrogation of unit #jj, coordinates computations and emission of coordinate message).

Example:
COORD: PNT (10) AZ= 182.32, EL= 95.37, DIST= 012.368

where:

AZ is the azimuth angle in degrees of the unit #jj in the local coordinate system of the Base unit (refer to interferometric frame geometry definition), **000.00≤ AZ ≤ 359.99**,
EL is the elevation angle in degrees of the unit #jj in the local coordinate system of the Base unit (refer to interferometric frame geometry definition), **000.00≤ EL ≤ 179.99**,
EL is the distance in metres of the unit #jj in the local coordinate system of the Base unit (refer to interferometric frame geometry definition), **000.000≤ DIST ≤ 262.140**,

9.2.4.4   PARAM: UNIT (jj) report message

This message is reported by CM when a parameter message is send from the unit #jj (jj between 1 and 31 included).

Example:
PARAM: UNIT (10) C0= 1487.36 HEAD.= 279.6
where:
where C0 unity is metre per second (m/s), between 1200 and 1800 m/s. The heading is an angle between 000.00 and 359.99 degrees (always positive).
(refer also to DAT: C0 and DAT: HEADING message for full explanation of content).

REQUEST MESSAGES

9.2.4.5   REQ: CAPT PNT (jj) FROM BASE (nn) report message

This message is reported by CM when a capture request is send to the unit #nn (nn between 1 and 31 included). This message is in fact rarely reported because this is often the CM that sends this message following the monitor command **CAPT**.

Example:
REQ: CAPT PNT (10) FROM BASE (15)

9.2.4.6   REQ: PING (jj) report message

This message is reported by CM when a PING request is send to the unit #jj (jj between 1 and 31 included). This message is in fact rarely reported because this is often the CM that sends this request.

Example:
REQ: PING (10)

9.2.4.7   REQ: INCLIN. (jj) report message

This message is reported by CM when an inclination angles request is send to the unit #jj (jj between 1 and 31 included). This message is in fact rarely reported because this is often the CM that sends this request.

Example:
REQ: INCLIN. (10)

9.2.4.8   REQ: HEAD (jj) report message

This message is reported by CM when a heading angle request is send to the unit #jj (jj between 1 and 31 included). This message is in fact rarely reported because this is often the CM that sends this request.

Example:
REQ: HEAD (10)

9.2.4.9   REQ: PARAM. (jj) report message

This message is reported by CM when a parameters request is send to the unit #jj (jj between 1 and 31 included). This message is in fact rarely reported because this is often the CM that sends this request.

Example:
REQ: PARAM. (10)

9.2.4.10   REQ: C0 (jj) report message

This message is reported by CM when a sound celerity request is send to the unit #jj (jj between 1 and 31 included). This message is in fact rarely reported because this is often the CM that sends this request.

Example:
REQ: C0 (10)

9.2.4.11   REQ: THRESHOLD (jj) report message

This message is reported by CM when a receiver threshold request is send to the unit #jj (jj between 1 and 31 included). This message is in fact rarely reported because this is often the CM that sends this request.

Example:
REQ: THRESHOLD (10)

9.2.4.12   REQ: V_EMI (jj) report message

This message is reported by CM when a emitter voltage request is send to the unit #jj (jj between 1 and 31 included). This message is in fact rarely reported because this is often the CM that sends this request.

Example:
REQ: V_EMI (10)

9.2.4.13   REQ: V_BAT (jj) report message

This message is reported by CM when a batteries voltage request is send to the unit #jj (jj between 1 and 31 included). This message is in fact rarely reported because this is often the CM that sends this request.

Example:
REQ: V_BAT (10)

9.2.4.14   REQ: TEMP (jj) report message

This message is reported by CM when a internal temperature request is send to the unit #jj (jj between 1 and 31 included). This message is in fact rarely reported because this is often the CM that sends this request.

Example:
REQ: TEMP (10)

9.2.4.15   REQ: REC. LEVEL (jj) report message

This message is reported by CM when a receiver level request is send to the unit #jj (jj between 1 and 31 included). This message is in fact rarely reported because this is often the CM that sends this request.

Example:
REQ: REC. LEVEL (10)

9.2.4.16   REQ: INIT (jj) report message

This message is reported by CM when an initialisation request is send to the unit #jj (jj between 1 and 31 included). This message is in fact rarely reported because this is often the CM that sends this request.

Example:
REQ: INIT (10)

SETTING MESSAGES

9.2.4.17 SET: C0 (jj) report message

This message is reported by CM when a sound celerity setting is send to the unit #jj (jj between 1 and 31 included). This message is in fact rarely reported because this is often the CM that sends this request.

Example:
SET: C0 (10) 1489.36

9.2.4.18 SET: SLEEP (jj) report message

This message is reported by CM when a sleeping mode activation setting is send to the unit #jj (jj between 1 and 31 included). This message is in fact rarely reported because this is often the CM that sends this request.

Example:
SET: SLEEP (10)

9.2.4.19 SET: THRESHOLD (jj) report message

This message is reported by CM when a receiver threshold setting is send to the unit #jj (jj between 1 and 31 included). This message is in fact rarely reported because this is often the CM that sends this request.

Example:
SET: THRESHOLD (10) 1.23

9.2.4.20 SET: V_EMI (jj) report message

This message is reported by CM when an emitter voltage setting is send to the unit #jj (jj between 1 and 31 included). This message is in fact rarely reported because this is often the CM that sends this request.

Example:
SET: V_EMI (10) 07.69

DATA MESSAGES

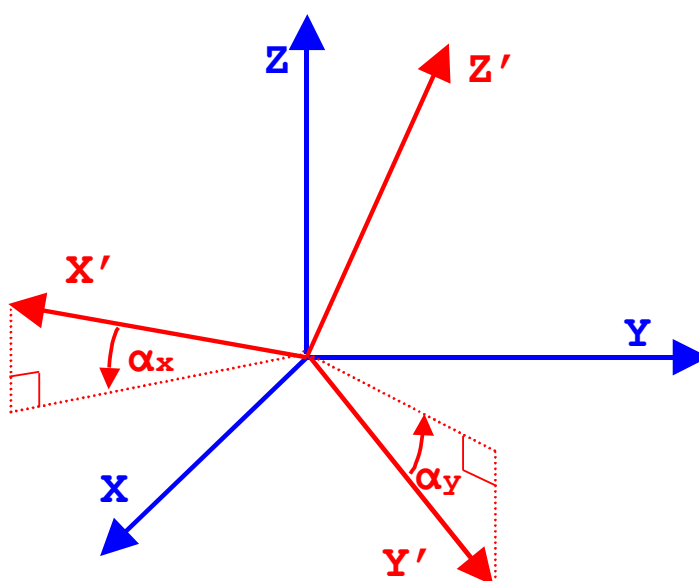### 9.2.4.21 DAT: INCLIN. (jj) report message

This message is reported by CM when an inclination angles data is send from the unit #jj (jj between 1 and 31 included). This message is often send after an inclination request.

Example:
DAT: INCLIN. (10) X= +09.45 Y= -12.01   *(returned by unit #10)*

Where:
X is the angle between the X axis of the unit and the horizontal plane, and Y the angle between the Y axis of the unit and the horizontal plane. The angles are positive when the axis goes below the horizontal plane (see illustration below).

In blue: local geographic coordinate system (with Y axis North oriented and Z axis vertical)

In red: underwater unit coordinate system

Inclination angles definition, here αx is negative and αy positive

Note: these angles are not mathematically equivalent to the definition of pitch and roll angles.

9.2.4.22 DAT: HEAD (jj) report message

This message is reported by CM when a heading angle data is send from the unit #jj (jj between 1 and 31 included). This message is often send after a heading request.
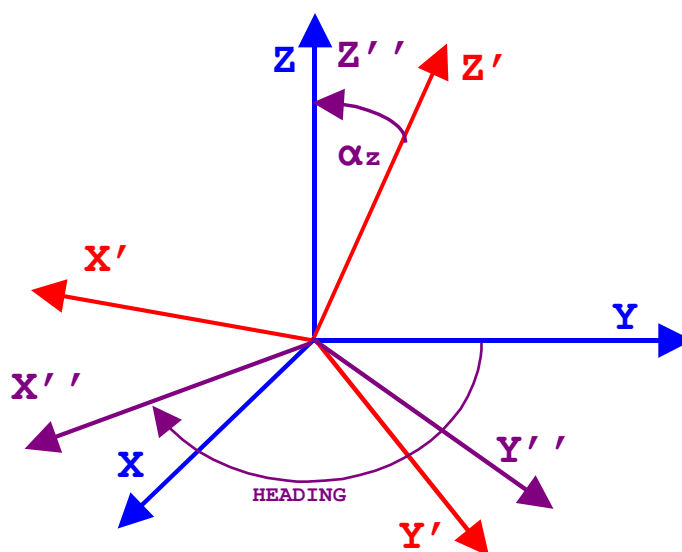Example:
DAT: HEADING (10)= 096.67   *(returned by unit #10)*

Where:

The heading is an angle between 000.00 and 359.99 degrees (always positive).

The heading is measured from the X'' axis that is defined as the axis X' after the single rotation (angle α_z) in the space that makes the Z' axis being vertical (Z'' and Z are identical after this rotation).

In blue: local geographic coordinate system (with Y axis North oriented and Z axis vertical)
In red: underwater unit coordinate system

HEADING definition

9.2.4.23 DAT: C0 (jj) report message

This message is reported by CM when a sound celerity data is send from the unit #jj (jj between 1 and 31 included). This message is often send after a sound celerity request or setting (refer to REQC0 or SETC0 monitor command).

Example:
DAT: C0 (10)= 1452.36   *(returned by unit #10)*

where C0 unity is metre per second (m/s), between 1200 and 1800 m/s.

9.2.4.24 DAT: DISPO (jj) & WARNING report message

This message is reported by CM when a warning status data is send from the unit #jj (jj between 1 and 31 included). This message is often send after PING to unit #jj.

Example:
DAT: DISPO (10)= 0x20 WARNING= 0x000000   *(returned by unit #10)*

where:
Dispo code is the device code (0x10 for D3000 Base and 0x20 for a D3000 Pointer) and warning code includes all warnings set during the last initialisation (to be listed later).
Note: all warning codes are also stored in flash memory and can be read using the AQUA-TOOL or AQUA-CAD software.

9.2.4.25 DAT: DISPO (jj) & ERROR report message

This message is reported by CM when an error status data is send from the unit #jj (jj between 1 and 31 included). This message is often send after PING to unit #jj.

Example:
DAT: DISPO (10)= 0x20 ERROR= 0x000000   *(returned by unit #10)*

where:
Dispo code is the device code (0x10 for D3000 Base and 0x20 for a D3000 Pointer) and error code includes all error set during the last initialisation (to be listed later).
Note: all error codes are also stored in flash memory and can be read using the AQUA-TOOL or AQUA-CAD software.

9.2.4.26 DAT: MEAS. THRESHOLD (jj)… report message

This message is reported by CM when measured threshold data is send from the unit #jj (jj between 1 and 31 included). This message is often send after a request to unit #jj.

Example:
DAT: MEAS. THRESHOLD (10) V1-4=0.51 0.47 0.47 0.55   *(returned by unit #10)*

where:
The measured thresholds are the actual noise level for each receiver channel. This is a voltage outputted from a logarithmic amplifier with 25 mV per dB. In case of Pointer, only channel #1 is relevant (the other channel measured threshold will be 0.00). The tuned receiver threshold is 1.0 if measured receiver threshold are less or equal to 1.0. A typical measured value is between 0.35 and 0.75, if greater than 1.0, the tuned receiver threshold will be set above 1.0 and the range will be affected.

9.2.4.27 DAT: THRESHOLD (jj) report message

This message is reported by CM when a receiver threshold data is send from the unit #jj (jj between 1 and 31 included). This message is often send after a request or setting to unit #jj.

Example:
DAT: THRESHOLD (10)= 1.02   *(returned by unit #10)*

where:
The tuned receiver threshold is 1.0 if measured receiver threshold are less or equal to 1.0. A typical measured value is between 0.35 and 0.75, if greater than 1.0, the tuned receiver threshold will be set above 1.0 and the range will be affected.

9.2.4.28 DAT: V_EMI (jj) report message

This message is reported by CM when an emitter voltage data is send from the unit #jj (jj between 1 and 31 included). This message is often send after a request or setting to unit #jj.

Example:
DAT: V_EMI (10)= 08.52   *(returned by unit #10)*

where:
The emitter voltage can be tuned by user to lower the radiated power and improve behaviour in highly reverberant environment. It is set to 8.5 volts during initialisation and may not be changed by user when working in open area (may only be changed when working in harbour or closed to pier is expected).

9.2.4.29 DAT: V_BAT (jj) report message

This message is reported by CM when a batteries voltage data is send from the unit #jj (jj between 1 and 31 included). This message is often send after a request to unit #jj.

Example:
DAT: V_BAT (10)= 08.12   *(returned by unit #10)*

where:
The batteries voltage typical value is between 7.5 and 9.5 volts. A batteries voltage lower than 7.5 and greater than 6.5 will issue a warning, and an error if lower than 6.5 Volts.
If the unit is powered by external supply, this voltage will be constant, about 9.3 Volts (+/-0.5), providing that external supply voltage remains in the range 15 to 27 Volts.

9.2.4.30 DAT: TEMP (jj) report message

This message is reported by CM when an internal temperature data is send from the unit #jj (jj between 1 and 31 included). This message is often send after a request to unit #jj.

Example:
DAT: TEMP (10)= +25.2   *(returned by unit #10)*

where:
The temperature unity is degree Celsius between –35 and +90 °C.

9.2.4.31 DAT: ROVNAV (jj) report message

This message is reported by CM when a ROV Pointer #jj has been interrogated and configured to send navigation message through the acoustic after an interrogation (see chapter describing the ROV Pointer for more details).
Only a R300/R3000 Base or Pointer with embedded software 3.04 or later can report this message.

The message is send according the format:
DAT: ROVNAV (xx) HEAD= yyy.yy PRE= zz.zzz
Where:
-    xx is the address of the ROV Pointer,
-    yyy.yy is the ROV Pointer heading from 000.00 to 359.99°
-    zz.zzz is the static pressure measured in bars (Newton per cm^2),

Example:
DAT: ROVNAV (06) HEAD= 158.23 PRE= 12.758

Please refer to appendix to find how to transform pressure in bars to water depth.

9.2.4.32 DAT: MODE (jj) report message

This message is reported by CM when a mode of operation data is send from the unit #jj (jj between 1 and 31 included). This message is send after a mode request or set to unit #jj.
Only a R300/R3000 Base or Pointer with embedded software 3.06 or later can report this message.

The message is send according the format:
DAT: MODE (jj) = yyy
Where:
-    jj is the address of the unit,

- yyy is the mode of operation of unit #jj between 0 and 255 (see SETMOD command for explanation of different modes of operation).

Example:
DAT: MODE (10)= 0   *(returned by unit #10)*

MSG (info) MESSAGES

9.2.4.33 MSG: UNIT (jj) TILT>10° report message

This message is reported by CM when the tilt angle of the unit #jj (jj between 1 and 31 included) is greater than 10°. This message is only send if compensated coordinate are expected.

Example:

MSG: UNIT (10) TILT>15°   *(send by unit #10)*

9.2.4.34 MSG: UNIT (jj) CAPT. NO ANSWER° report message

This message is reported by CM when the unit #jj (jj between 1 and 31 included) do not succeed in getting any answer to interrogation. This message is only send if a capture request was send to this unit.

Example:

MSG: UNIT (10) CAPT. NO ANSWER   *(send by unit #10)*

9.2.4.35 MSG: UNIT (jj) CAPT. CALC. ERROR report message

This message is reported by CM when the unit #jj (jj between 1 and 31 included) do not succeed in computing coordinate solution following capture measurement. This message is only send if a capture request was send to this unit.

Example:

MSG: UNIT (10) CAPT. CALC. ERROR   *(send by unit #10)*

9.2.4.36 MSG: UNIT (jj) CAPT. MULTIPATH ERROR report message

This message is reported by CM when the unit #jj (jj between 1 and 31 included) do not succeed in computing coordinate solution due to multipath environment. This message is only send if a capture request was send to this unit.

Example:

MSG: UNIT (10) CAPT. MULTIPATH ERROR   *(send by unit #10)*

9.2.4.37 MSG: UNIT (jj) SLEEPING report message

This message is reported by CM when the unit #jj (jj between 1 and 31 included) enters sleeping mode. This message is only send if a sleeping mode request was send to this unit.

Example:

MSG: UNIT (10) SLEEPING   *(send by unit #10)*

10 Appendix

10.1   Pressure definition

The pressure measured by the ROV Pointer gauge is output in bar.

One bar equal 10^5 Pa (Pa= Pascal= 1 Newton/m^2)

One bar is equal to 10 Newton per cm^2.

One psi equal 0.6895 Newton per cm^2

One bar= 14.5038 psi

10.2   Pressure to water depth conversion

The following equation gives the water depth ***h*** (in metre) function of the measured pressure ***P*** (in bar), water relative density ***d*** (1.0 for fresh water at 4°C) and local acceleration due to gravity ***g*** (in metre per second per second).

> ***h= 100.0 * P / (d * g)***

The pressure P is supposed to be referenced to the surface (0.0 bar at 0.0 metre).

The above equation is in fact an approximation because the density depends on pressure, temperature and salinity, which are depth dependent. In first approximation, density can be evaluated as 1.0 for fresh water (0°C to 30°C) and 1.027 for seawater (0°C to 30°C, salinity around 35g/l).

For a better estimation, refer to EOS80 water density estimation formulae.

The gravity is latitude and altitude dependent. In first approximation, it can be evaluated by the following formula:

> ***g= 9.7804 + 0.0517*sin^2(latitude) – 57.7 10^{-6} *sin^2(2*latitude) – 3.086 10^{-3} *H***

where :

  Latitude is the geographic latitude in degrees,

  H is the altitude in km.

G is about 9.81 m/s^{-2} at 45° latitude and sea level.