GAPS

Carbon V.1

User Guide

Warranty

iXBlue provides a standard warranty of one (1) year covering this product against any defect in materials or manufacture. The warranty starts from the date of shipment of the product from iXBlue's manufacturing premises to customer's location and its duration is indicated in the certificate of warranty delivered with the product. In the event that a defect in materials or manufacture becomes obvious during the stipulated warranty period, iXBlue will undertake, at its sole discretion, either to repair the defective product, bearing the cost of all parts and labor, or to replace it with an identical product.

In order to avail itself of this warranty, Customer must notify iXBlue of the defect before expiry of the warranty period and take all steps necessary to enable iXBlue to proceed. Customer shall be responsible for the packaging and the shipment of the defective product to the repair center notified by iXBlue, the cost of such shipment being borne by Customer. iXBlue agrees to bear the cost of return freight, based on CPT (Cost Paid To) Customer's airport location, import tax-free.

This warranty shall not be construed as covering defects, malfunctions or damages caused by improper use or inadequate maintenance of the product. Under no circumstances shall iXBlue be due to provide repair or replacement under this warranty in order a) to repair damage caused by work done by any person not representing iXBlue for the installation, repair or maintenance of the product ; b) to repair damage caused by improper use or connection to incompatible equipment, and specifically, the opening of the housing of the equipment under warranty shall cause the warranty to be automatically cancelled ; c) to maintain any product that has been modified or integrated into a larger configuration, if such modification or integration increases the duration or difficulty of the maintenance of said product.

This warranty covers the product hereunder and is provided by iXBlue in place of all and any other warranty whether expressed or implied. iXBlue does not guarantee the suitability of the product under warranty for sale or any specific use. iXBlue's liability is limited to the repair or replacement of defective products, this being the sole remedy open to Customer in the event the warranty becomes applicable. iXBlue cannot be held liable for indirect, special, subsequent or consequential damage, irrespective of whether iXBlue has or has not received prior notification of the risk of occurrence of such damage.

Export Regulation

This product is classified as a dual-use good: it has been developed for non-military use, but could be used for military applications.

As a consequence, this product is subject to dual-use goods export control procedures:

- iXBlue can deliver this product freely to France or any other country of the European Union;
- iXBlue can export this product under its own Community General Export Authorization EU 001 to the following countries: Australia, Canada, USA, Japan, New-Zealand, Norway and Switzerland;
- iXBlue can also export this product to other countries but only through the issuance of an individual export license by the French authorities.

Once in its country of first destination:

- From a country member of European Union, this product is free of movement (travel) as long as it remains within the European Union;
- From a country member of European Union, this product can only be re-exported to a non European Union member country under the dual-use goods export control procedures set forth by the national authorities;
- From another country, this product can only be re-exported under both the conditions of the original export license from France (depending on its type and content) and the dual-use goods export control procedures set forth by the national authorities.

If an individual export license has to be issued by the French authorities, iXBlue requires you to provide as needed a description of your usual activity (and the one of the end-user if different) and the end-user to fill out an end-user certificate which includes:

- The description of the intended application of the product
- A commitment not to re-export the product (without applying for an export license to the competent national authorities as set above).

This product cannot be exported or re-exported to Cuba, Syria, North Korea, Libya, Sudan and Iran.

Overview of GAPS User Guide

This document is the User Guide for iXBlue's GAPS. It must be read and understood prior to using the GAPS system. The manufacturer shall in no case be held liable for any application or use that does not comply with the stipulations in this manual. This issue is updated for use with GAPS MMI software 2.09.01 and higher.

The GAPS User Guide is divided into six parts:

- Part 1: Introduction and Technical Description

This section contains a general and technical description of GAPS as well as the technical conventions that apply.

- Part 2: Installing GAPS

In this section you will find the procedure for installation the GAPS system, to assess its geometrical configuration parameters, and to plan all connections to external systems.

- Part 3: Configuring GAPS

In this section you will find the procedure for GAPS configuration with the MMI Software. It describes how to configure the GAPS unit and the transponders with all required parameters before operating the system.

- Part 4: Operating GAPS

This section provides the full description of GAPS performance and operation.

- Part 5: Maintenance

This section provides the preventative and corrective maintenance for GAPS.

- Part 6: Library Interface

This section is the protocol library documentation for GAPS. It contains the description of all available GAPS protocols.

The abbreviations and acronyms used in this manual are listed hereafter.

Text Usage

Bold	Bold text is used for items you must select or click in the software. It is also used for the field names used into the dialog box.
`Courier`	Text in this font denotes text or characters that you should enter from the keyboard, the proper names of disk Drives, paths, directories, programs, functions, filenames and extensions.
Italic	Italic text is the result of an action in the procedures.

Icons

The **Note** icon indicates that the following information is of interest to the operator and should be read.

THE **CAUTION** ICON INDICATES THAT THE FOLLOWING INFORMATION SHOULD BE READ TO FORBID OR PREVENT PRODUCT DAMAGE.

THE **WARNING** ICON INDICATES THAT POSSIBLE PERSONAL INJURY OR DEATH COULD RESULT FROM FAILURE TO FOLLOW THE PROVIDED RECOMMENDATION.

Abbreviations and Acronyms

DGPS	Differential Global Positioning System
FOG	Fiber Optical Gyroscope
GAPS	Global Acoustic Positioning System
GPS	Global Positioning System
IIF	Individual Interrogation Frequency
IMU	Inertial Measurement Unit
INS	Inertial Navigation System
MMI	Man Machine Interface
MFSK	Multi-Frequency Shift Keying
NA	Not Applicable
NIS	Noise Isotropic Spectrum
NMEA	National Marine Electronics Association
RTK	Real-Time Kinematics
SNR	Signal to Noise Ratio
USBL	Ultra Short Base Line

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I INTRODUCTION AND TECHNICAL DESCRIPTION

I.1 System Overview

The Global Acoustic Positioning System, GAPS, is a portable Ultra Short Base Line (USBL) with integrated Inertial Navigation System (INS) and Global Positioning System (GPS).

Plug and Play

The GAPS system is recommended for mobile or fixed installations. It can be combined with an additional hoisting system. It is a plug & play installation and calibration is required neither before using it nor after reinstalling it.

Accuracy

The GAPS system is used to deliver:

- The position of one or more underwater objects or vehicles, which can maneuver at depth up to 3,000 meters. Greater depths are possible depending on the beacon type used.
- The accuracy is up to 0.2% accuracy of the Distance to Go (or DTG at 1σ) depending on environmental and operational conditions.
- The heading, attitude, motion and position of the support vessel or buoy.

GAPS Operation Principles

The underwater objects or vehicles are located using acoustic transponders, GAPS acoustic array is deployed underwater and is typically mounted below the ship hull or on a buoy (see Figure 1).

Figure 1 - GAPS typical mounting

The operation principle is based on a bi-directional exchange of underwater acoustic signals between the acoustic transponders and the GAPS unit that comprises one transducer for transmitting and four reception hydrophones.

The GAPS has an operating field over 200 degrees coverage below the ship (see Figure 2). During the positioning operations it can be used at 3 or 4 knots or more depending on the expected performances and at 12 knots during the transit operations.

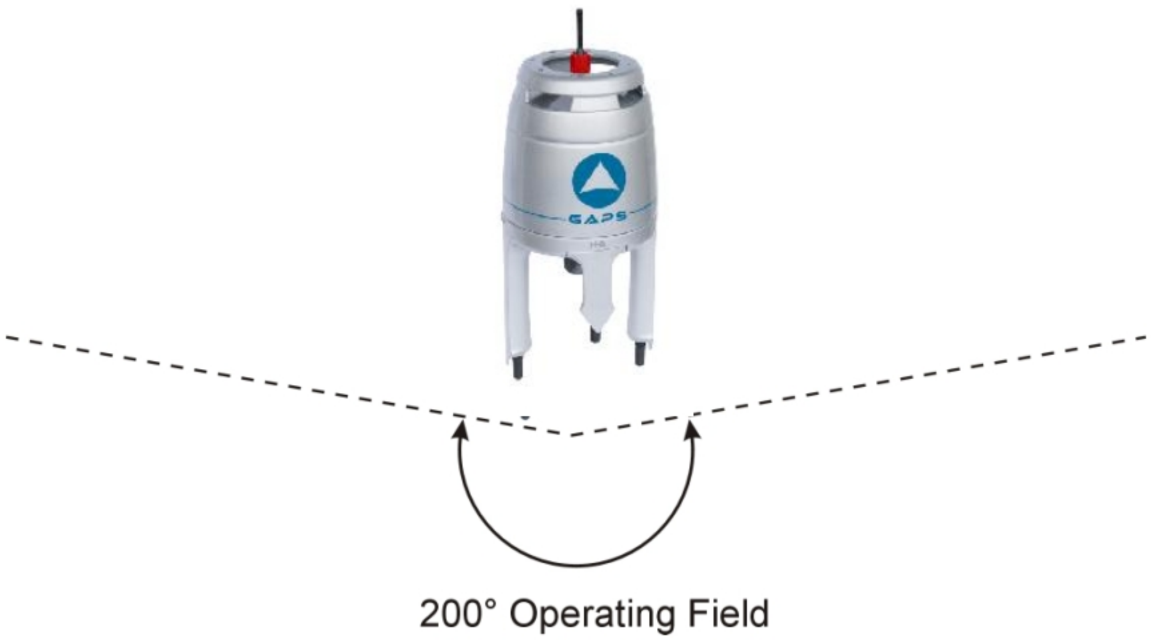

Figure 2 - GAPS Operating Field

I.2 Acoustic Positioning Principles

The positioning of the acoustic transponder(s) is performed as follows (see Figure 3):

- The transmitting transducer sends an interrogation signal to the transponder.
- The four receiver hydrophones of the GAPS unit receive the MFSK reply from the transponder.
- The GAPS processing unit
  - ❑ detects the signal,
  - ❑ measures the phases of the signals arriving at the four hydrophones and the elapsed time between the interrogation and the reply.
- GAPS takes into account the attitude of the acoustic array (provided by the internal fiber-optic gyros at the exact moment of the reception of the signal). The processing unit deduces the relative position of the transponder.
- The INS sensor also processes also the data coming from the DGPS antenna with its own gyros and acceleration sensors in order to accurately determine the absolute position of the acoustic array at the exact moment when the transponder signal has been received.
- The absolute position of GAPS is given by the GPS. The position of the transponder relative to GAPS position is computed. GAPS can then provide the accurate absolute position of the transponder.
- This absolute position feeds a Kalman filter, which is able to provide an estimation of the current position of the transponder in real-time.
- Additionally, the position, heading, roll and pitch of the acoustic array (or the ship) are available as output.

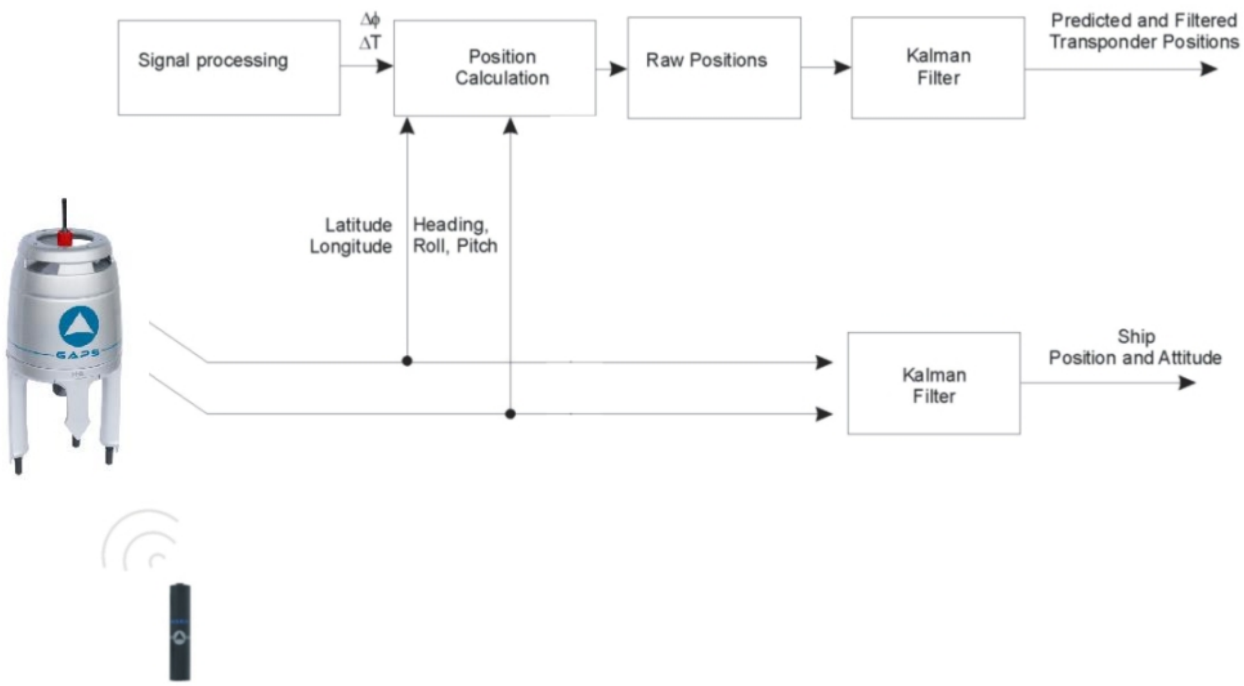

Figure 3 - GAPS Operation Synoptic

I.3 Technical Description

I.3.1 OVERVIEW

The GAPS system consists of four main parts (see Figure 4)

- The acoustic array, i.e. the **GAPS unit** (see section I.3.2)
- One or several **acoustic transponders** that can be mounted on objects, vehicles, divers etc. (see section I.3.3)
- The **DGPS** integrated antenna (see section I.3.4)
- **Man Machine Interface (MMI) software** used to configure (mandatory) and to monitor (optional) the real time data (see section III of this manual)

Other elements of the system are listed below:

ECB

A junction box named Easy Connect Box (ECB) simplifying the connections between the GAPS unit and other devices is also available (see section II.3 of this manual).

GAPS does not need any external sensor to provide the position of the transponders but depending on the conditions, external sensors – in particular a pressure sensor - can be used in order to

- Increase the accuracy in noisy environments
- Simplify the installation of GAPS

Control

The Control System is any PC on which the MMI Software is installed, it can be

- Either directly connected to GAPS through the MMI DIALOG RS 422 serial link
- Or to the MMI DIALOG RS232 serial link available on the junction box

The purpose of the Control System is

- To configure GAPS (input/output configuration, sound velocity profile, etc) if necessary
- To visualize the position(s) of the transponder(s)

The use of the Control System is not mandatory once GAPS is configured: GAPS stores all its settings when turned off and resumes its last behavior when started up.

Cables

Three cables are used in the GAPS system:

- The 50 m main cable between GAPS and the ECB. An optional length of 100 m is also available upon request. This cable is fitted with a 16-pin SUBCONN at one end (GAPS side) and a 19-pin SOURIAU at the other end (ECB side).
- The Y cable can be used to connect the GPS directly to the GAPS. A 6 pins SUBCONN end is connected to the GPS. The two other ends link the GAPS to the ECB using the 50 m main cable.
- The 10 m GPS cable links the Y cable to the GPS antenna. It is equipped with 6-pin SUBCONN connectors.

GPS If the expected accuracy of an external GPS is greater than the GAPS integrated DGPS, it is possible to connect it to the ECB (through the External GPS RS 232 serial link) and to use its positioning data. **In that case, the "Y" cable is not used.**

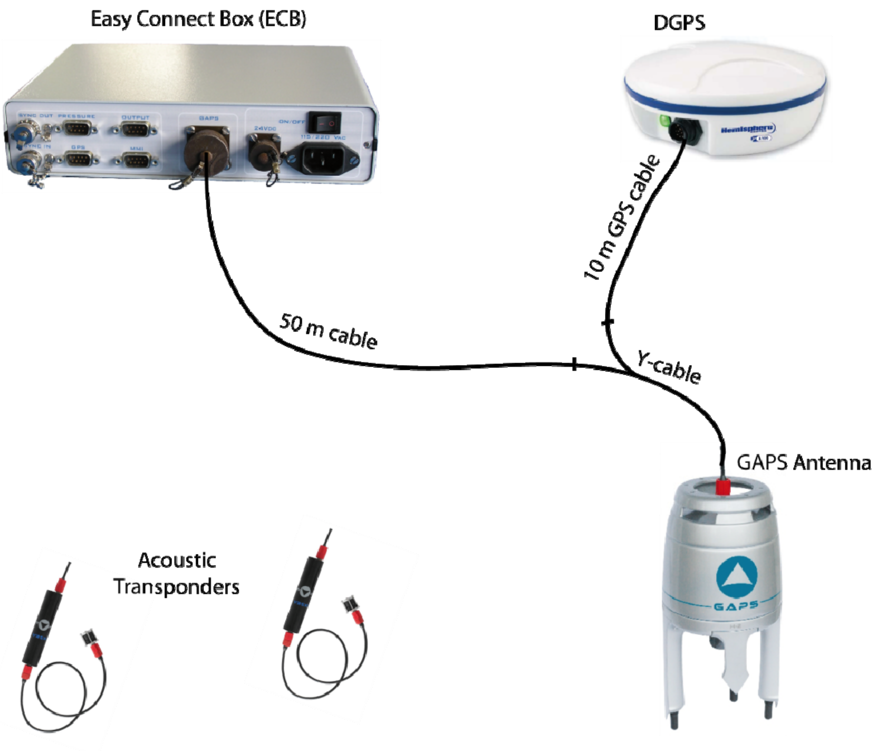

Figure 4 – GAPS System Components

I.3.2 GAPS UNIT

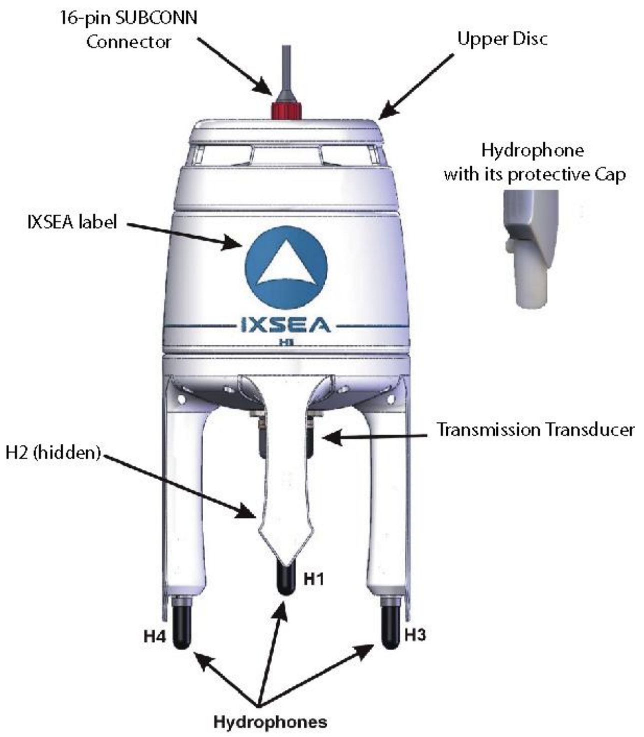

Figure 5 - GAPS Unit

Mechanical Description

GAPS has a carbon housing to deal with weight and mechanical characteristics. It is composed of (see Figure 5)

- An upper disk for handling
- A transmission transducer
- Four reception hydrophones of different lengths to take 3D measurements
- The four hydrophones are protected by plastic caps protect them
- A 16-pin SUBCONN connection plug

Contents

The GAPS unit contains:

- The acoustic electronics for reception based on the MSFK Chirp modulation technique
- An Inertial Navigation System (INS)
- The acoustic transmitter electronics

Power Supply

GAPS must be powered by a 28 to 36 V - 50W - DC power supply.

GAPS Unit

The GAPS unit ensures

- the transmission of The acoustic (or electrical) triggering signals to the Transponders,
- The reception of the replies,
- The processing taking into account the attitude provided by the fiber-optic sensor
- The transmission of the results.

I.3.3 ACOUSTIC TRANSPONDERS

Five different acoustic transponders are compatible with the GAPS system:

- **MT8**: the standard GAPS transponder, see a description in section I.3.3.1 and in the specific User Guide
- **ET8**: equivalent to the MT8 transponder with 10 times longer autonomy with larger dimensions, please refer to the ET8 User Guide
- **BT8**: directive transponder, configured only in factory (IIF, code), robust design, batteries inside, single recurrence value at 6.7 s, no responder mode, please refer to the BT8 User Guide
- **MT9**: the new generation transponder, compatible with MT8 and is configured using control software, use additional codes and batteries, please refer to the MT9 User Guide
- **ORE 435xB**: monochromatic acoustic transponder, please refer to the manufacturer User Guide

I.3.3.1 Acoustic Transponder MT8x2 and ET8x2 Series

The Acoustic Transponder series designed to be used with GAPS are:

- iXBlue MT 832 E – HD – R: Designed to depths up to 3,000 m (remote transducer)
- iXBlue MT 832 E – R: Designed to depths up to 3,000 m
- iXBlue MT 862 S – HD – R: Designed to depths up to 6,000 m (remote transducer)
- iXBlue MT 862 S – R: Designed to depths up to 6,000 m
- iXBlue ET 862 S – HD – R: Designed to depths up to 6,000 m (remote transducer)
- iXBlue ET 862 S – R: Designed to depths up to 6,000 m

Specifications

Acoustic Level

188 ± 4 dB ref. 1µPa at 1m (other levels 191 dB or 185 dB available).

Reception Channel (IIF)

The reception channel frequency, or IIF (Individual Interrogation Frequency) is selectable with a switch (19.5, 20.0, 20.5 or 21 kHz) located on the lower end plate of the transponder. This switch is also used to turn off the transponder or to check the batteries (Test position). Only one reception channel is available on this series of transponder.

Transmission Channel

When the transponder is triggered by an IIF signal (or electrically triggered), it replies with a MFSK chirp signal. This signal is composed of fourteen various pulses at frequencies ranging from 22 to 30 kHz.

Chirp Code

The order of transmission of these frequencies is determined by the code of the chirp (22 or 23). The default code is **22**.

Turn Around Time

There is a delay between the reception of the triggering signal and the transmission of the reply. See Figure 6.

In responder mode, this delay is fixed at 2 ms, when the switch position is 0 or 1 otherwise the settings are the same as in transponder mode.

In transponder mode, this delay is adjustable from 20 to 90 ms. When the switch, located inside the transponder (see the MT832 User Guide for further information) is in position

- 0 and 1, the delay is 20 ms
- N = 2 to 9, the delay is N x 10 ms

The default turn around time is **90** ms. See Figure 6.

Blanking Time

After having transmitted, no other transmission is possible for a certain time. See Figure 6. This period is called the blanking time and is adjustable from 0.5 to 9.9 s. The default blanking time is **0.8** s.

The Chirp Code, Turn Around Time and Blanking Time can be selected using the switches located inside the transponder (see the MT832 User Guide for further information).

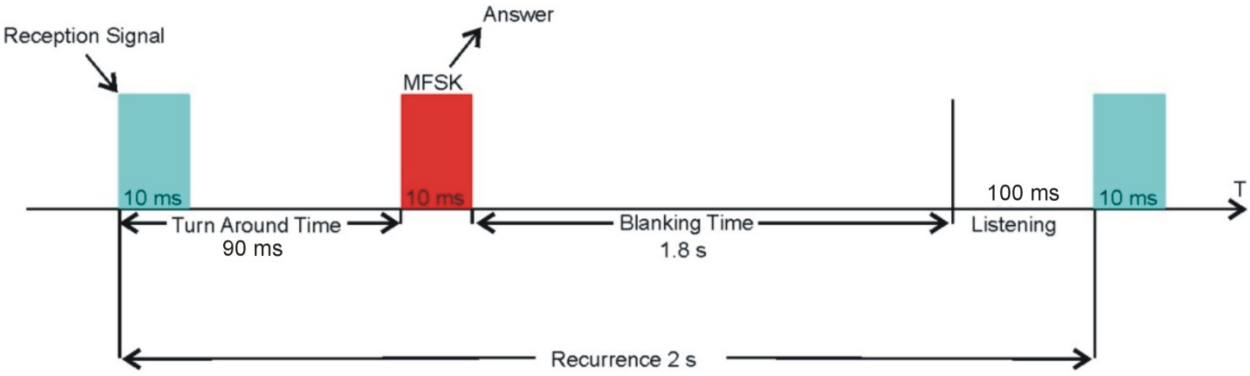

Figure 6 - Sketch of a 2 s Acoustic Transponder Recurrence

Optional Features

Responder Mode

Every iXBlue acoustic transponder with the letter "-R" at the end of its designation (e.g. MT 832 E**-R**) is equipped with a waterproof plug, that is used for:

- The Electrical Triggering of the transponder in Responder mode
- The External Power Supply of the transponder

Electrical Triggering

The transponder can be triggered by a 5 V differential active high signal (rising edge trigger) 10 ms pulse sent to this input (minimum value).

On the MT 832 series, there is no need to set the transponder either to transponder or responder mode: if an electrical triggering signal is received through the responder input, the transponder automatically switches to responder mode and the acoustic IIF channel is inhibited.

After 20 seconds without receiving any electrical trigger, the transponder switches back to the Transponder mode and starts to listen to its reception channel.

Power Supply

The transponder is usually externally powered. The batteries will be used only (and automatically) if the external supply is lost. With full batteries and transmission at 188 dB (factory settings), approximately 50,000 chirps can be sent by the transponder. The power can be raised to 191 dB to improve the range but in this case the maximum chirp number decreases. The power voltage can be any value from 15 to 40 V.

Table 1 - Power Supply Specifications for MT8x2 Series

External power Range	15 - 40 VDC, 20 W peak
Consumption	900 µA under 9 VDC and 550 µA under 25 VDC
Internal back-up batteries	3 packs of 3 Lithium batteries Type **DL123A** (size 2/3 A, ≅ 3.9 Ah) from **DURACELL** Type **CR123A** from **VARTA**

Table 2 - Power Supply Specifications for ET8x2 Series

External power Range	15 - 40 VDC, 20 W peak
Consumption	900 µA under 9 VDC and 550 µA under 25 VDC
Internal back-up batteries	3 packs of 6 Alkaline batteries type R20 (size D) ≅ 45 Ah On option Lithium (LSH20 from SAFT)

In standby mode, the backup battery packs offer **4 months** for MT8x2 series and **30 months** for ET8x2 series (with Alkaline batteries, 50 months with Lithium batteries). In operation, the backup battery packs offer the following **typical number of pulses transmitted** depending on Sound Power Level (SPL) and temperature (which applies from hardware version 4.7) and two types of battery pack, see Table 3 and Table 4.

Table 3 – Number of Chirps vs. Battery Types for MT8x2 Series

SPL in dB ref 1µPa at 1m (5 sec. transmit rate)	**185 dB**	**188 dB (default configuration)**		**191 dB**
Temperature (Celsius)	20°C	0°C	20°C	20°C
DL123A (DURACELL)	115,000	33,000	**47,000**	21,000
CR123A (VARTA)		40,000	**53,000**	

Table 4 – Number of Chirps vs. Battery Types for ET8x2 Series

SPL in dB re. 1µPa at 1m (5 sec. transmit rate)	**185 dB**	**188 dB (default configuration)**		**191 dB**
Temperature (Celsius)	20°C	0°C	20°C	20°C
Alkaline (Default configuration)	1 300,000	350,000	**550,000**	250,000
Lithium (LSH20)	2 300,000	700,000	**900,000**	410,000

Remote Transducer

Every iXBlue Acoustic Transponder with the letters "-HD" at the end of its designation (e.g. MT 832 E-R-HD, see Figure 7) has a transducer separate from its body with this separated transducer the transponder can be more easily installed on a underwater vehicle. It is also easier not to mask the acoustic transmission/reception head.

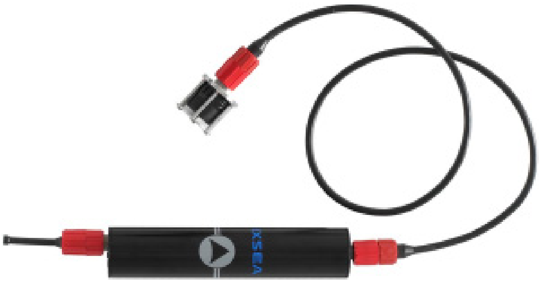

Figure 7 - Acoustic transponder MT 832 E–R-HD

I.3.3.2 Acoustic Transponder BT812 Series

BT812 Special Features

The technical features of the BT812 beacon are set in the factory and they are only modifiable in the factory.

- The interrogation frequency is fixed to F2 (20 kHz)
- The Chirp Code can be 22 or 23
- Turn Around Time is 25 ms
- The Blanking Time is 260 ms
- The iXBlue BT 812 S is designed for a depth up to 700 m

The BT812 beacon can neither have a remote hydrophone nor operate in responder mode. For more details, please refer to the BT812 User Guide.

I.3.4 INTEGRATED DGPS

The integrated DGPS has a WAAS / EGNOS / MSAS compatible active antenna. See the coverage of the three Satellite Based Augmentation Systems on Figure 9.

Figure 8 - Integrated DGPS

Figure 9 – WAAS, EGNOS and MSAS coverage

I.4 Conventions and Specifications

I.4.1 General Characteristics

Positioning

Characteristics	Values
Range depending on ambient noise and velocity	4,000 m
Coverage	200° below the acoustic array
Acoustic Level	192 +/-3 dB ref. 1 μPa/V
Operating frequency	22 to 30 kHz MFSK chirp modulation technique
Heading / Roll / Pitch accuracy needed	0.01°

Operating / Environment

Characteristic	Value
Power supply / consumption	28 to 36 V DC / 35 W (45 W at starting up)
Operating temperature	-5 °C to 35 °C
Storage temperature	-20 °C to + 70 °C

I.4.2 Geometrical Conventions

Vessel Attitude

The Figure 10 shows how the Roll, Pitch and Heading are measured on the ship and the signs of these angles.

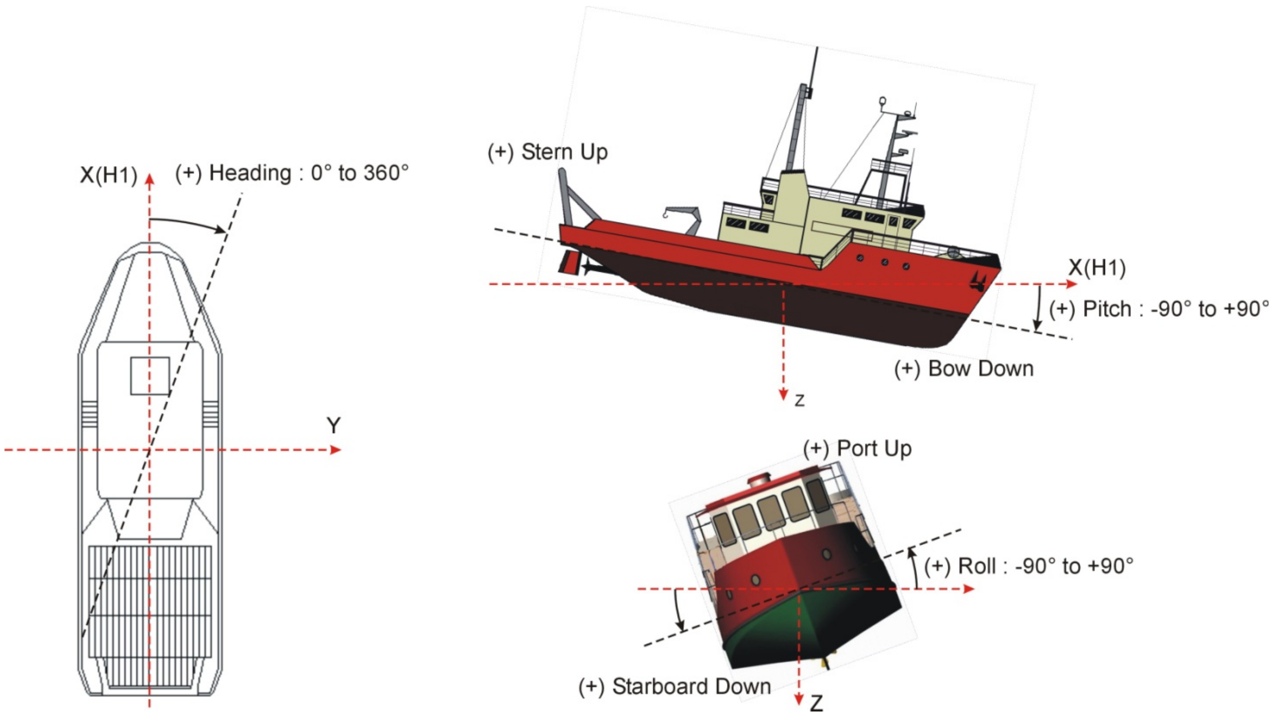

Figure 10 – Vessel Attitude Definition and Signs

Hydrophones

The GAPS reference frame is based on the H1, H2, H3 and H4 hydrophones.

The hydrophones are numbered as follows (see Figure 11):

- H1 is a short arm hydrophone, it is written H1 on it
- H2 is the short arm hydrophone located to the opposite of H1 short arm hydrophone
- H3 is the long arm hydrophone located on the right when H1 hydrophone faces you
- H4 is long arm hydrophone located to the opposite of H3 long arm hydrophone.

Figure 11 - H1, H2, H3 and, H4 hydrophones

Reference Axes

The axes in the GAPS reference frame are as follows (see Figure 12 and Figure 13):

GAPS being in vertical position,

- H1 & H2: longitudinal axis (X) – H1 in front (positive)
- H3 & H4: transverse axis (Y) – H4 on starboard (positive)
- Z-axis positive towards the sea bottom

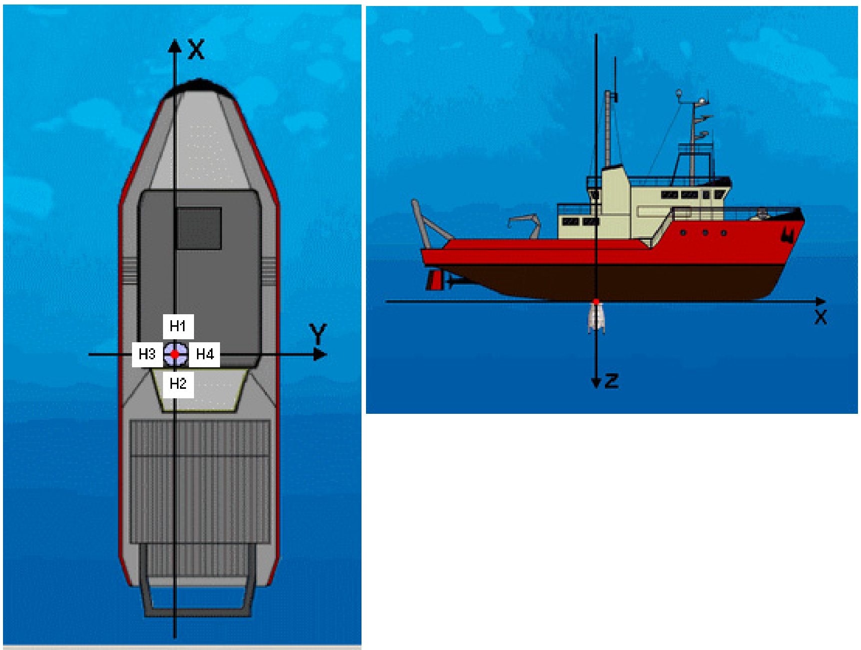

Figure 12 - GAPS reference axes

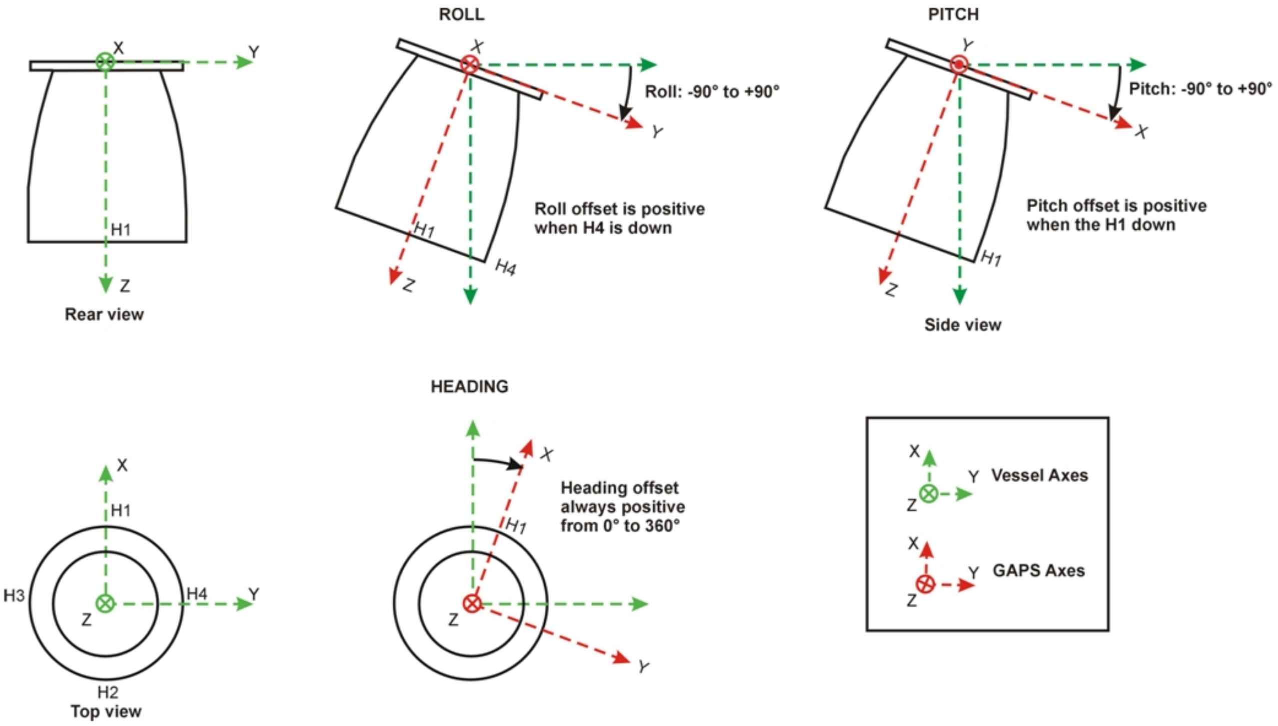

Figure 13 - GAPS angular offsets

TO INSURE COMPATIBILITY WITH OUR EXISTING SYSTEMS AND SOFTWARE, THE CONVENTION USED FOR THE X AND Y AXES (SEE FIGURE 12 AND FIGURE 13) MAY BE DIFFERENT FROM THE CONVENTION USUALLY USED (X TO THE BOW, Y TO PORT, Z UPWARD).

I.4.3 MECHANICAL SPECIFICATIONS

Table 5 - Acoustic Antenna

Characteristics	Values
Housing	Carbon
Weight in air / water	16 kg / -7 kg
Housing diameter x H (mm)	296 x 638 (fits in 12” gate valves)
Array depth-rating	25 m

Table 6 - Acoustic Array Cable 50 m (± 1.5m)

Connector SUBCONN on GAPS side	16 pins diameter connector 26 mm diameter locking sleeve 35.5 mm
Connector Souriau on ECB side	diameter 26 mm 19 pins
Cable Diameter	15 mm
Dynamic Bend Radius	150 mm
Static Bend Radius	75 mm
Breaking Strain	150 DaN

THE GAPS CABLE IS NOT A TOW CABLE.

I.4.4 ELECTRICAL SPECIFICATIONS

Connection You can find below a table describing the connections of all the 19-pins SOURIAU connector (see Figure 14) connecting the main cable to the ECB (see Table 7).

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OH OG OF

Figure 14 - 19 PINS Souriau socket (Ref. 851 06EC1419S50)

Table 7 - Association of the SOURIAU 19-pin, SUBCONN 16-pin and signals

MINI SUBCONN	SOURIAU 851	Signal
1	M	PWR +
2	B	PWR GND
3	C	SYNCHRO IN +
4	P	SYNCHRO IN -
5	N	SYNCHRO OUT - RESPONDER MODE +
6	L	SYNCHRO OUT - RESPONDER MODE -
7	D	OPTIONAL EXTERNAL PRESSURE SENSOR IN RS 422 –Rx+
8	R	OPTIONAL EXTERNAL PRESSURE SENSOR IN RS 422 –Rx-
	A	PRESSURE SENSOR WIRES SHIELD
9	E	MMI DIALOG INPUT – RS 422 –Rx+
10	S	MMI DIALOG INPUT – RS 422 –Rx-
11	T	MMI DIALOG OUTPUT – RS 422 –Tx+
12	J	MMI DIALOG OUTPUT – RS 422 –Tx-
	F	MMI WIRES SHIELD
13	U	OPTIONAL EXTERNAL GPS MESSAGE INPUT – RS 422 –Rx+
14	K	OPTIONAL EXTERNAL GPS MESSAGE INPUT – RS 422 –Rx-
	V	GPS WIRES SHIELD
15	G	STANDARD OUTPUT – RS 422 –Tx+
16	H	STANDARD OUTPUT – RS 422 –Tx-

External Power Supply

GAPS must be electrically powered by a 28 to 36 V / 50W DC source. See Figure 15.

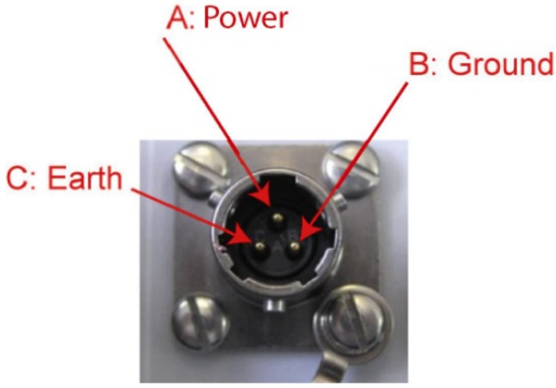

Figure 15 – 28 to 36 V power supply 3-pin SOURIAU plug

The whole system (GAPS+ECB+PC) must be powered by a 110-220 V / 50Hz source (consumption: less than 50 W).

End User System

The positioning messages are available on the Standard Output RS 422 serial link (cable output) or on the RS232 serial link (ECB output). These four DB9/RS232 ECB input/output (Pressure IN, MMI IN and OUT, GPS IN, Output OUT) are used with straight cables. Baud rate, parity and, bit stop are adjustable in the MMI Software (see Part IV of this manual).

Control System

A RS422 or a RS232 (ECB) serial link is necessary to connect the MMI DIALOG link (baud rate 57,600, parity odd and stop bit 2 are fixed).

Responder Mode

The SYNCHRO OUT – Responder mode signal is sent to the transponder if the responder mode is activated. Two types of signal are available:

- A differential triggering signal is sent from the BNC of the front face of the ECB.

- A TTL triggering signal is sent from the BNC of the rear face of the ECB.

Table 8 – TTL and differential synchro out signals

	TTL	Differential
Synchro OUT +	0 / 5 V	0 / 3.5 V
Synchro OUT –	0 V	0 / -3.5 V
(Synchro OUT +) - (Synchro OUT –)	0 / 5 V	0 / 7 V

A TTL signal can independently trigger a TTL and differential input.

A differential signal cannot trigger a TTL input.

The simultaneous output of two different signals allows the independent triggering of both MT8 and MT9 transponders (from all possible configurations).

Most of the time, these signals have to be re-amplified between GAPS and the transponder. There can be a delay between the transmission of this signal by GAPS and its reception by the transponder.

The Table 9 below describes the compatibility between the different types and versions of iXBlue transponders with the different versions of the ECB.

Table 9 – Compatibility between ECB and transponders

	MT8	**MT9** before 02/2012	**MT9** after 02/ 2012
ECB before 09/ 2010	**OK**	**OK**	**OK**
ECB between 09/ 2010 and 01/ 2012	**OK**	**NOK**	**OK**
ECB after 01/ 2012	**OK**	**OK** rear of ECB **NOK** front of ECB	**OK**

IF YOU ARE IN ONE OF THE SITUATIONS OF INCOMPATIBILITY DESCRIBED IN THE TABLE 9, CONTACT IXBLUE TECHNICAL SUPPORT.

External Synchro

The SYNCHRO IN (external) triggering signal is an active high pulse longer than 100 µs (0 - 5 V). The GAPS is triggered on the rising edge.

The duration between two consecutive SYNC IN pulses must be greater than 1 s.

Electrical level	**Active High**	**Length**
0 - 5 V		≥ 100 µs

If GAPS is triggered from the outside and in responder mode, with a transponder in responder mode triggered on the sync IN input (the triggering pulse length must be higher than 5 ms), the synchro shift between the recurrence and the transponder will last 1 s maximum. For this reason, it is strongly recommended to trigger the transponder on the Sync OUT.

External GPS

If used, an external GPS has to be connected to the external optional GPS message input RS 422 serial link or RS232 when using the ECB.

Baud rate (maximum 57,600 bauds), parity and bit stop are adjustable from the MMI Software.

The message expected by GAPS is the standard NMEA $xxGGA message (see section VI.1.1) and xxZDA (see section VI.1.2) is automatically taken into account for the update of the GAPS internal time if available. “xx” means that the first two letters of the format name can be any letter.

II INSTALLING GAPS

Before installing GAPS for the first time, it is recommended to check the contents of the boxes delivered (see section II.1). The installation is achieved in four steps:

- Installing the GAPS antenna, see section II.2
- Installing the Easy Connect Box, see section II.3
- Installing the DGPS Antenna, see section II.5
- Installing a Transponder, see section II.6

II.1 Checking of the Pack Contents

You have just received your equipment in protective boxes. Before starting the installation, **we recommend that you check the contents of the pack and the equipment immediately on receipt of your GAPS System**. Check that all items are present on delivery and that none has been damaged during shipping.
Use the packing-list detailing all the shipped items. This packing list was compiled by iXBlue shortly before shipment.

ON RECEIPT OF THE EQUIPMENT, ITS OVERALL CONDITION SHOULD BE CHECKED AND IXBLUE INFORMED OF ANY DAMAGE SUFFERED DURING SHIPPING. CHECK THAT EVERY PARCEL SHOCK LABEL IS STILL WHITE. IN THE OPPOSITE CASE IT IS HIGHLY RECOMMENDED TO CONTACT THE INSURANCE COMPANY.

NEVER OPEN THE GAPS UNIT.

II.2 Installing the Acoustic Antenna

II.2.1 Recommendations Prior to Installation

Containing its own attitude sensor, GAPS can be installed at the location and in the position that best suit the operational constraints.
Nevertheless, some factors concerning the installation can **decrease** the final global performances of the system if they are not taken into account.

II.2.1.1 Noise Level

As with every acoustic system, the noise generated by the environment can decrease the performance of the system. Range and accuracy of the positioning greatly depend on the signal to noise ratio.
On a ship, it is recommended to install the GAPS unit in the front third of the ship (in order to decrease the noise level from the propeller) and as far as possible from any water discharge system.

II.2.1.2 Reflective Surfaces

Even though the MFSK signal treatment strongly increases the multi-path immunity, there are still situations where the direct signal detection is disturbed by reflective signals.
To avoid such cases, it is recommended that GAPS is kept at least 1 m away from reflective surfaces.
The sea surface may be considered as a reflective surface depending on the depth of the transponder: if both the transponder and the acoustic array are close to the surface, there will be multi-path phenomenon at specific distances.
The transponder depth is usually an operational constraint and therefore difficult to change. In that case, it is recommended to increase the depth of GAPS.
For deep-water applications (more than 250 m), a depth of 1 m is usually enough for the acoustic array. For more details about GAPS performances versus depth, see section IV.1.

II.2.1.3 Corrosion

An electrical equipment which operates underwater like GAPS is submitted to differences of potential that can lead to the corrosion of the mechanical structure of the antenna.

It is your responsibility to minimize the differences of potential between the GAPS antenna and the surrounding structures. The GAPS antenna must benefit from the electrolytic protection of the vessel.

Depending on the electrical installation of the different vessels (for example pole connected to the ground or not), it is possible to change the ground configuration of the GAPS in the ECB. This operation must be done by an iXBlue engineer, during the installation of the equipment. See section II.4 for more details.

CONTACT IXBLUE TECHNICAL SUPPORT IF YOU NOTICE CORROSION DAMAGES ON THE EIGHT TITANIUM SCREWS HOLDING THE GAPS OR DIRECTLY ON THE ANTENNA HOUSING (BLISTERS OF THE PAINT FOR EXAMPLE).

II.2.2 INSTALLATION PRINCIPLES

Orientation

When you set up GAPS on the ship, **the hydrophone H1 (see Figure 16) must be oriented towards the bow**. Positioning H1 towards the bow generates more drag but, in this position, the acoustic noise is reduced.

Figure 16 - GAPS H1 hydrophone location

Insulation

In case GAPS is fixed on metallic plates of different materials (electro-chemical potential, aluminum for example) it is necessary to electrically insulate it in order to avoid any electro-galvanic reaction that will result in structure corrosion and GAPS acoustic array fouling.

Location

The location requirements for the GAPS antenna are listed below:

- There must be enough place for the wire way on the connector side of GAPS
- GAPS can be fixed using the eight M8 screws, however as there are several possible deployments (see section II.2 for how to install your GAPS unit).

Mechanical Plans

The mechanical plan of the antenna is displayed on Figure 17.

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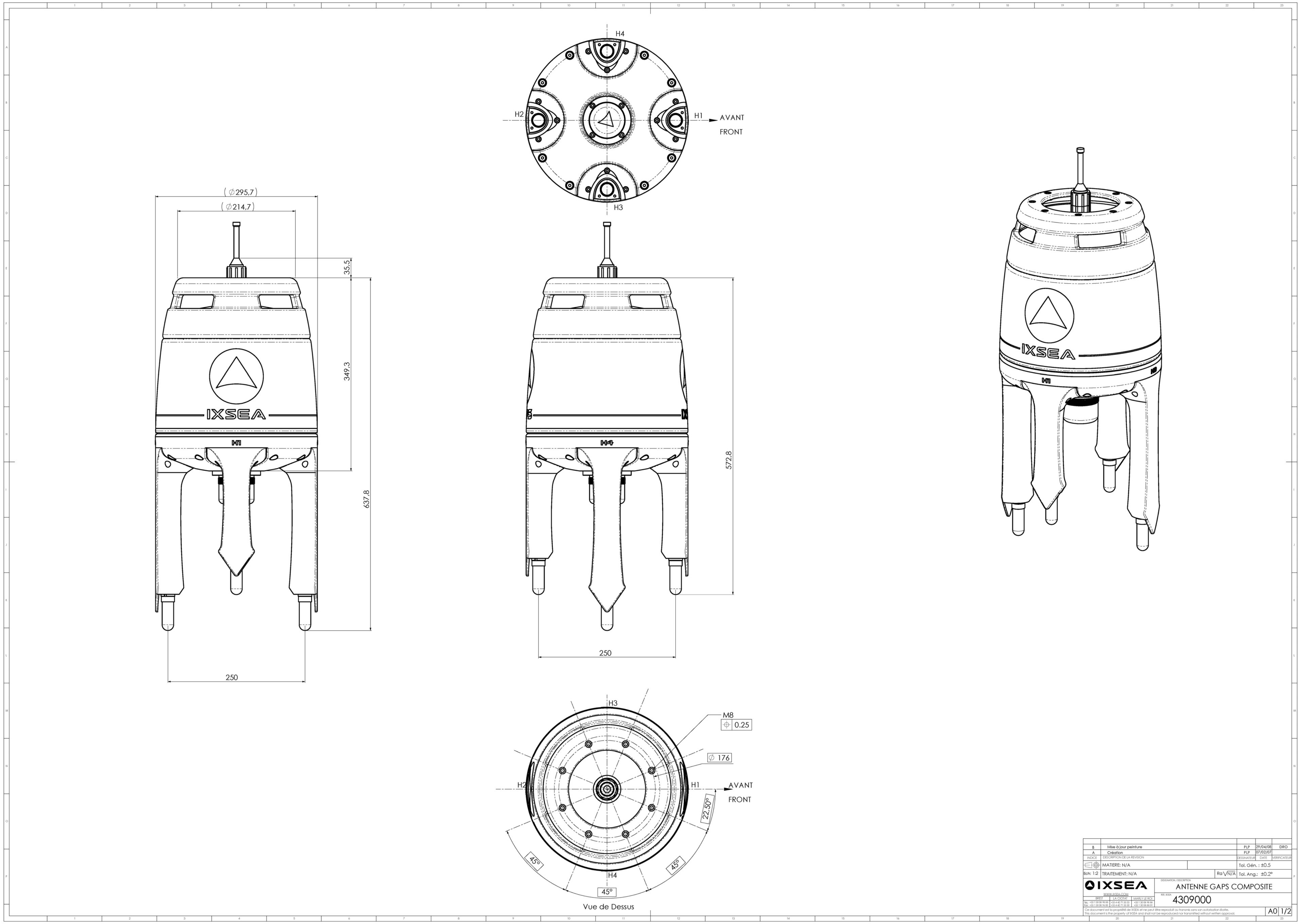

Figure 17 – GAPS Mechanical Plan

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II.2.3 Deployment Examples

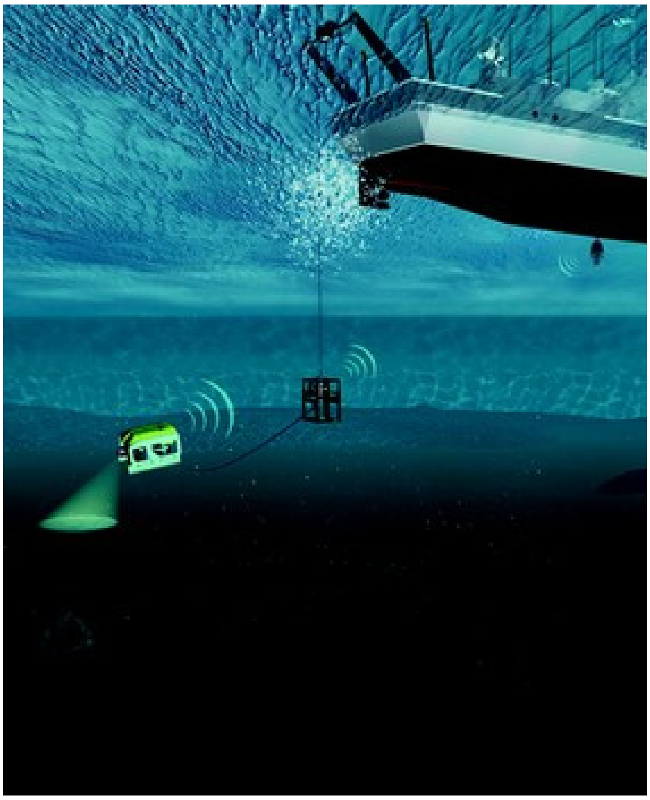


Figure 18- GAPS fixed on the hull and a transponder on a ROV

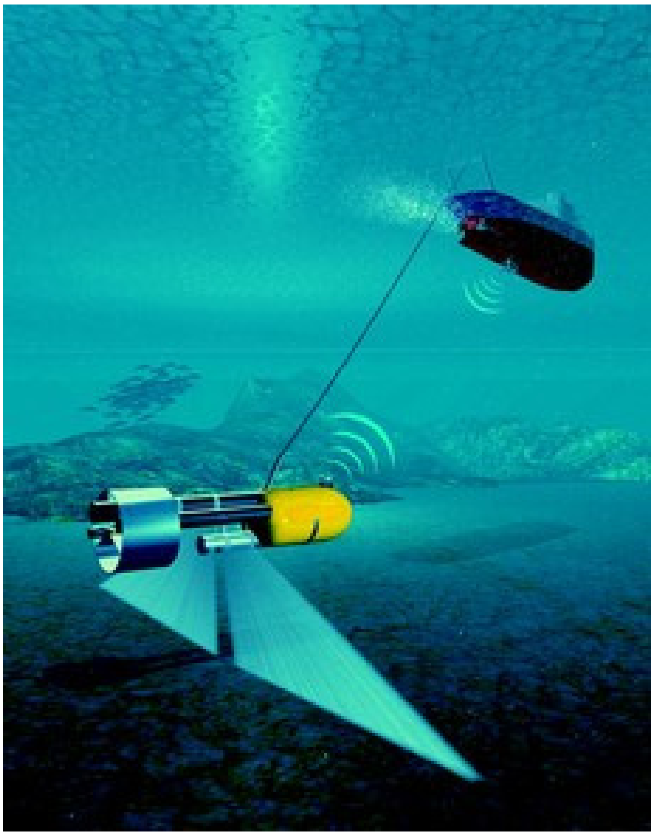


Figure 19 GAPS fixed on the hull and a transponder on a tow fish

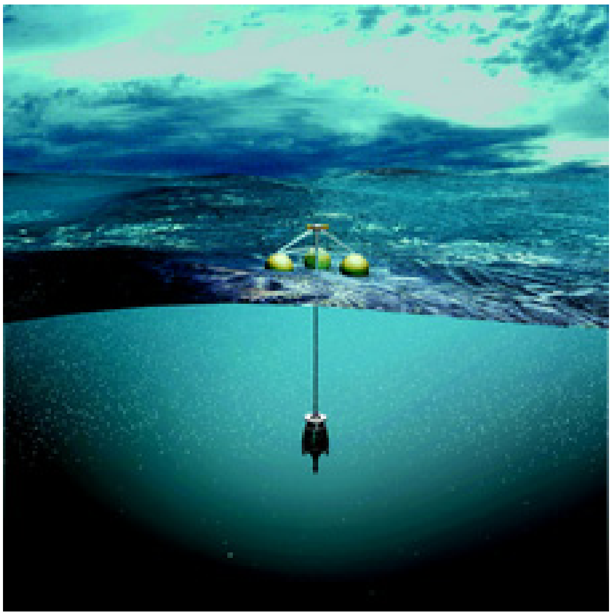


Figure 20 - GAPS mounted under a tripod

Figure 21 - Transponder fixed on a scuba cylinder

Figure 22 – GAPS inside a hoisting pool

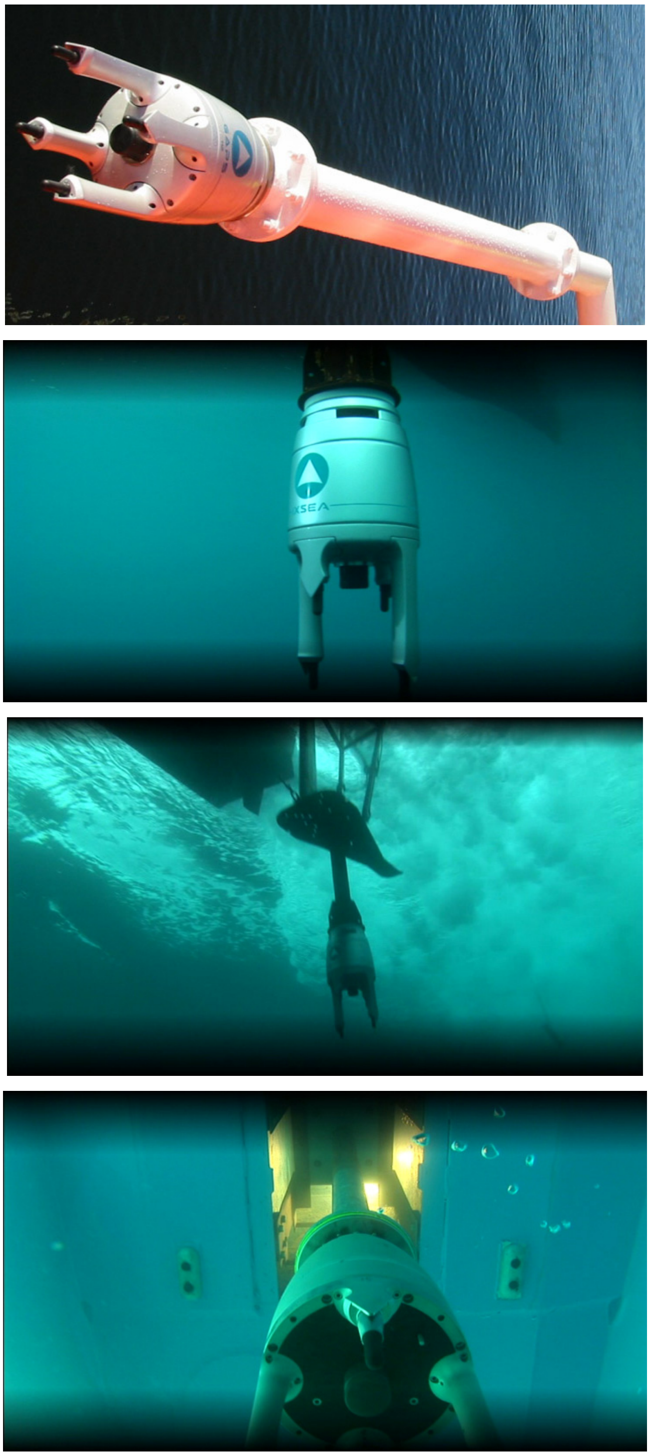


Figure 23 - Different installations on a pole, underneath the keel or in a moon pool

II.3 Installing the Easy Connect Box

The connections between the different devices can be set up through the iXBlue junction box called 'Easy Connect Box' (ECB). See Figure 24. Through the Easy Connect Box, you can set up all connections between the different devices of the system.

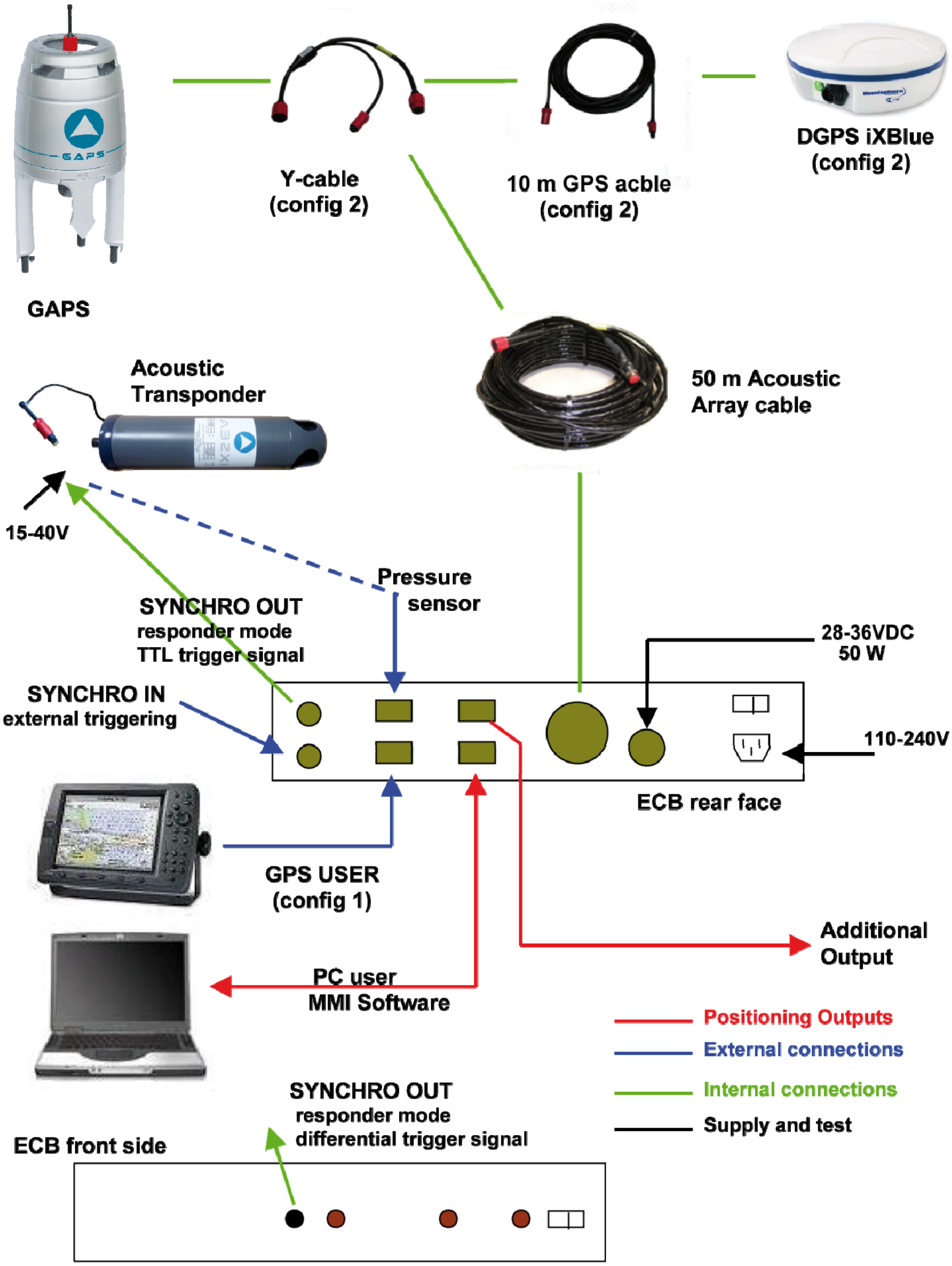


Figure 24- GAPS System Architecture

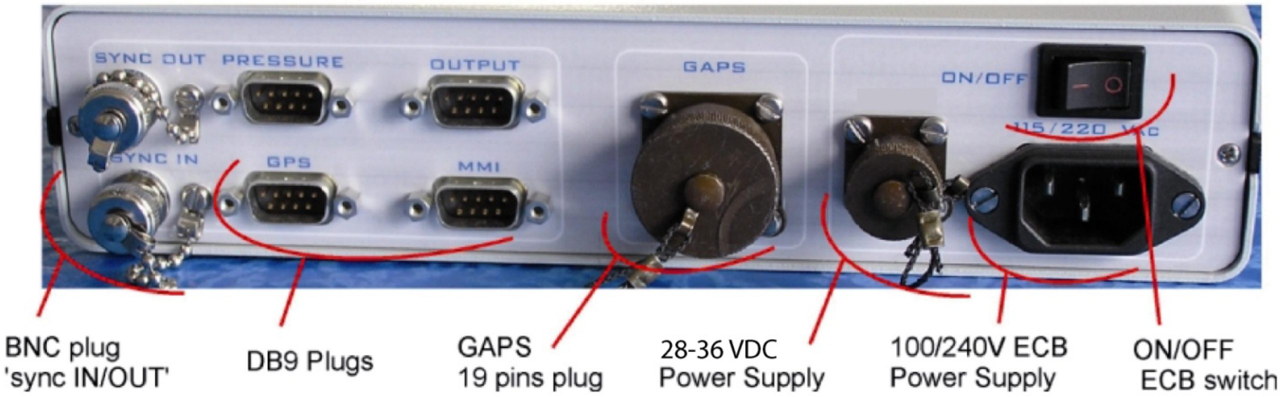


Figure 25 - ECB Box, Front Face and Back Face

II.3.1 CONNECTIONS ON THE FRONT FACE

From left to right (see Figure 25):

- BNC SYNC OUT plug with its status light triggers the transponder in responder mode with a differential signal
- Power status light for ECB (ON/OFF switch on the back)
- ON/OFF switch for GAPS with its status light

II.3.2 CONNECTIONS ON THE BACK FACE

From left to right (see Figure 25):

- 2 BNC plugs for
  - ❑ SYNC OUT to trigger the transponder in responder mode with a TTL signal
  - ❑ SYNC IN GAPS acoustic recurrence triggered by an external device (side-scan sonar for example)
- 4 DB9 plugs for RS232 Serial Links (use of straight cables)
  - ❑ Input connection to the PRESSURE sensor, the input configuration of which being Baud rate = 19200 bps, Data Bits = 8, Parity = none, Stop Bit =1
    Note: 10 dBar correspond to 0 m and 20 dBar correspond to 10 m depth.
  - ❑ OUTPUT of position and attitude available in various formats
  - ❑ Input/output MMI connection to the user PC for configuration and real-time control

- Input GPS connection to an external GPS receiver

- The GAPS 19-pin plug for the Acoustic Array cable
- The 28 to 36 V - 50W DC (2A) ECB power supply plug
- The 100 to 240 V, 50-60Hz ECB power supply plug, automatically detected, no adaptation needed
- The ON/OFF switch for ECB

Both 100 – 240 V and 28 – 36 VDC ECB power supply inputs can be connected simultaneously. The 100 – 240 V is converted into 28 VDC. The ECB automatically switches on the highest voltage input between the 100 – 240 V converted and the 28 – 36 V.

The ECB is supplied with a female connector on which can be welded a 28 – 36 VDC power supply cable of your own. See the connector in Figure 26.

Figure 26 – Female Connector for ECB 28 – 36 VDC Power Supply

II.4 Checking the Electrical Ground Continuity

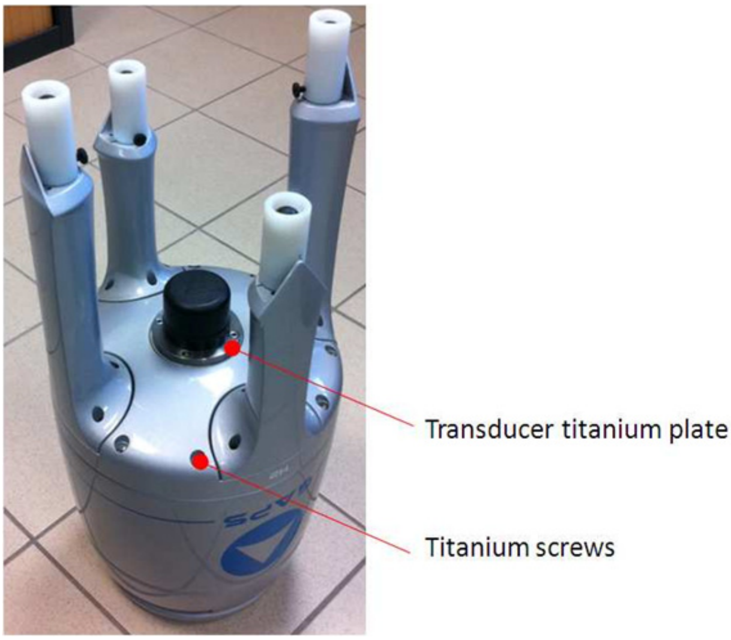
You must ensure that the electrical installation is correct in order to prevent the antenna from corrosion. Before proceeding to the test, please make sure that you have:

- Installed the GAPS acoustic antenna
- Installed and powered the ECB
- Connected the cable between the ECB and the acoustic antenna

The test consists in measuring the voltage between the GAPS antenna and the hull of the ship with a multitester.

Procedure

Step	Action
1.	Put the first probe of the multitester on a conductive part of the housing of the GAPS antenna. It can be the transducer titanium plate or the titanium screws.



Step	Action
2.	Put the second probe on a conductive part of the ship hull.
3.	Read the voltage between these two points. *The voltage must be below 1.0 V.*
4.	End of procedure.

If the voltage between the GAPS antenna and the hull of the ship is below 1.0 V, the system is electrically well installed.

IF THE VOLTAGE BETWEEN THE GAPS ANTENNA AND THE HULL OF THE SHIP IS **GREATER THAN 1.0 V**, CORROSION WILL IMPACT YOUR SYSTEM. A MODIFICATION MUST BE MADE IN THE ECB TO CHANGE THE ELECTRICAL GROUND CONFIGURATION. TO DO SO:

CONTACT IXBLUE TECHNICAL SUPPORT. SEE COORDINATES PAGE 133.

II.5 Installing the GPS Antenna

The integrated DGPS antenna has to be fixed (see Figure 27). You can use a mast (not provided) to do it.

Figure 27 - DGPS antenna installation

Two configurations are possible:

- With the ship GPS (see config. 1 on Figure 24)
- With the DGPS provided by iXBlue (see config. 2 on Figure 24)

II.5.1 Installing an External GPS

In this case, you must not use the Y-cable to be plugged to the GAPS. Plug your GPS directly on the ECB via the GPS DB9 plug or on your Souriau socket of your acoustic array cable if you do not use an ECB.

II.5.2 Installing the iXBlue DGPS

The DGPS DB9 plug of the ECB is not used in this case. Plug the 10 m GPS cable on the Y-cable then the DGPS.

II.5.3 MEASURING THE GPS LEVER ARMS

GPS Antenna Lever Arms

Even though it is designed to work in the vertical position, GAPS acoustic array can be tilted if necessary and also be placed in the horizontal position.

To calculate the absolute position of a transponder, GAPS needs to know its own position. This information is provided by the GPS, either the integrated or an external one. In both cases, the offsets between the GPS antenna and the GAPS acoustic array must be known.

When GAPS is tilted, the three offsets between the GPS antenna and the acoustic array have to be entered accurately. When GAPS is in horizontal position, the axes are inverted, the attitude outputs are then irrelevant.

There are 2 different solutions to install the GPS antenna with different implications on the mounting of the acoustic array:

- GPS antenna right above GAPS
- GPS antenna not exactly above GAPS

GPS Antenna Above GAPS

Connected with a Rigid Link

This is typically when GAPS is mounted on a mast or held by a rigid pole.

When GAPS is vertical, all the offsets between the GPS antenna and the acoustic array are set to 0 except the height (h) which must be entered accurately in order to calculate the position offset when the system attitude changes.

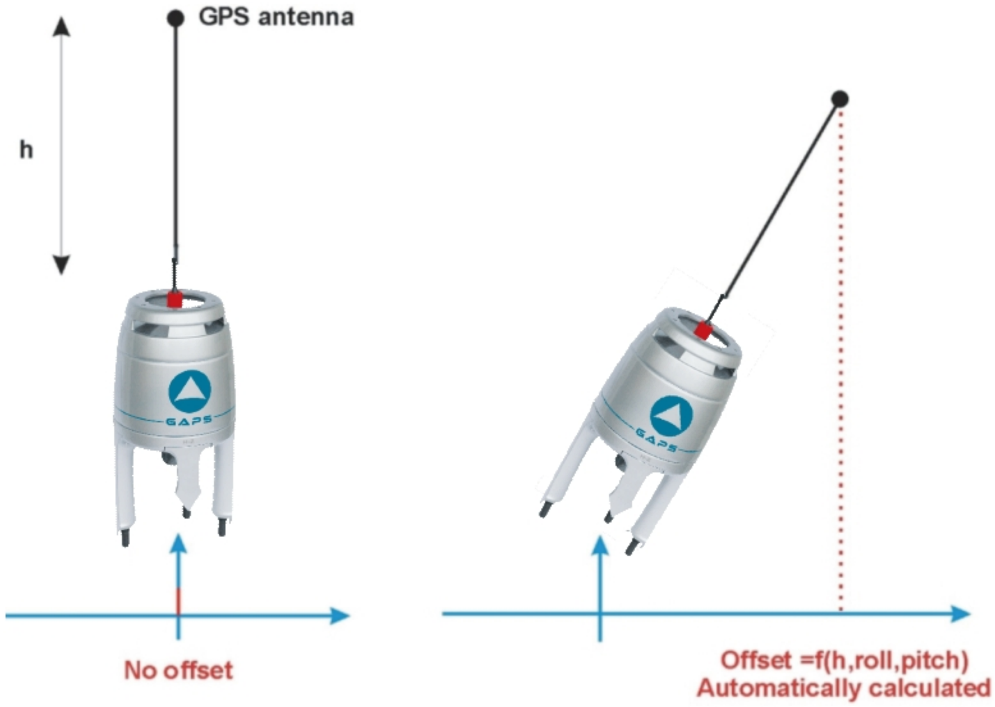


Figure 28 - Vertical GPS Antenna Lever Arm

Connected with a flexible link

This is typically when GAPS is held by a rope.

In that case, the height value (h) must also be set to 0 (to avoid the calculation of the offset). The accuracy of the positioning will decrease if the position of GAPS relative to the GPS antenna changes.

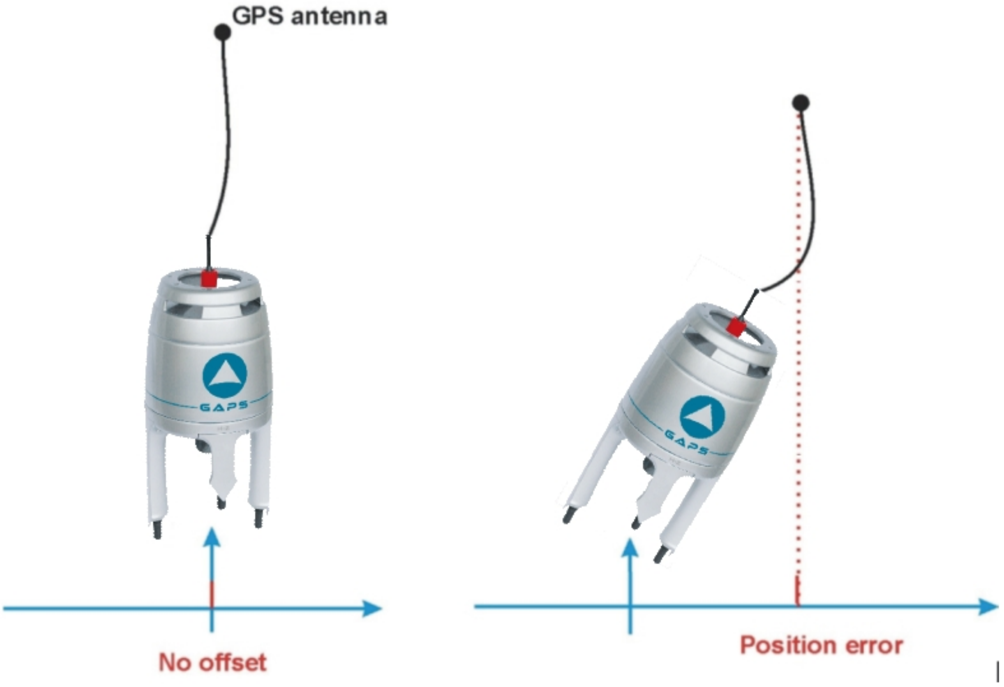


Figure 29 - Vertical GPS Antenna Lever Arm

GPS antenna not above GAPS

When the GPS antenna is not located right above GAPS, its position in the GAPS frame has to be determined. The definition of these lever arms, Xgps, Ygps and, Zgps is given in Figure 30.

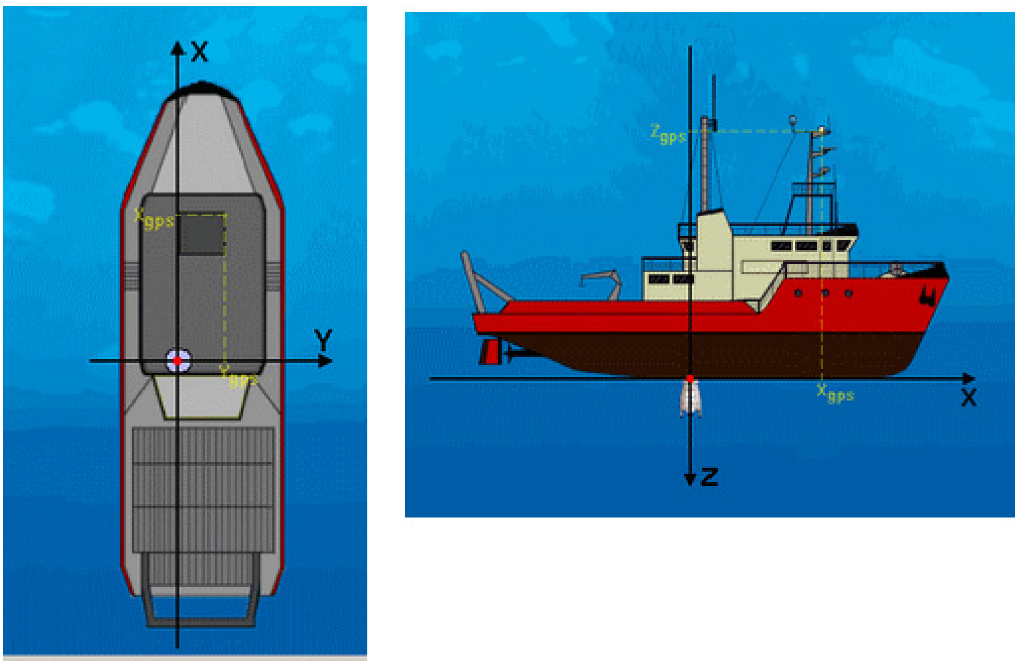


Figure 30 - GPS antenna Lever Arms (antenna not above GAPS)

In this case, the heading of the acoustic array must be fixed and known. No matter if this heading is not the same as that of the ship (yet it will have to be taken into account if GAPS is also used as an onboard gyrocompass), but its value must be known in order to calculate the position of the GPS in the GAPS reference frame (see Figure 31).

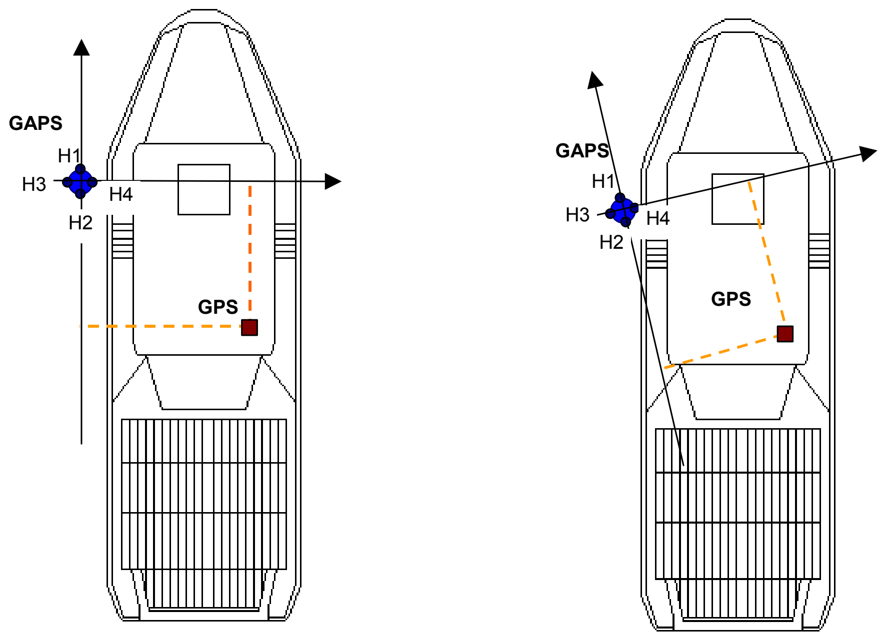


Figure 31 - Same headings (on the left) and different headings (on the right) for GAPS and ship

- If the GAPS H1-H2 axis is not parallel to the ship aft forward axis, two options are possible to enter the GPS offsets with respect to the GAPS reference system:
- Enter the offset distances of the GPS with respect to the ship reference system shifted above the GAPS antenna. Then enter the angular offsets of the GAPS reference system with respect to the ship reference system using the antenna offsets tool box window.

ENTER THE OBSERVED OFFSETS VALUES AND NOT THE CORRECTION TO BRING TO THE OFFSETS.

- Enter the distances offsets of the GPS antenna directly in the tilted GAPS reference system

The closer GAPS is to the GPS, the better is the accuracy of the measurement of the heading of the acoustic array.
It is the same for the roll and pitch if the GAPS is intentionally not in the vertical position.
Measure the position of the GPS reference point with respect to the reference frame linked to the GAPS unit. Measurement is performed along the three axis Xgps, Ygps, Zgps (see section I.4.2 for the definition of the GAPS reference frame).
The required precision on the lever arm is below 10 cm. See Figure 32.

Figure 32 – Measure of GPS lever arms with respect to GAPS

II.5.4 SETTING THE GPS TIME

GAPS automatically updates its internal time. No menu in the MMI software enables you to do it. Two cases can occur:

- Either the GPS is used as a reference. In this case, the GPS must be configured in order to send ZDA frame (with a minimum rate of 1 s). As no PPS signal is used, the precision reached is equal to ± 15 ms after the PPS signal
- Or if no ZDA frame is received by GAPS, the last time recorded by GAPS is used.

If the GPS do not deliver ZDA strings, then the time is taken from the GGA strings and the precision of the positioning is still less than 1 second.

II.6 Installing a Transponder

The transponder is installed on the fixed or the mobile device that you are going to track. The installation depends mainly on your equipment. Keep in mind that the transponder head must be as much as possible

- Free from obstacles
- Directed towards the hydrophones of the GAPS antenna.

See installation examples in section II.2.3.

See section IV.2.4 to bring the transponder in operation.

III CONFIGURING GAPS

GAPS System is controlled by a user PC on which the Man Machine Interface software is installed. All its functionalities are described in this section.

III.1 Installing the Man Machine Interface

Required environment

To set GAPS, the Man Machine Interface software provided with the system must be installed on a PC.

The minimum PC configuration must be:

- Pentium III or Celeron 800 MHz
- 512 Mo RAM
- 20 Mb Hard Disk
- 1024 x 768 screen (the screen must be configured with a character size of 96 ppp)
- Microsoft Windows ™XP, VISTA and SEVEN

The installation of the Man Machine Interface cannot be achieved elsewhere than in the `C:/Program Files/IXSEA` folder. In foreign versions of the operating system, the `C:/Program Files` folder may not exist. Please make sure to create it before running the installation procedure.

Procedure

Step	Action
5.	Insert the MMI software CD-ROM in the CD-ROM drive. *The installation should start automatically otherwise double click on Setup in the CD-ROM directory.*
6.	Follow the instructions displayed on screen. *Once the installation is completed, an IXSEA\GAPS MMI directory is created in the default file C:/program files on your computer.*
7.	End of procedure.

On Windows SEVEN and VISTA, make sure to edit the security properties of the `iXSea` folder and all sub-folders so writing in these folders is allowed.

III.2 Overview of the Man Machine Interface

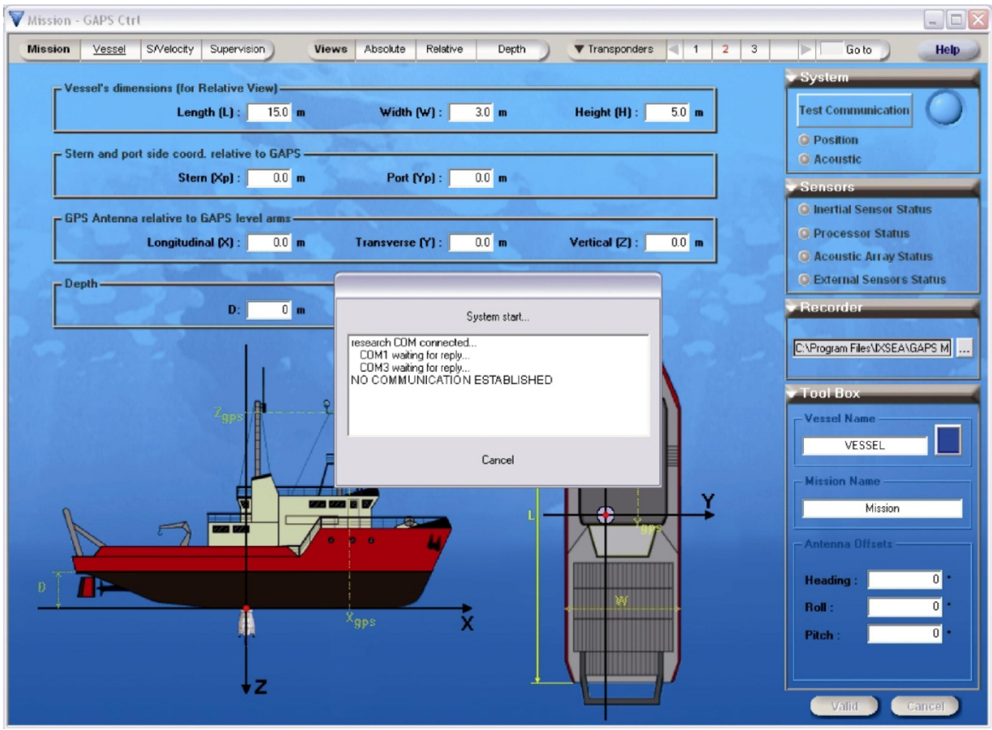
III.2.1 STARTING THE MAN MACHINE INTERFACE

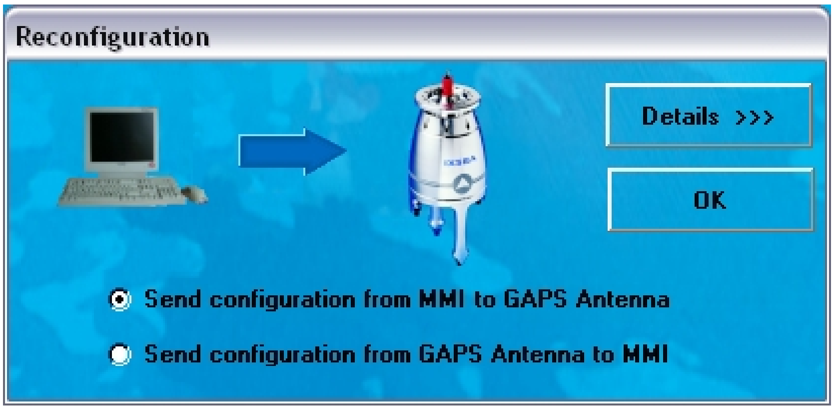
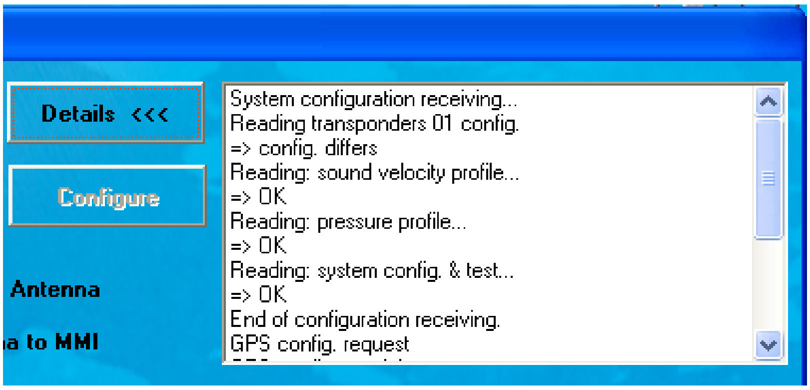
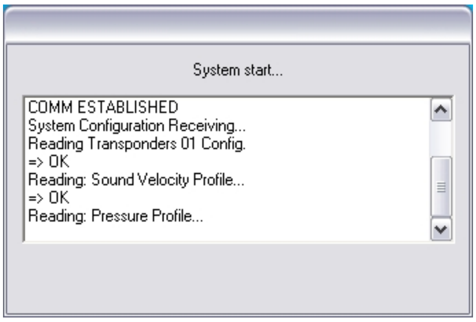
Once the MMI installation is completed and when you have achieved all connections between the devices, you can start the MMI Software.

Figure 33 – Starting GAPS MMI, launching window

Procedure

Step	Action
1.	From **Start** menu, select **Programs/ GAPS MMI/Man Machine Interface Software**. *The MMI is started. The Communication ports of the PC are scanned by MMI to recognize which devices are connected.* • *If GAPS is not connected, the following window appears:*



Step	Action
	• *Otherwise, if GAPS is connected and if both configurations between GAPS and the MMI are different, the following dialog box appears:*  *In this case, you can know for which parameters the configurations differ by clicking on* ***Details*** *button:*  • *Otherwise, if GAPS is connected and if the configurations of the GAPS and the MMI are the same, the following window appears:* 
2.	If needed, choose between the MMI or GAPS configuration. • *If GAPS is not active, the system button located in the upper right side of the main window is labeled 'START Tracking' and the associated light is blue* • *If GAPS is active, the system button located in the upper right side of the main window is labeled 'STOP Tracking' and the associated light is green*
3.	End of procedure.

III.2.2 MAIN WINDOW

MMI software always opens with **Vessel** tab selected under the **Mission** menu (see Figure 34).

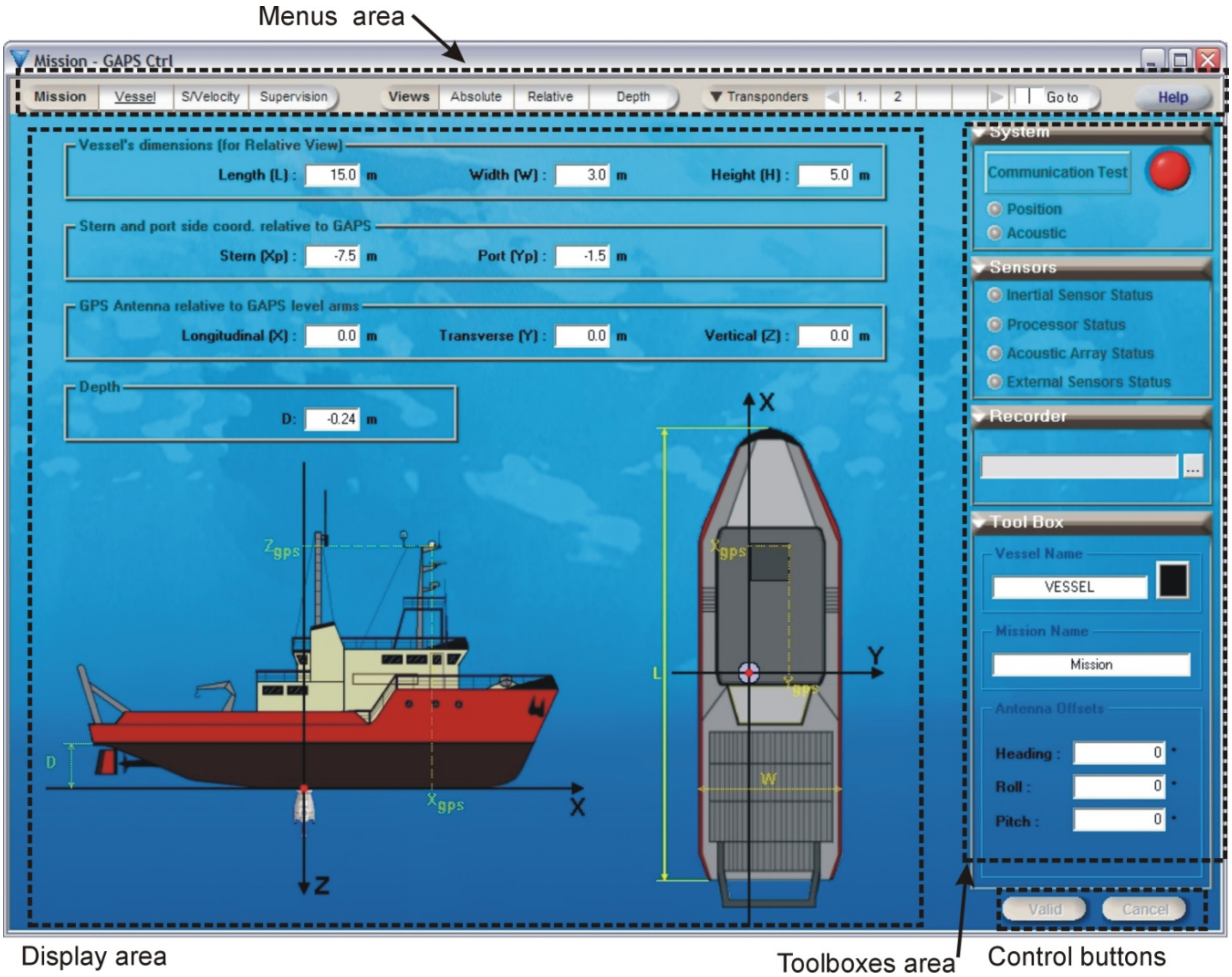


Figure 34 - Main MMI Window

This main MMI window is divided into four areas:

- Menu bar: it enables to access the main menus and Help file.
  - **Mission** menu: it enables to configure the system and the interface parameters (see section III.3.2) and, to enter the sound velocity profiles (see section III.3.9)
  - **Views** menu: to display the real time data either in a geographic reference frame (see section Figure 44), or in a ship dependent frame (see Figure 45) or in a time-depth frame (see Figure 46)
  - **Transponder** menu: to add, define, modify and, suppress the devices you are tracking with GAPS (see section III.3.10)
- The Tool Boxes area: these boxes enable you to monitor your mission.
  - **System** box: see section III.4.5 for more details.
  - **Sensors** box: see section III.4.5 for more details.

- ❑ **Recorder** box: it enables to select the folder where the real time data will be stored (see section III.5).
- ❑ **Tool Box**: the content of this box depends on the selected menu and/or on the selections made in the above boxes.

- Control buttons
  - ❑ **Valid** button: to validate the modifications entered and to save them in the GAPS.
  - ❑ **Cancel** button: to cancel the modification you have entered.
- Display area: The display area is menu dependent. It can display vessel parameters (see section III.3.2), real time data display (see section III.4.1), sound velocity profile (see section III.3.9) etc.

III.2.3 COLOR CODE

When you modify some parameters in the different windows or toolboxes, the corresponding menu titles are set to red. This color code means that modifications have been made but not applied yet in the MMI and/or GAPS itself. Use the **Valid** button to apply them.

FUNCTIONAL PARAMETERS CANNOT BE VALIDATED WHEN GAPS IS OPERATING. WHEN YOU MODIFY FUNCTIONAL PARAMETERS WHILE GAPS IS OPERATING, THE COMMUNICATION BUTTON E.G., 'STOP TRACKING' LABEL, DISPLAYS A RED CONTOUR AND IT IS FLASHING.

YOU HAVE TO STOP TRACKING BEFORE APPLYING THE MODIFICATIONS.

III.3 Configuring GAPS

III.3.1 CONFIGURING THE SURVEY PARAMETERS

Before running the survey, you have to define the mission parameters.

Window Access

To configure and/or modify the mission parameters, select the **Vessel** tab under the **Mission** menu.

Parameters

In the displayed window (see Figure 35 and Figure 36), you have to define:

- In the associated tool box:
  - The **Vessel Name** and color for the real time data is displayed. This setting is optional.
  - The **Mission Name.** This setting is optional.
  - The angular offsets of the GAPS called **antenna offsets** (Heading, Roll and Pitch). Normally GAPS must be in vertical position and oriented so that the hydrophone H1 is towards the bow (see Part 2 of this manual). In such a configuration, the angular offsets are set to zero. If GAPS is tilted so that the angles are greater than a few degrees then you have to enter these angular offset.

TRICK TO DETERMINE THE ANGULAR OFFSETS:

WHEN THE SHIP IS AT A 0° HEADING, 0° ROLL AND 0° PITCH, THE VALUES AND **SIGNS OF THE ANGULAR OFFSETS** CAN BE FOUND IN THE **VIEWS** WINDOWS IN THE ATTITUDE FIELDS.

- In the Display area, the following values are only used in the relative views. They do not affect positioning.
  - The vessel dimensions: the **Length, Height** and **Width** values (only used in the relative views)
  - The location of the ship stern and port side with respect to GAPS: **Stern (Xp), Port (Yp)**.

Example: For a GAPS located at the stern level at 2 m of the port side (inside the ship), these values are the following:

Xp = 0 m , **Yp** = -2 m

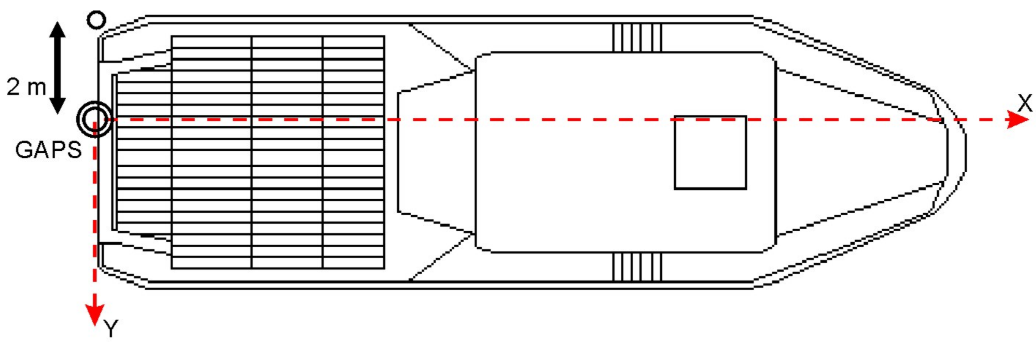


Figure 35 - Position of the stern port point with respect to GAPS

- The lever arms of the GPS antenna with respect to GAPS: **Longitudinal** (**X**), **Transverse (Y)**, **Vertical (Z)** values. These parameters affect directly the positioning. The further the GPS is from GAPS, the bigger the error in the lever arms will be. See Figure 37 for numerical examples.
- The draft **D** of the ship relative to GAPS.

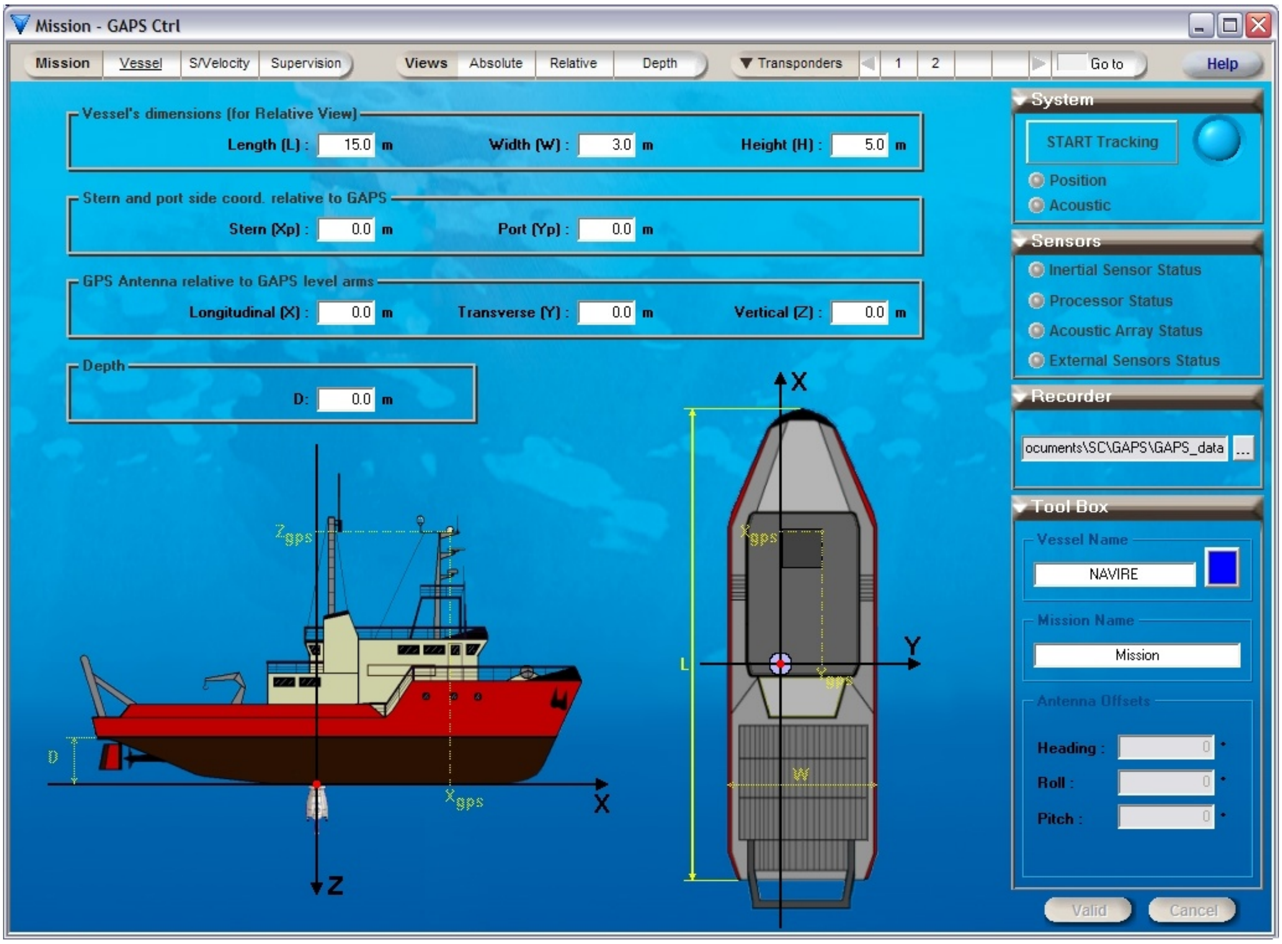


Figure 36 - Vessel Window

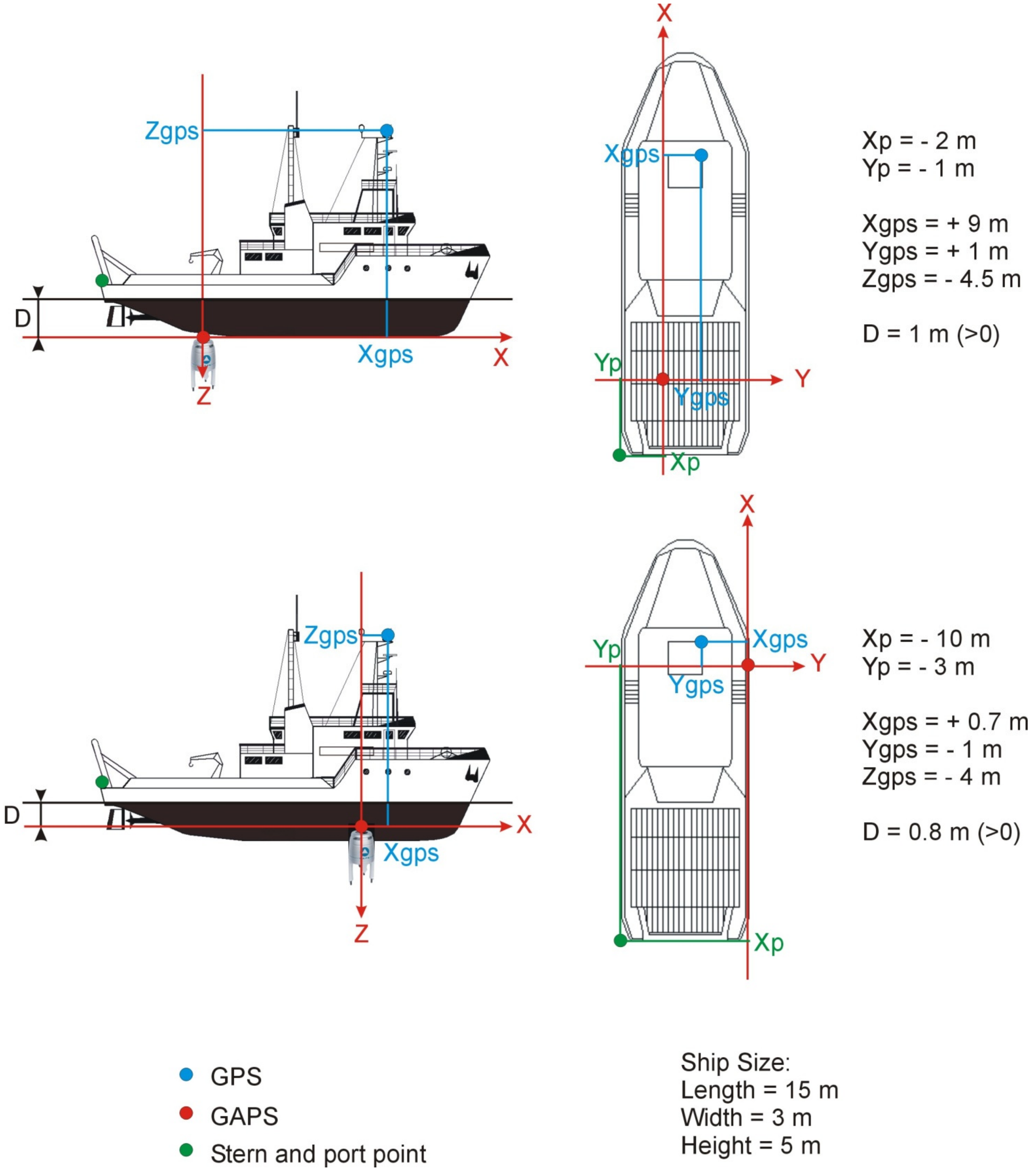


Figure 37 – Examples of Numerical values for the ship dimensions and the GPS offsets with respect to GAPS

All offsets and distances are in meters and signed with respect to the axis drawn in the window.

Procedure

Step	Action
1.	In the **Vessel Dimensions** display area, fill in the vessel dimensions by clicking on the corresponding fields. *When you click on a distance field that you want to fill, the style of the associated line in the ship representation below is highlighted in order to be easily identified and to avoid confusion between distances.* *The drawing of the vessel window does not change. The Vessel tab label turns red.*
2.	In the **Stern and Port side coord. Relative to GAPS** display area, fill in the ship port side and stern with respect to GAPS by clicking on the corresponding fields. *When you click on **Xp** or **Yp** field that you want to fill, the style of the associated line in the ship representation below is highlighted in order to be identified and avoid confusion.* *In the relative view, the reference frame corresponds exactly to the position of GAPS with respect to the ship.*
3.	In the **GPS Antenna relative to GAPS lever arms** display area, fill in the GPS lever arms by clicking on the corresponding fields. *When you click on a lever arm field that you want to fill, the style of the associated line in the ship representation below is highlighted in order to be easily identified and to avoid confusion between lever arms.*
4.	In the **Depth** display area, fill in the depth of the antenna by clicking on the **D** field.
5.	In the associated tool box, enter the following optional parameters • The **Vessel Name** *The entered vessel name will appear in the different available views.* • In the associated toolbox, click on the color button to choose the color of the symbol representing the vessel in the real-time data displays. *A color palette is displayed.* • The **Mission Name** The mission name appears in the window title.
6.	Enter the GAPS angular offsets: **Heading**, **Roll** and **Pitch**. All values are expressed in degrees.
7.	Click **Valid** button to validate the modifications if GAPS is not operating otherwise stop GAPS before clicking the **Valid** button.
8.	End of procedure.

III.3.2 CONFIGURING THE SYSTEM PARAMETERS

Before running the survey, you have to define all the parameters of the different interfaces of GAPS, MMI software, serial link, GPS, Inertial sensor, processor, acoustic array and output.

Window Access

To configure and/or modify the GAPS System parameters, select the **Supervision** tab under the **Mission** menu.

Version Choice

When the MMI is not connected to a GAPS unit, two radio buttons appear on the right of the antenna display. These two radio buttons allow the user to select the GAPS version:

- **Titanium Version V_0 and V_2:** not described in this document.
- **Carbon Version**: this system is described in the present manual.

When the MMI is connected to a GAPS unit, the MMI software switches automatically between the two versions.

Parameters

In the displayed window (see Figure 38), you can configure or display:

- The MMI serial link parameters: port number, baud rate (maximum 57,600 bauds), parity, stop bit
- The MMI parameters: alarm sound and automatic recording of data files
- The GPS parameters: baud rate (maximum 57,600 bauds), protocol, parity and, stop bit
- The processor parameters: position rate delivery and acoustic recurrence
- The acoustic array parameters: Interrogation Frequency, Signal/Noise Ratio parameters
- The output parameters: protocol (which kind of data are delivered), period, Baud rate (maximum 57,600 bauds), Parity, Stop bit

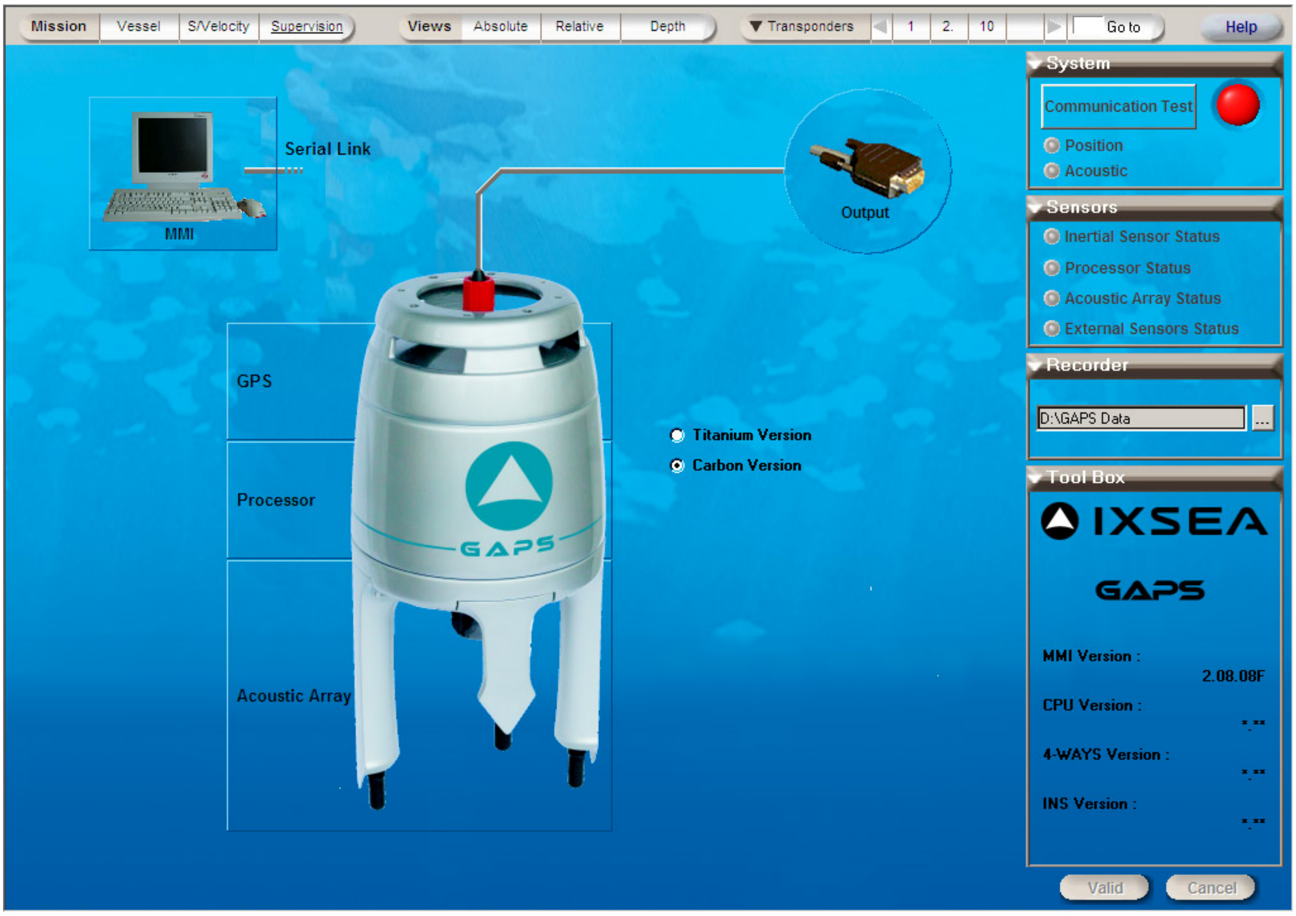
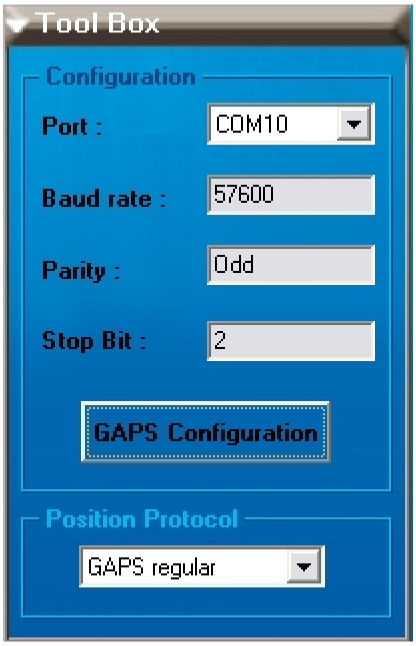


Figure 38 - Supervision Window

In the **Supervision** window, the **Tool Box** displays some versions about the system components: MMI software version, CPU version, 4Ways version and INS version.

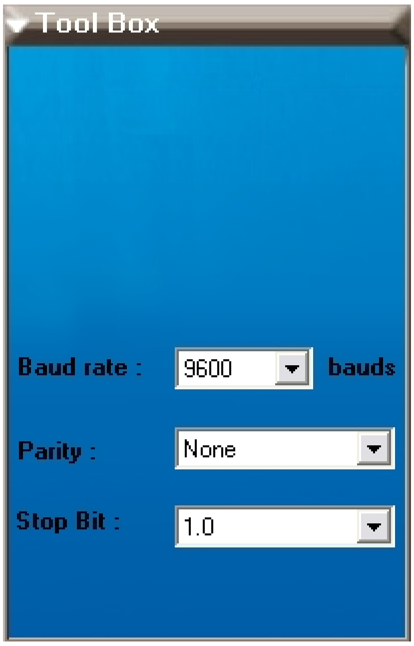
III.3.3 CONFIGURING THE SERIAL LINK

Step	Action
1.	In the **Supervision** display area (see Figure 38), click on **Serial Link** label. *The associated tool box appears.*
2.	In the associated toolbox, you can reload in GAPS the configuration displayed in MMI by clicking on **GAPS Configuration**. *The serial link parameters already saved are then displayed.*
3.	In the Tool Box, if necessary • Choose the **Port** number by selecting it in the scrolling list • Only on iXBlue customer support request, choose the **Position Protocol**: GAPS **Extended** (only for factory usage). By default, it is the protocol **GAPS Regular** that it is used.  *In the Display area, the **Serial Link** label turns red to remind you that you have to validate your choices.*
4.	Click **Valid** button to validate the modifications if GAPS is not operating otherwise stop GAPS before clicking the **Valid** button.
5.	End of procedure.

III.3.4 CONFIGURING THE INTERFACE PARAMETERS

Step	Action
1.	In the **Supervision** display area (see Figure 38), click on **MMI** label. *The associated tool box appears.*
2.	In the tool box, if needed • Choose to be informed by a sound when any status light of the sensor tool box becomes red: select the **Alarm Sound** check box. • Choose to record automatically the real time data: select **Automatic Recording** check box.  *In the Display area, the **MMI** label turns red to remind you that you have to validate your choices.*
3.	Click **Valid** button to validate the modifications if GAPS is not operating otherwise stop GAPS before clicking the **Valid** button.
4.	End of procedure.

III.3.5 CONFIGURING THE GPS PARAMETERS

Step	Action
1.	In the **Supervision** display area (see Figure 38), click on **GPS** label. The associated tool box appears.
2.	In the Tool Box, choose • The **baud rate** by selecting it in the scrolling list (maximum 57,600 bauds) • The **Parity** and **Stop Bit** by selecting them in the corresponding scrolling lists.  *In the Display area, the **GPS** label turns red to remind you that you have to validate your choices.*
3.	Click **Valid** button to validate the modifications if GAPS is not operating otherwise stop GAPS before clicking the **Valid** button.
4.	End of procedure.

III.3.6 CONFIGURING THE PROCESSOR PARAMETERS

You can choose the rate of the acoustic ping and the types of acoustic mode:

- **Internal Fixed** – it needs to set up the recurrence in the edit box at the bottom of the dialog box. The minimum value is 1 s. The recurrence obey the following inequalities:
  - $R > \frac{D_{\max}}{1,500} * 1 + TAT$ in responder mode
  - $R > \frac{D_{\max}}{1,500} * 2 + TAT$ in transponder mode

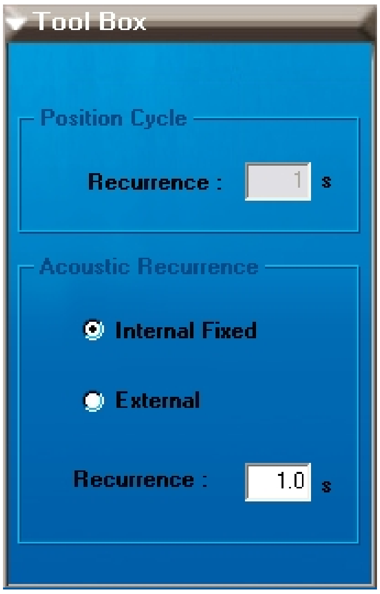
  R is the recurrence, D_{max} is the distance between the antenna and the transponder and TAT is the turn around time. See Table 10.

Table 10 – Maximum working distance versus recurrence with a TAT = 90 ms

		Maximum working distance (m)	
		Responder mode	**Transponder mode**
Recurrence (s)	1	1,365	682
	2	2,865	1,432
	3	4,365	2,182
	4	5,865	2,932
	5	7,365	3,682
	6	8,865	4,432

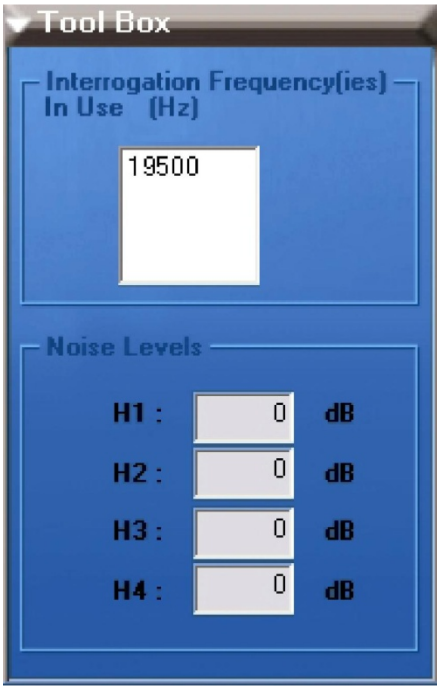
- **External** – coming from the synchro IN. The recurrence used may be slow. It must always be greater than 1 s. When the position cycle is lower than the acoustic recurrence, the INS helped with the GPS predicts the points between two pulses.

Procedure

Step	Action
1.	In the **Supervision** display area (see Figure 38), click on **Processor** label: 
2.	In the Tool Box, if needed • Enter the delivery rate in **Recurrence** in [second] if **Internal Fixed** is selected. • Otherwise choose **External**. *In the Display area, the **Processor** label turns red.*
3.	Click on **Valid** if GAPS is not operating otherwise stop GAPS before clicking on **Valid**.
4.	End of procedure.

III.3.7 CONFIGURING THE ACOUSTIC ARRAY PARAMETERS

There is no configuration to perform for the antenna, however there is the opportunity to check the NIS (Noise Isotropic Spectrum) on each hydrophone of the antenna. It gives an idea of the current acoustic noise in the sea and allows to quickly find out if a hydrophone is damaged.

Step	Action
1.	In the display area, click on **Acoustic Array** label. *The associated tool box appears.*  *The Interrogation frequency used is displayed according to the transponder configurations.*
2.	Check the NIS on each hydrophone. Verify that the given values are homogeneous. In the opposite, the hydrophone giving a strongly different value than the others is probably faulty.
3.	End of procedure.

III.3.8 Configuring the Output Parameters

In this toolbox can be set up the parameters of the additional output data: which kind of data and the associated port configuration.

The list of protocols available is (“none” means no Output):

For the string containing the transponder position:

- GAPS Standard
- GAPS Light
- HiPap HPR 418 BCD (Rev C) Mobile
- HiPap HPR 418 BCD (Rev C) Fixed
- HiPap HPR 400
- Nautronix ATS II
- POSIDONIA 6000
- IXSEA USBL-INS 1
- IXSEA USBL-INS 2
- GPGGA (GAPS antenna) + VTG

For the strings containing information relative to the GAPS antenna but NO position of the transponder:

- GyroCompass
- Halliburton
- Navigation
- HEHDT
- Phins Standard
- Simrad EM
- Autosub
- Post processing (for factory use only)

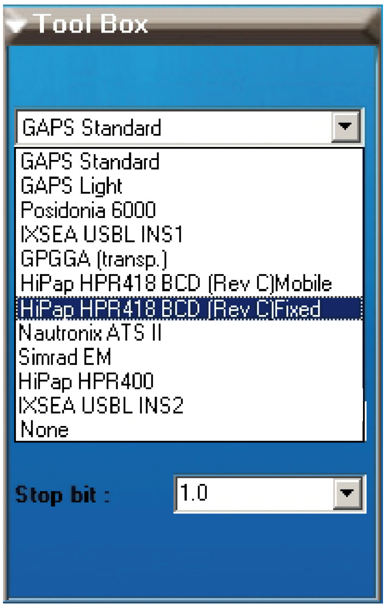
Procedure

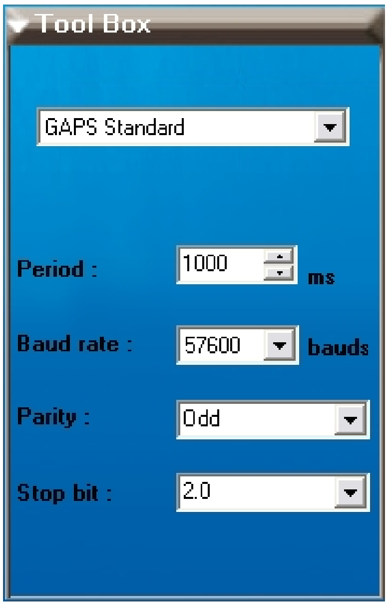
Step **Action**

1. In the **Supervision** display area (see Figure 38), click on **Output** label.

   The associated tool box appears.

2.
   - Choose the **Protocol** by selecting it in the scrolling list
   - Enter the real time data **Period** in [ms] (see **Note** below)
   - Choose the **Baud rate** by selecting it in the scrolling list (maximum 57600 bauds)
   - Choose the **Parity** and **Stop bit** by selecting them in the scrolling lists.





   *In the Display area, the **Output** label turns red to remind you to validate your choices.*

3. Click **Valid** button to validate the modifications if GAPS is not operating otherwise stop GAPS before clicking the **Valid** button.

4. End of procedure.

If you select a protocol that uses raw positions (such POSIDONIA 6000, IXSEA USBL INS 1, IXSEA USBL INS 2), the position rate cannot be set as it is the rate of these raw positions that applies. In this case, the field **Period** has no meaning.

III.3.9 DEFINING A SOUND VELOCITY PROFILE

Entering a Velocity Profile

To compute the transponder position, the ray bending has to be taken into account. A sound velocity profile (SVP) must be defined.

You can either manually enter (point by point) the velocity values (between 1400 and 1600 m/s) with respect to immersions or import a sound velocity profile file. In this case, the file must be a list of

`Immersion depth (integer in [meter]), Celerity (integer in [m/s]) comma separated [CR/LF]`

e.g., `'2000,1500'` (At 2,000 meters depth the sound velocity is 1500 m/s)

in a text format. Imperatively, this file must contain a maximum of 55 couples (depth, celerity) classified in increasing depths. If there are more than 55 data, the last ones are lost.

The immersion depths can be modified manually in the file. The immersion depths are transformed into pressure values by the MMI before transmitting them to the GAPS.

The first depth value must be '0'. The last depth value cannot be greater than 7,000.

This input file or the manually input points can be saved in another file.

Window Access

To enter a sound velocity profile, select the **S/Velocity** tab under the **Mission** menu.

Window Description

The corresponding window (see Figure 39) appears. The Sound Velocity Profile and Ray Bending areas may be empty if you have not defined a sound velocity profile yet.

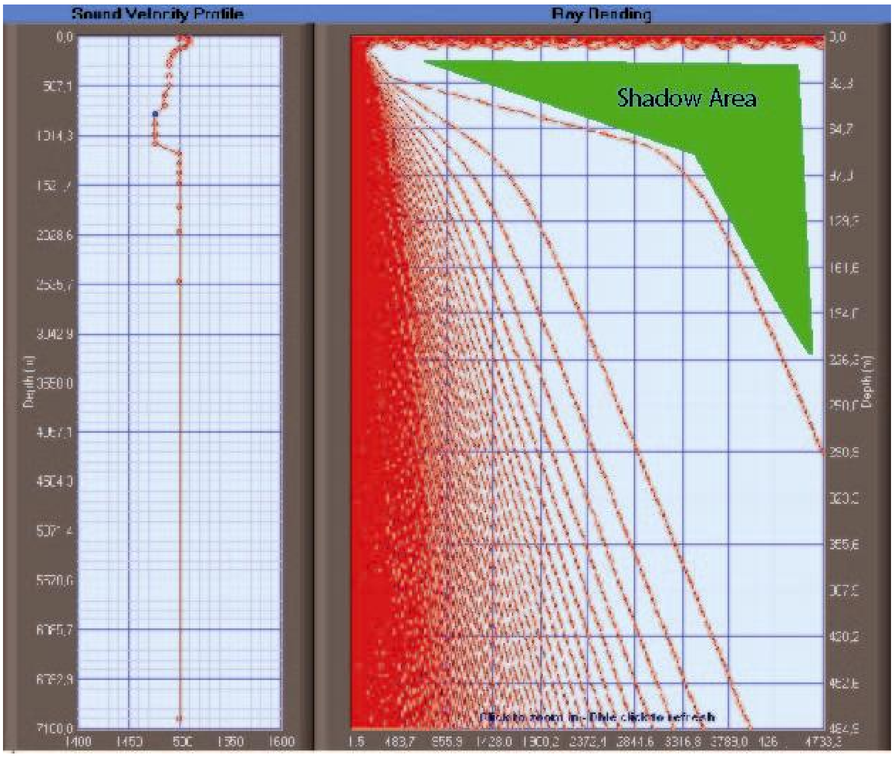


Figure 39 - Sound Velocity View Window

Manually Entering a Sound Velocity Profile

Step	Action
1.	Select the **S/Velocity** tab under **Mission** menu in the toolbox (see Figure 40), type in the **S.Velocity** value for each immersion depth appearing in the **Depth** field. Validate each sound velocity input by pressing the [enter] key. *The sound velocity profile updates at each input. The depth value increments and you are ready to enter the sound velocity corresponding to the next depth value.*
2.	You can save the profile you have defined in step 1. by clicking on  button. *The **Save as** window appears.*
3.	Choose the folder where you want to save the sound velocity profile, type in the filename and click **OK**. *Your sound velocity profile is saved in a text file with the format described above.*
4.	Click **Valid** button to validate the modifications if GAPS is not operating otherwise stop GAPS before clicking the **Valid** button.
5.	End of procedure.

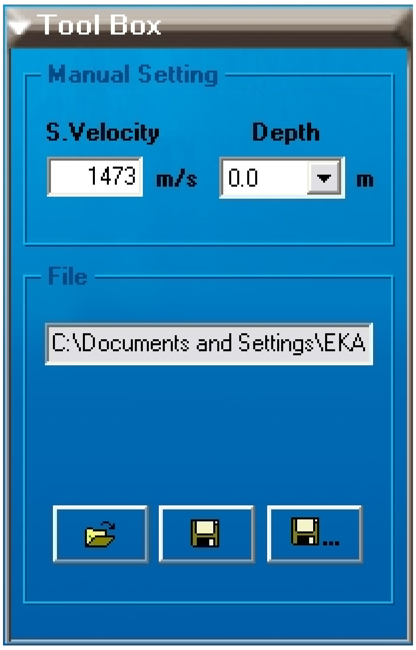


Figure 40 – Sound Velocity Toolbox

Importing a Sound Velocity Profile File

Step	Action
1.	Select the **S/Velocity** tab under **Mission** menu in the toolbox (see Figure 40), click on button to import a file. *The **Open…** window appears.*
2.	Select your sound velocity profile file and click **OK**. *The sound velocity profile appears in the Display area.*
3.	You can modify some sound velocity values (see the previous procedure) and then save the modified file under the same name (by clicking) or under another one (by clicking on) *Your sound velocity profile is modified.*
4.	Click **Valid** button to validate the modifications if GAPS is not operating otherwise stop GAPS before clicking the **Valid** button.
5.	End of procedure.

Looking for Shadows Areas

Once the velocity profile is input, you can compute, by double clicking on the right graph, the path that a sound ray would take with this velocity profile. The graph is computed for angles between 0° and 90° at a 1° step. The path is computed from the GAPS to the transponder. This allows you to see if there are areas where you could not see your mobile (shadow areas, see Figure 39). Note that the horizontal and vertical scales are not the same when looking at angles on the graph. You can zoom on the data by drawing a rectangle with the left mouse button down over the area of your choice.

Zooming

You can zoom on the area of your choice on the graph. Left-click on one of the graphs and draw a rectangle. Double click to come back to the full visualization.

III.3.10 Configuring the Transponder Parameters

Defining a Transponder

You can add a new transponder from a list or copy the settings of a transponder already in defined to the new one being entered. The available transponders are iXBlue–MT8 or ET8, iXBlue-MT9, iXBlue-BT8, ORE-435xB.

THE IXBLUE-MT9 IS CONFIGURED VIA THE CONFIGURATION WINDOW OF THE IXBLUE-MT8. SELECT AN IXBLUE-MT8 TRANSPONDER IN ORDER TO ADD A IXBLUE-MT9. THE CONFIGURATION PARAMETERS AVAILABLE FOR THE MT8 ARE APPLIED TO YOUR MT9 TRANSPONDER.

Access

The creation process of a new transponder displays successively two different windows:

- The New transponder window (see Figure 41): access it by selecting **New…** option under **Transponders** menu
- The transponder view in the Display area of the Main MMI window:
- See Figure 41 for a multi-frequency transponder: access it once you have clicked **Create** button in the New Transponder window.

These windows contain:

- **New Transponder window**: It contains the transponder **ID**, its **Manufacturer** and **Type** to define. You can copy the settings of an existing transponder to create a new one by selecting **Copy from** check box and selecting its **ID.** The transponder ID is the main transponder identifier in the MMI.
- **Transponder view:** The tool box enables you to set the transponder in the 'in use' state (i.e. to display it in the different views), to choose its display color for the absolute, relative and depth view and, to know and possibly modify its serial number, ID one and name. The display area contains:
  - The **Transmit** parameters are used to define the **MFSK code**, the **Blanking Time** i.e., the time during which no transmission is possible just after having transmitted and, the **Turn around Time** i.e., the delay between the reception of the triggering signal and the transmission of the reply.
  - The **Receive** parameters are used to define the Individual Interrogation Frequency (**IIF**) and if the transponder is used in **Responder** or **Transponder** mode (see Part 1 of this manual).
  - **Filtering for** is used to define the filter to use: **None**, **Towed Fish** (specific filter adapted to mobiles, predictable motion), **ROV/AUV** (specific filter adapted to mobiles, unpredictable motion), **Fixed Transponder** (specific filter adapted to fixed transponders, no motion).
  - **Pressure sensor**: **None**, **Serial link, Acoustic** or **External** with the **accuracy** in decimeter (for example for a pressure sensor given for 0.1% of the depth that would be used at a 3,000 m – depth, you would enter 30 dm in the accuracy field).

You can define up to 127 transponders.

THE TRANSPONDER CAN BE TRACKED ONLY WHEN IT IS 'IN USE'.

YOU CANNOT USE TWO (OR MORE) TRANSPONDERS WITH THE SAME IIF AND MFSK CODE SIMULTANEOUSLY.

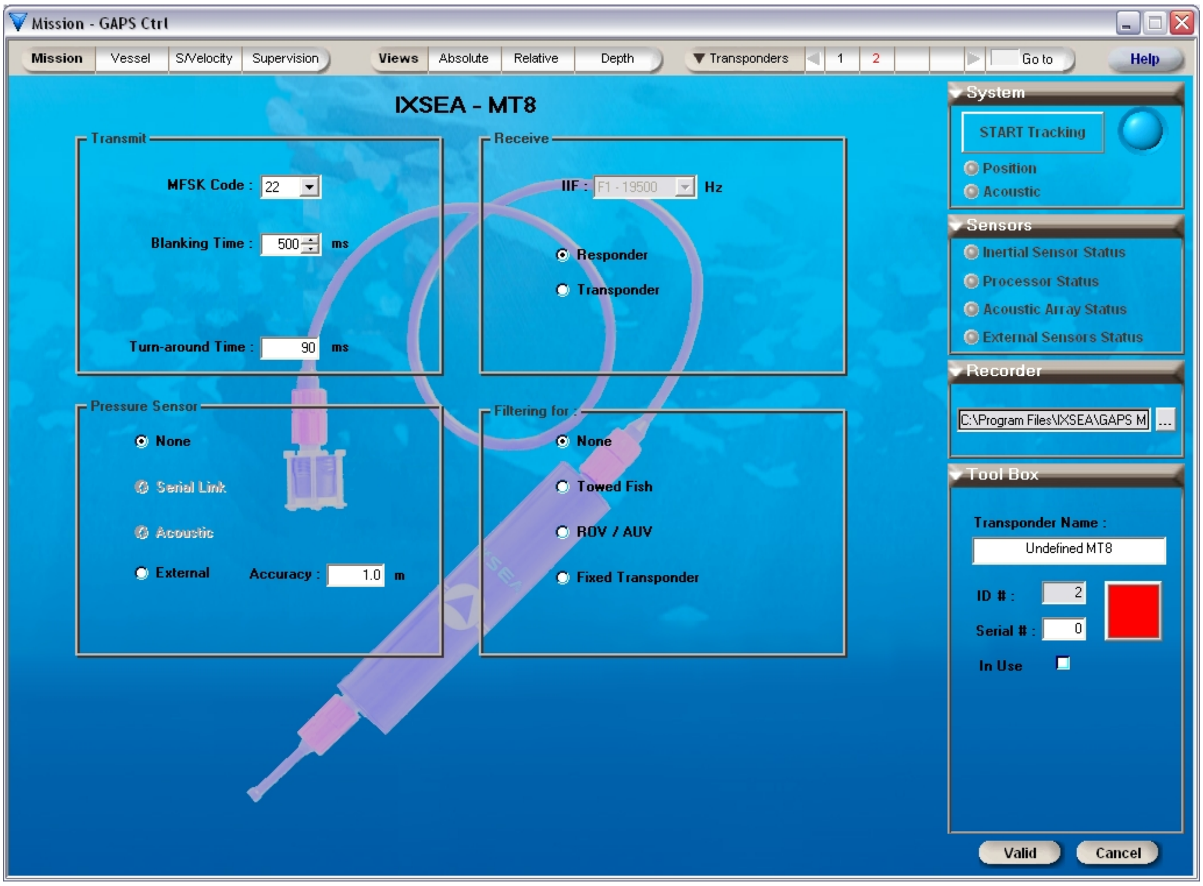


Figure 41 - Transponder MT8 view

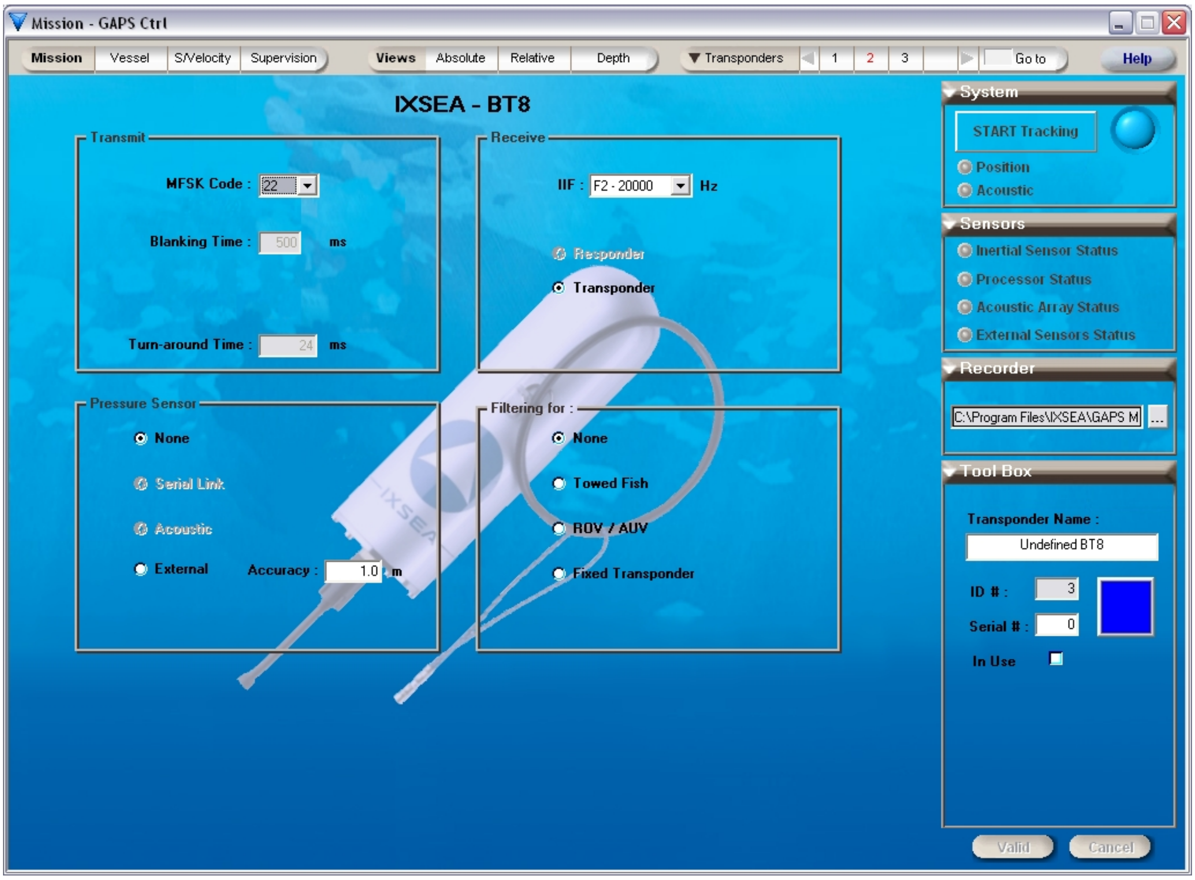


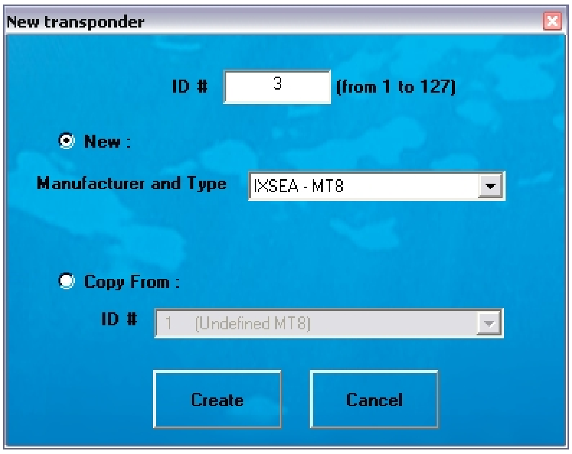
Figure 42 - Transponder BT8 view

Procedure

Step **Action**

1. Under **Transponders** menu select **New…** option to define the new transponder.

   The **New Transponder** *window opens:*



2. In the New transponder window, you can
   - Either select the Manufacturer and Type after having selected New check box.
   - Or define the new settings by selecting existing ones: select Copy from check box and choose the transponder ID to copy in the scrolling list.

3. Click **Create** button to create the new transponder.

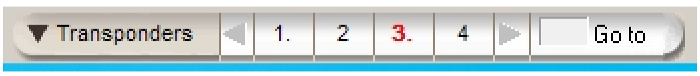
   The transponder settings are displayed in the Display area of the main MMI window. It contains default settings for a new transponder and the settings of an existing one in case of a copy.

   The transponder ID appears in the transponder list (near the ***Transponders*** *menu).*

4. You can
   - Modify the settings
   - Change the transponder display color by clicking on

5. Select **In Use** check box to track the transponder and to see this transponder in the different views.

   The transponder ID in the transponders list (near the ***Transponders*** *menu) turns red and a "." appears after the transponder ID number in the transponder menu:*



6. Click on **Valid** if GAPS is not operating otherwise stop GAPS before clicking on **Valid**.

   The transponder ID in the list (besides the ***Transponders*** *menu) turns black.*

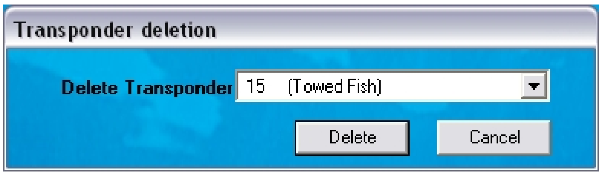
7. End of procedure.

Checking/ Editing

Step	Action
1.	• If its ID is displayed in the Transponder list near the **Transponders** menu, click on it. • Otherwise scroll in the ID number using the or button to find it and then select it by clicking. On its ID number. • Or use the **Go to** box Go to to enter directly its ID.
2.	End of procedure.

Suppressing

Step	Action
1.	Select **Suppress…** option in the **Transponders** menu. *The* Transponder deletion *window appears:*
2.	Select the transponder you want to delete in the **Delete Transponder** scrolling list and click **Delete**. *The transponder ID disappears from the transponder list near the* ***Transponders*** *menu.*
3.	End of procedure.



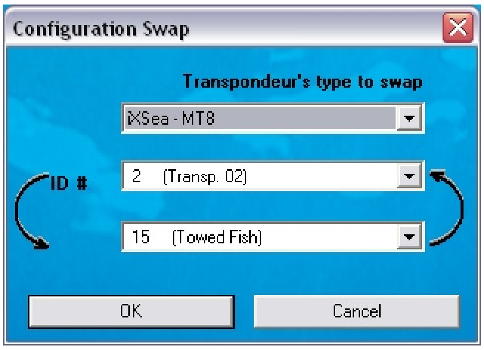
The transponder cannot be deleted when “in use” and /or when GAPS is tracking.

Sorting

You can sort the transponders list by chronological or numerical order by selecting **Chronological list** or **Numerical list** (on the **ID**) in the **Transponders** menu.

Swapping

To exchange the characteristics of two transponders: their IDs remain unchanged but all their characteristics are exchanged.

Step	Action
1.	Select **Swap…** option of the Transponders menu. *The* Configuration Swap *window appears:* 
2.	Select the two ID transponders you want to exchange and click **OK**. *The transponder IDs turn red in the transponder list.*
3.	Edit one of the swapped transponders.
4.	Click **Valid** button to validate the modifications if GAPS is not operating otherwise stop GAPS before clicking the **Valid** button. *The transponder ID in the transponders list (near the Transponders menu) turns black.*
5.	Edit the other swapped transponder.
6.	Click **Valid** button to validate the modifications if GAPS is not operating otherwise stop GAPS before clicking the **Valid** button. *The transponder ID in the transponders list (near the Transponders menu) turns black.*
7.	End of procedure.

Only the not ‘In Use’ transponders can be swapped.
Do not forget to check ‘In Use’ check box if necessary after swapping.

III.4 Monitoring the GAPS in Operation

III.4.1 CONTROLLING THE REAL TIME DATA

To control the real time data, the MMI software offers three kinds of view:

- The absolute view: it is a geographic mode, in which you can see all the mobiles evolving together
- The relative view: it is fixed on the ship. You can visualize the motion of the mobiles relative to the ship
- The depth view: it shows the mobile depths relative to time

All these three views have a common area: the Parameter Display area located top of the Display area (see Figure 43).

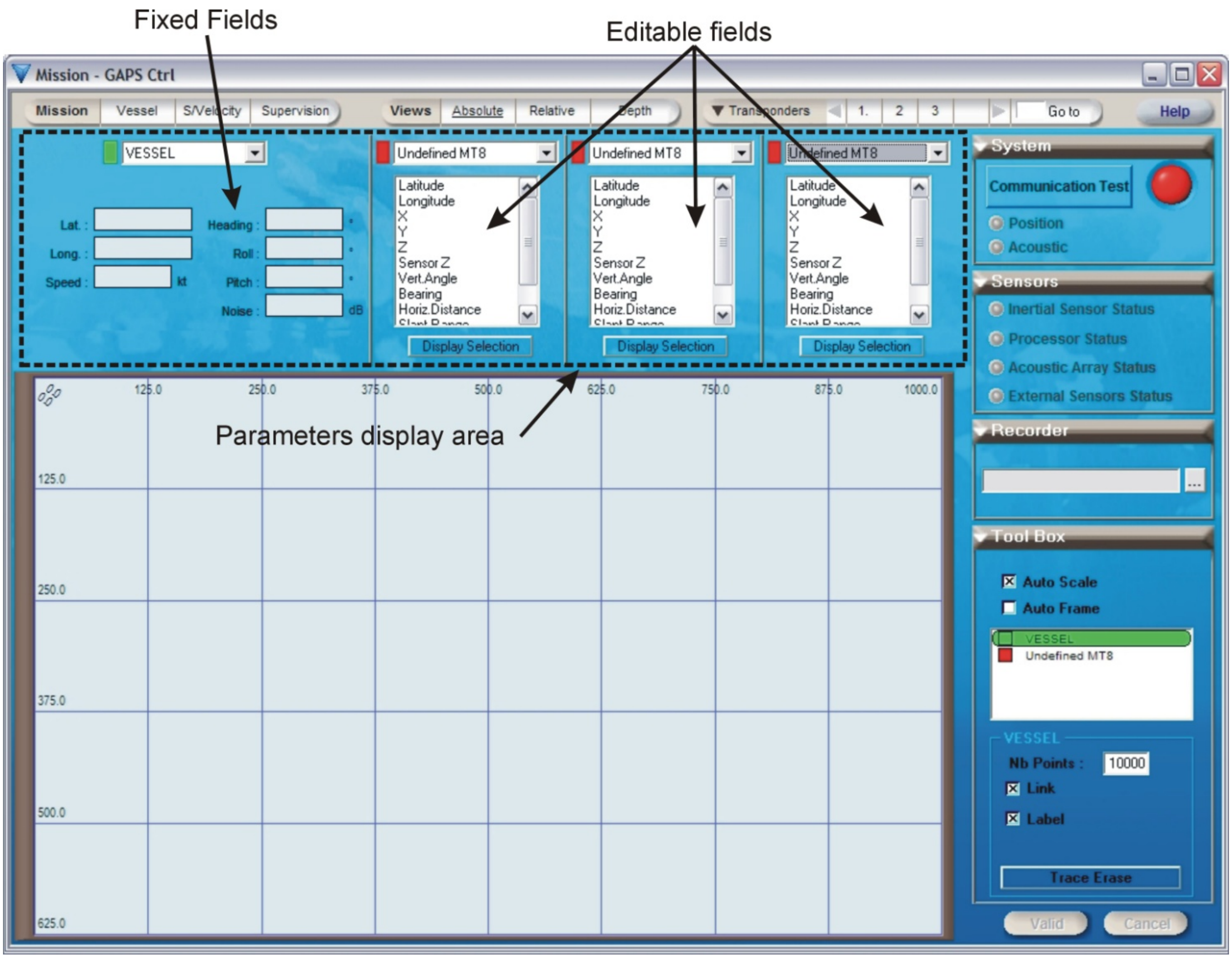


Figure 43 - Parameter Display Area (Absolute view case)

In this Parameter Display area, you can select

- From the upper left part: a mobile (vessel or transponder), the displayed fields are fixed and depend on your mobile choice.
- From the upper middle part:
  - ❑ The mobiles of which you want to visualize the parameters,
  - ❑ The parameters to visualize for each mobile.

Once selected, you can visualize them by clicking on **Display Selection** button below.

The parameters of four mobiles including the vessel can be visualized at the same time.

You can select and display the following parameters:

- For the vessel: latitude, longitude, speed, heading, roll, pitch, noise
- For the transponders: latitude, longitude, X, Y, Z, pressure sensor, Vertical Angle, Bearing, Horizontal Distance, Slant Range, Signal To Noise Ratio.

For all views, you can visualize the parameters of up to four transponders simultaneously including the vessel.

III.4.2 VISUALIZING WITH THE ABSOLUTE VIEW

Window Access

To display the real time data in a geographic display, select **Absolute** tab under the **Views** menu.

Window

The corresponding window (see Figure 44) appears.

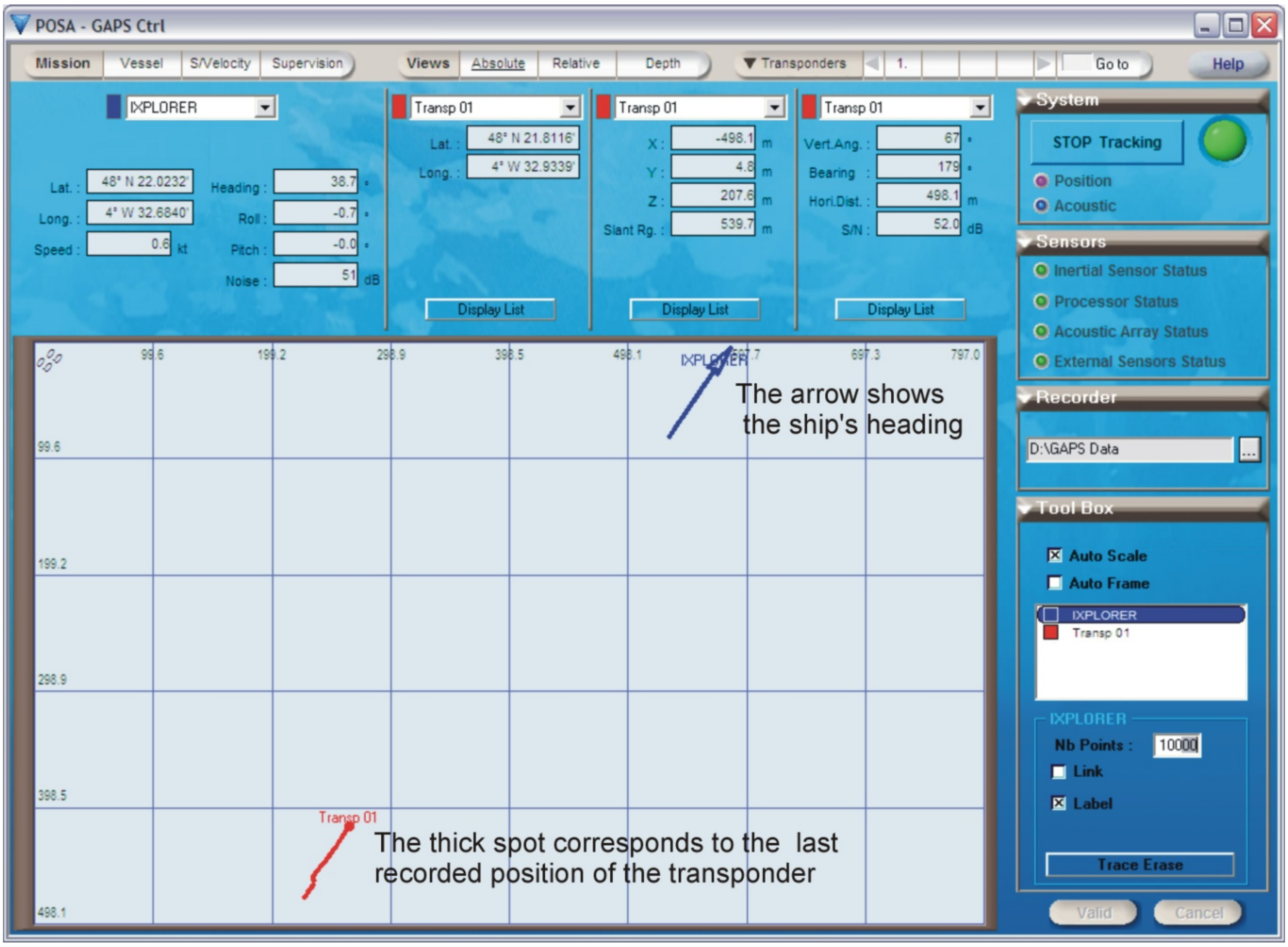


Figure 44 - Absolute view

The **Tool Box** contains the following parameters:

- **Auto Scale**, (full extent, grid limits are set in order to view all data in graph) applied to selected mobile in the bow below.
- **Auto Frame**, (when the selected mobile crosses the grid limits these limits are updated) applied to the selected mobile in the bow below:
  - Check this box: a cross-mark appears in the Vessel box
  - Then click on the box of the selected mobile (for example, in the of the fish mobile in the Figure 44): the cross-mark is now displayed in the box of the selected mobile.
- The mobile you want to set the focus on. All the graphical settings will be applied relatively to this selected mobile. By default the vessel is selected.
- Number of displayed points
- Link (draw a line between all the points of the mobile)
- Label (add the name of the mobile in the map) close to the last position received

The grid can be either in geographical coordinates (**latitude, longitude**) or in **metric** ones. To switch between the units, press the shortcut keys: **[Alt]+ mouse Left Click**. The metric display has its origin in the upper left corner of the graph.

You can **zoom in** the graph with a **left click** and **zoom out** with a **right click**.

You can **move the center** of the graph by holding down **[shift]** key **+ left click.**

You can erase all points of the selected mobile with the **Trace Erase** button.

A bigger spot than all the others symbolizes the last position of the displayed point. It represents the last known position of the mobile. The arrow, which represents the ship, is oriented following the current ship heading (see Figure 44).

III.4.3 VISUALIZING WITH THE RELATIVE VIEW

Window Access

In the relative view, you can see the trajectory of the mobile relative to the ship. The view is centered on the vessel. To display the real time data in a relative display, select **Relative** tab under **Views** menu.

Window Description

The corresponding window appears. The Figure 45 displays the relative view with a GAPS located at 6 m from the stern and at 2 m from the port side (inside the ship): **Xp** = -6 m and **Yp** = -2 m in this case.

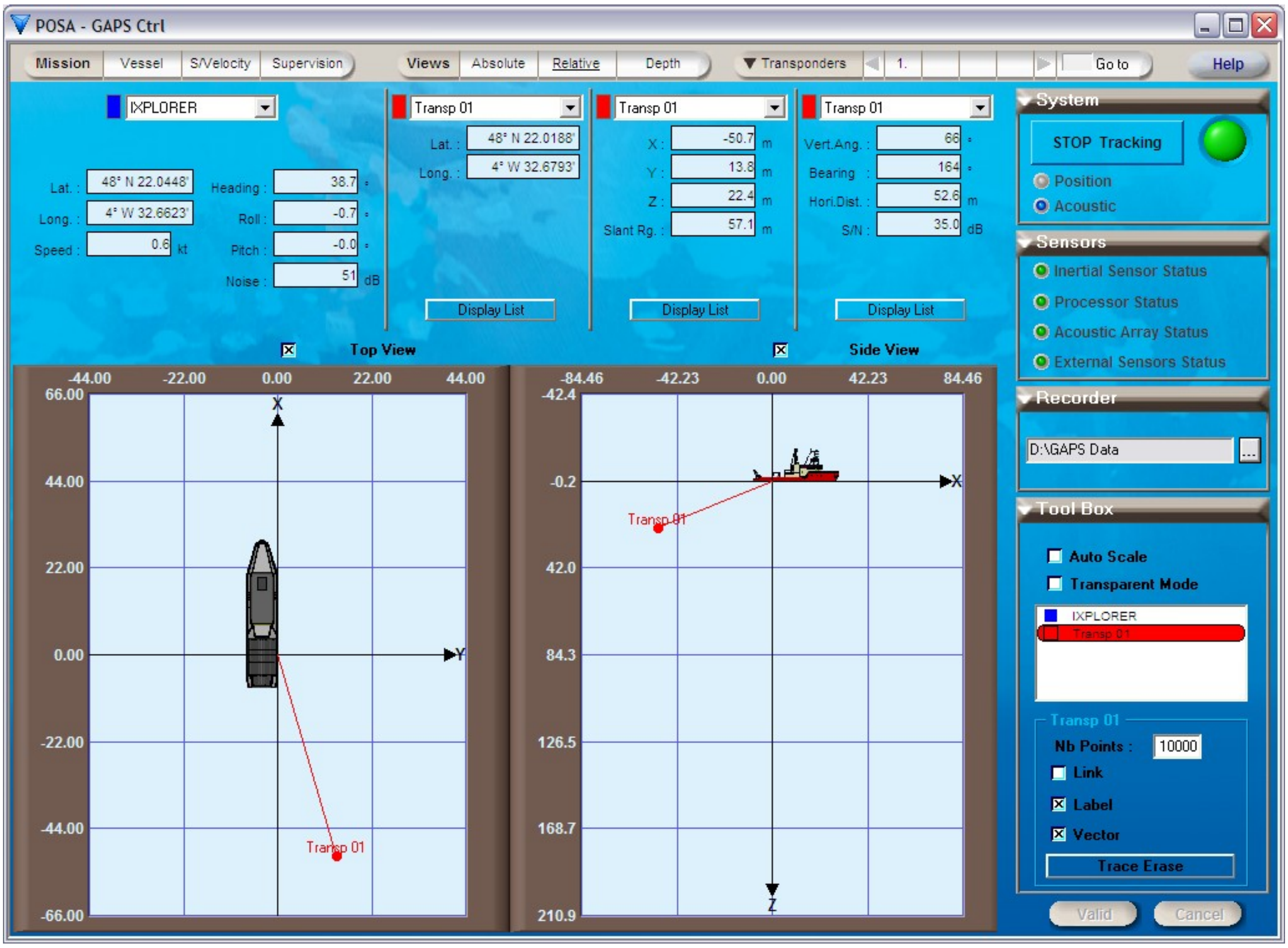


Figure 45 - Relative view

All the graphical settings are the same than in the absolute view except that you have:

- A transparent mode that allows you to see data taken under or behind the ship (case of a diver swimming under the ship).
- A vector that can be drawn (it draws a line between the last point and the vessel).

You can also choose to see only the **Side View** or the **Top View** by clicking the check boxes on top of both views.

With the **Auto Scale** option checked, the full extent is made on the data, the ship disappears, the origin or GAPS remains on the display.

III.4.4 VISUALIZING WITH THE DEPTH VIEW

Access The depth window displays the mobile depth.

To display the real time data in a depth view, select **Depth** tab under **Views** menu.

Window The corresponding window (see Figure 46) appears.

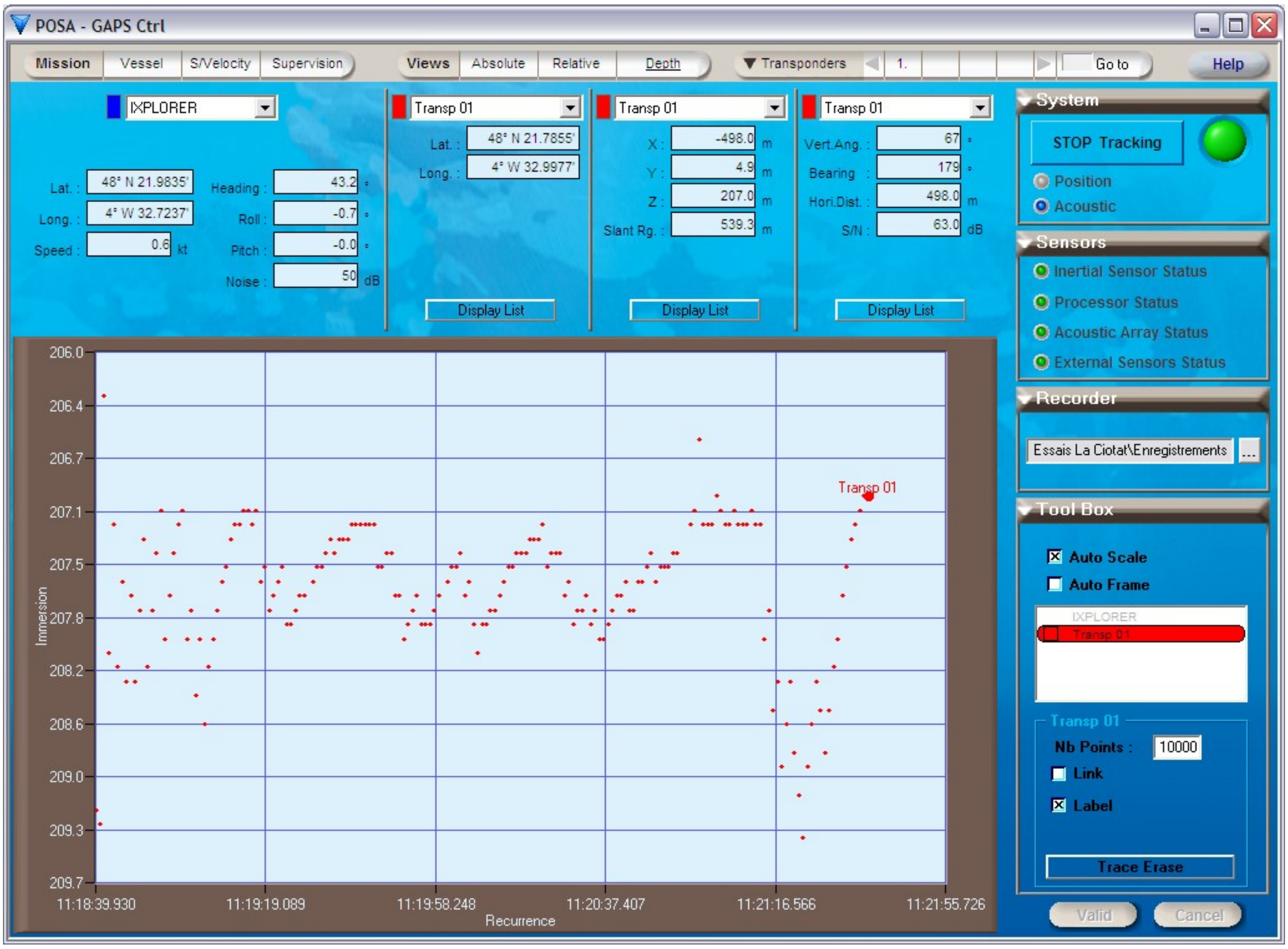


Figure 46 - Depth view

The graphical settings are the same than in the absolute view.

- **Auto Scale**: on the immersion, maximum extent of all points
- **Auto Frame**: on the immersion, maximum extent of the points of the selected mobile(s)
- **Nb Points**: as long as the entered number of displayed points is not reached, the display is compressed. When this maximum number is reached, the display shifts along the left of the time scale

III.4.5 CONTROLLING THE GAPS STATUS

The **System** and **Sensors** boxes are designed to help you to monitor the GAPS status.

System Box

The **System** box is composed of (see Figure 47):

- A communication button. Changing a functional parameter anywhere in the software while a GAPS is tracking and validating it will make this button flash with a red frame. This means that the changed parameter is not applied to the GAPS and that if you want to apply it you will need to stop the system
  This button is labeled as follows:
  - "**Communication Test**" if GAPS is **not connected**,
  - "**STOP Tracking**" if GAPS is **connected and active**. Clicking this button stops the acoustic part of GAPS, no emission and reception is performed anymore. Inertial and GPS activities (attitude and GAPS/vessel position) are still ON.
  - "**START tracking**" when GAPS is **connected but not active**.
- A system status light:
  - **Red** when GAPS not connected to the PC (or when it is stopping or starting the tracking)
  - **Blue** if GAPS is not active
  - **Green** when GAPS connected and active
- Two status and command buttons for **Position** and **Acoustic ping** outputs. These status buttons flash in blue/mauve each time an acoustic ping is transmitted or position signal is received. This effect gives an idea of the actual recurrences of the position and acoustic ping transmitted. Clicking on the associated buttons brings you to the Supervision window with a specific tool box allowing the set-up of acoustic and position parameters.

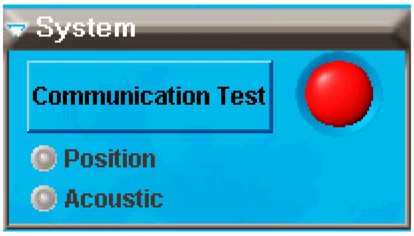


Figure 47 - System box

Sensors box

Four status and buttons are available (see Figure 48). Each of these buttons opens specific tool box. The color button follows a code giving the status of the sensor.
The color code for the four status lights is the following:

- **Red** for Alarm
- **Orange** for Warning
- **Green** for Normal

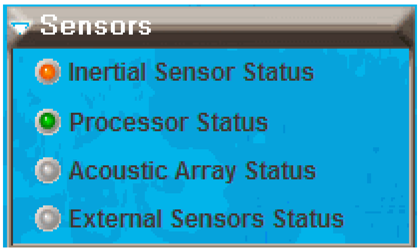


Figure 48 - Sensors Box

In the associated tool box, you can see the operating state of the device:

- Inertial Sensor Status Tool Box: it contains status lights and a diagnostic zone displaying alarm or warning messages (see Part V).
- Processor Status Tool Box: it contains a diagnostic zone displaying alarm or warning messages (see Part V).
- Acoustic Array Status Tool Box: it shows the status of the four hydrophones (see Figure 49). A red status means that the hydrophone did not receive an expected signal. If one of the hydro status stays red during several interrogations the hydrophone might be damaged (contact iXBlue for support and assistance). The **CPU temperature** is the temperature of the electronics contained in GAPS. It is the temperature of the warmer electronic component (CPU).
- If the rectangle light is **orange**: the temperature is high (> 70°C). This situation must be kept under very close control. For example check if the GAPS antenna is not out of water.
- If the rectangle is **red**: the temperature is very high (> 75°C). You must switch off the GAPS and contact iXBlue support.

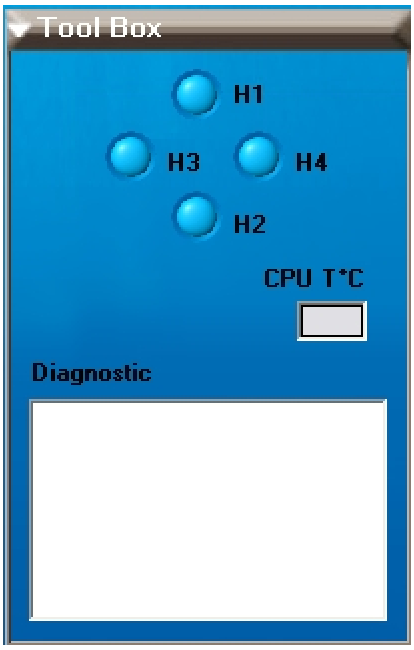


Figure 49 - Acoustic Array Tool Box

- External Sensor Status Tool Box : it allows a quick check on the status of GPS and optional pressure sensor (see Figure 50). It also contains a diagnostic zone displaying alarm or warning messages.

Figure 50 – Tool box of the External Sensors Status

Ambient Noise

The sea ambient noise is measured at the hydrophones faces and displayed in the tool box in the Supervision menu after clicking on the acoustic antenna:

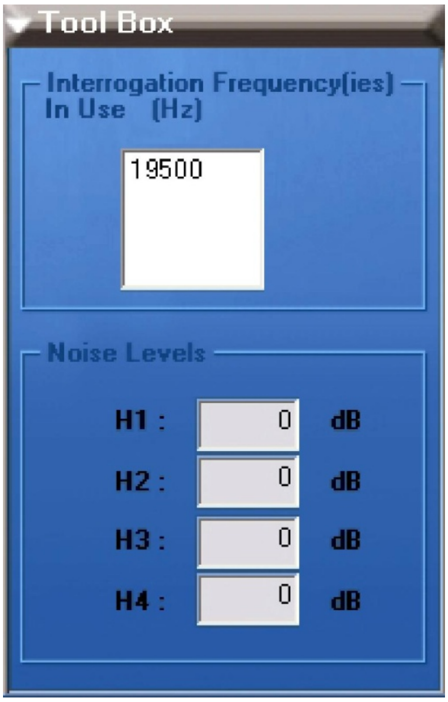


Figure 51 – Tool box displaying the noise level for all the hydrophones

III.5 Recording the Data

A recorder box allows data recording in a file in real time. This recording is automatic when the check box **Automatic Recording** is checked (see Figure 52). This check button can be found in the Supervision menu in the toolbox of the MMI parameters button.

The automatic file name format of the file is “YearMonthHourMinuteSecond.dat”.
Each time the data file size reaches 1 Mo a new data file is created.
The whole software configuration is always saved in the first data file.

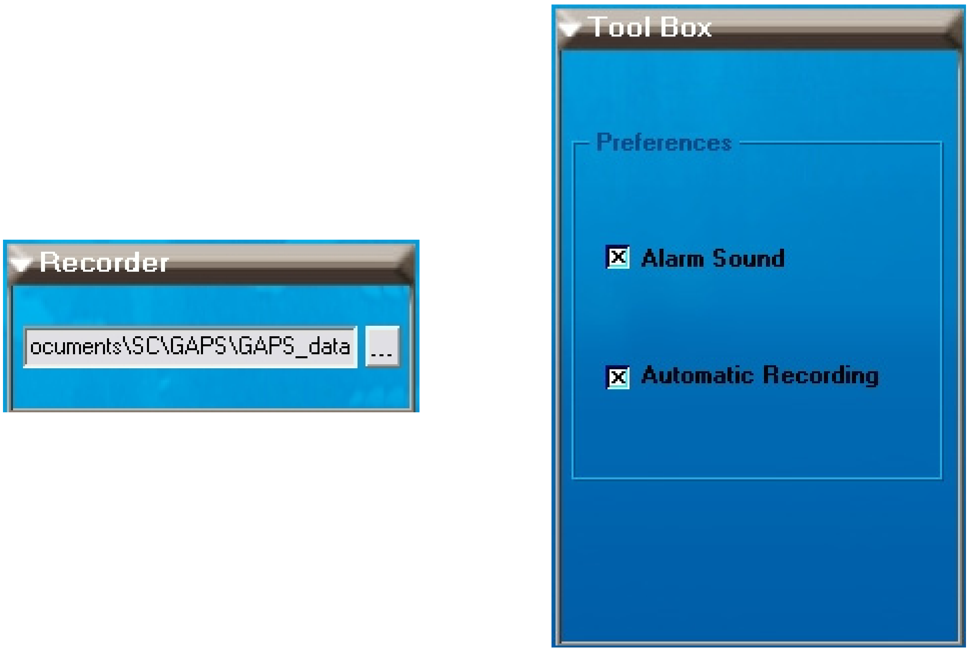


Figure 52 - Recorder box – Automatic recording check box

IV OPERATING GAPS

Before starting any operation, you should know what to expect in terms of performances, range and accuracy (see section IV.1). Every operation starts by the configuration of the system and its initialization (see section IV.2). During the survey, you can control the operation (see section IV.3).

IV.1 Performances

In complex marine environments, GAPS offers different levels of performances. See below the global GAPS performances depending on the GPS operating modes (section IV.2.1) and the variation graphs of the range and the accuracy versus depth, noise level and SNR.

IV.1.1 POSITION ACCURACY FOR MT8, MT9 AND ET8 TRANSPONDERS

Characteristics	**Typical Values**	
Positioning accuracy for MT8, MT9, ET8 transponder	**Deep water**	**Shallow water**
	• Accuracy: from 0.2 to 0.7% depending on noise level • Range: 4,000 m • Rejected Erroneous Positions: from 0 to 0.3%	• Accuracy: around 1% • Range: > 1,000 m (2 to 4 times more depending on the weather) • Rejected Erroneous Positions: from 0 to 0.3%
Positioning accuracy for ORE transponder	**Deep water**	**Shallow water**
	• Accuracy: around 3 % depending on noise level • Range: 1,000 m Rejected Erroneous Positions: around 50 % vertically and propellers stopped	• Accuracy: around 2 to 5 % depending on angle • Range: a few hundred meters Rejected Erroneous Positions: from 30 to 90 % depending of the angle from 0° to 60° from vertical
GPS Position accuracy	2 to 5 cm (external RTK receiver) 0.5 to 3 m (integrated DGPS or internal or external) 5 to 15 m (GPS receiver)	
Position drift (during GPS drop out)	2 m / 2 minutes	

IV.1.2 MULTI PATH

The multi-path phenomenon is usually a major issue for standard USBL systems. GAPS uses wide-band spectrum signals and is fitted with a powerful signal processing that reduces a lot the result of the multi-path signals.

Nevertheless this phenomenon may happen from time to time and lead to noisy positions under specific conditions (specific distances between the transponder and/or the GAPS antenna and a reflective surface).

- Multi-path

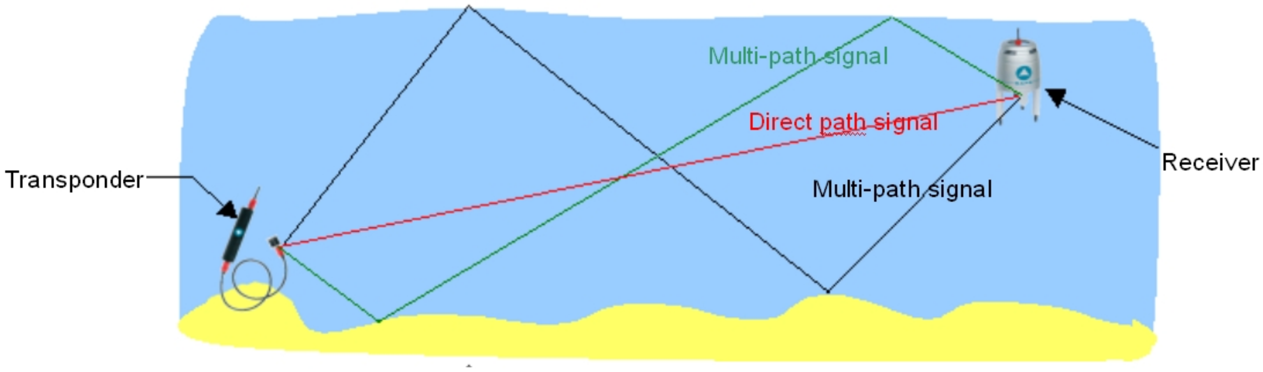


Figure 53 – Multi-path Phenomenon

The transponder transmits one signal. The GAPS antenna receives this signal plus additional echoes mixed together.

- Analogy with images

IV.1.3 RANGE VERSUS NOISE LEVEL

The GAPS performances are on the Figure 54 with

- GAPS Signal Level of 191 dB
- Transponder Signal Level = 188 dB

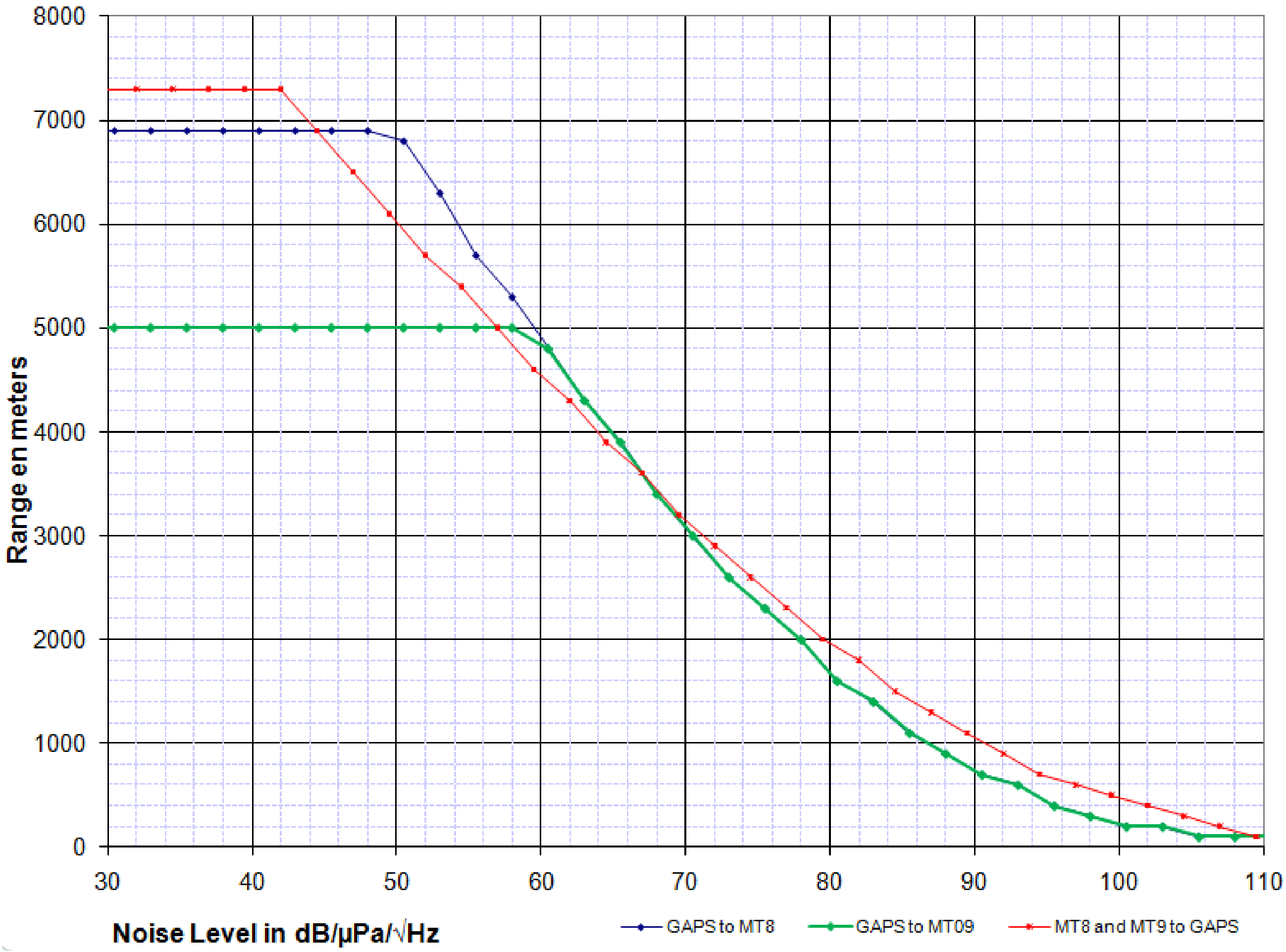


Figure 54 – GAPS Performances in Range versus Noise Level

IV.1.4 Accuracy versus SNR

The GAPS performances are described on the Figure 55 with:

- Slant Distance ≥ 1,000 m
- Vertical Angle < 30 deg
- Roll & Pitch Error = 0.01 deg
- Heading Error = 0.1 deg
- GPS error ≤ 1.5 m

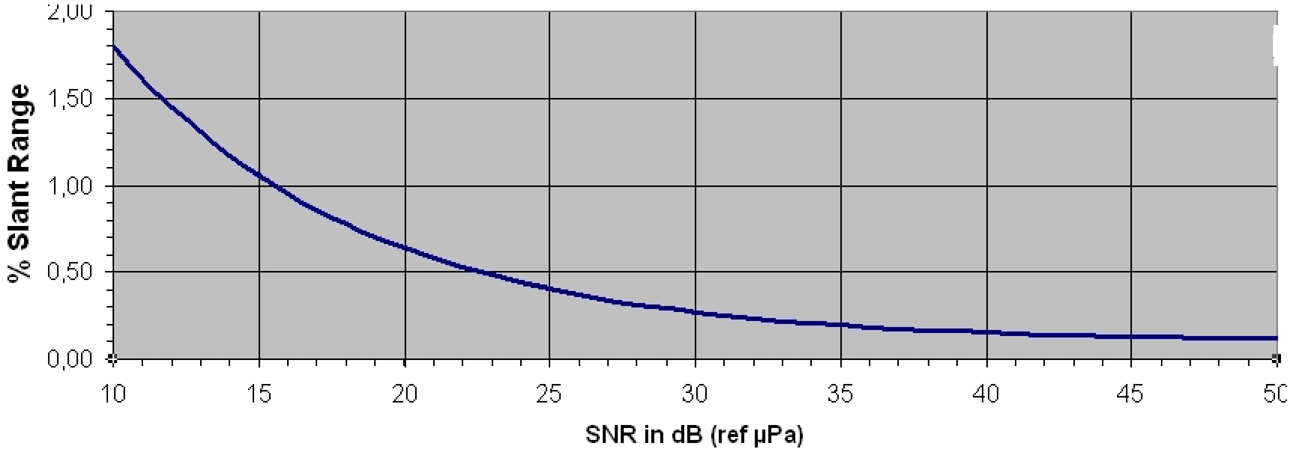


Figure 55 – GAPS Performances in Accuracy versus SNR (SNR at GAPS processing output)

IV.2 Initializing and Configuring a Survey

You need to choose the mode in which GAPS is going to operate (section IV.2.1) before initializing the system (section IV.2.2). The choice of the operating mode constrains the configuration (section IV.2.3).

IV.2.1 OPERATING MODES

IV.2.1.1 Synchronization Mode / Recurrence

The system can be synchronized by and with another system or can generate itself its acoustic recurrences:

- **Internal recurrence**: the interrogation time for the transponder is automatically determined by GAPS. The Internal recurrence is fixed: it is configured to a fixed value with the MMI.
- **External Synchronization**: an external system generates a synchronization to operate GAPS.
- **External Synchronization with inhibition**: the GAPS minimum recurrence inhibits the short external recurrence after one received trigger. GAPS is triggered on the rising edge of the signal. This mode is described on the Figure 56.

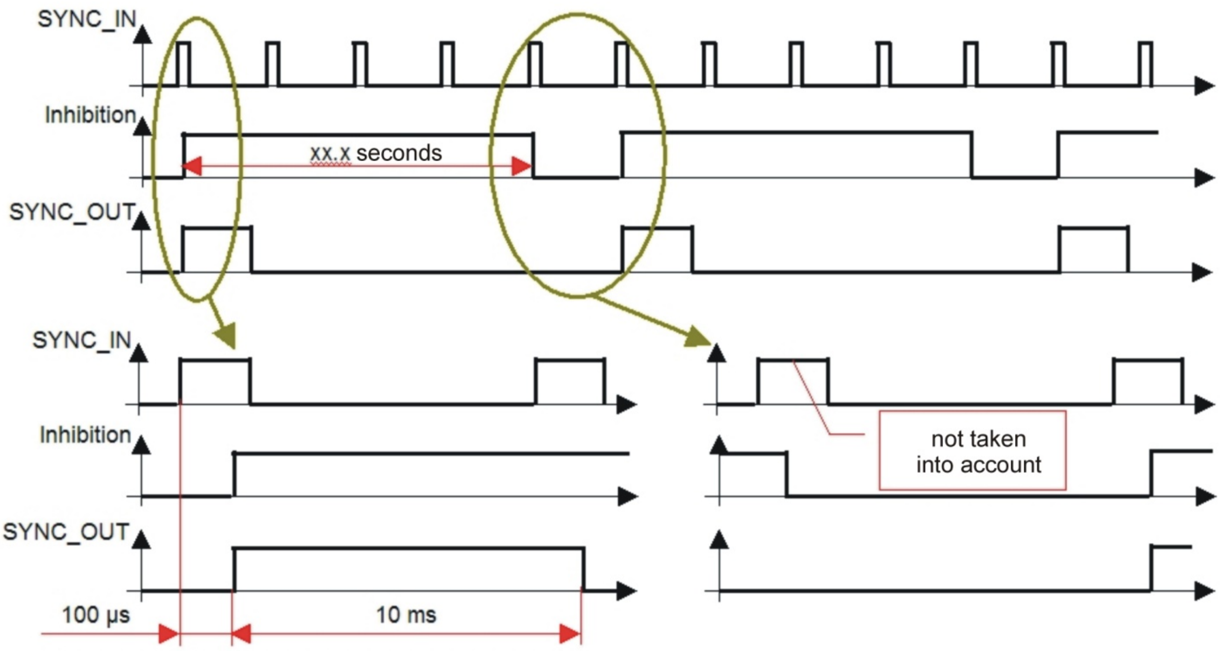


Figure 56 – Inhibition window during an external synchronization

IV.2.1.2 Two Modes

The GAPS interrogates acoustically (transponder mode) or electrically (responder mode).

- **Transponder mode**: GAPS acoustically interrogates the transponder that replies with a MFSK signal. The time between signal interrogation and reception is approximately 1 second every 750 m transponder range with a velocity of 1500 m/s.
- **Responder mode**: the transponder is electrically triggered through the SYNCHRO OUT- RESPONDER MODE output and GAPS does not send acoustic signal anymore. This mode has many advantages:
  - ❑ The position update is twice faster in responder mode than in transponder mode because there is only one acoustic travel in this mode. The first travel is electric. There are two acoustic travels in transponder mode.
  - ❑ The transponder cannot be accidentally triggered by any parasitic sound.
  - ❑ The transponder is always triggered despite noise (e.g. ROV propellers).
  - ❑ Depending on the environmental conditions, the maximum range of the system is sometimes limited by the reception of the acoustic triggering signal by the transponder. This is no more limitation in responder mode and the maximum range is only limited by the reception of the reply by the GAPS acoustic array.

The drawback is that the electrical signal has to be transmitted up to the transponder usually through an electrical or a fiber optic wire or by using synchronous clocks (GAPS in external synchronization mode).

IV.2.1.3 Multi Transponders Mode

Several Acoustic Transponders can be interrogated simultaneously. The transponders are separated thanks to the two MFSK codes (22, 23) and the four Individual Interrogation Frequencies (IIF). Thus, up to 8 (4 x 2) transponders can be positioned.

You can also use seven beacons in transponder mode (by using the four different Individual Frequencies available and the two codes 22 and 23) and one beacon in responder mode in the same configuration.

If you want to use two transponders, the first one in transponder mode, the second one in responder mode, and if you want to interrogate them simultaneously (i.e., in the same recurrence), both transponders must be configured with the same IIF. When they are configured with two different IIF, they will be interrogated alternatively every second recurrence. See Figure 57.

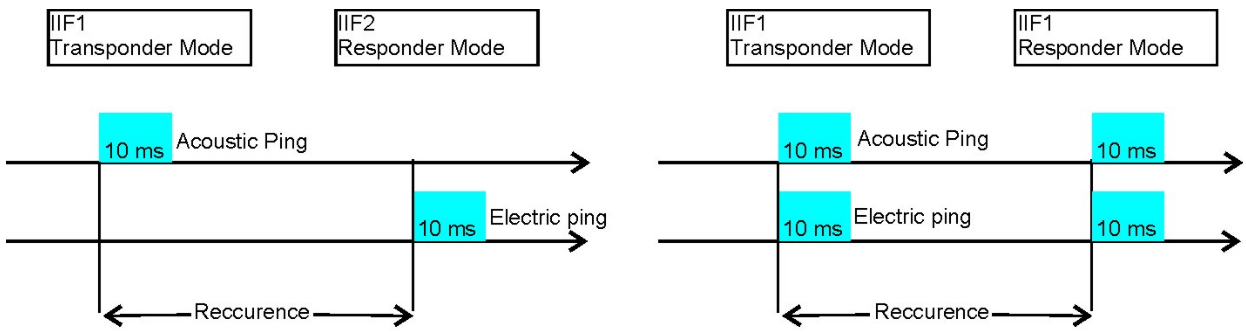


Figure 57 - Two Transponders in Transponder and Responder modes

When a transponder is configured in transponder mode, no signal is generated on the SYNC OUT output of the ECB (responder mode).

WHEN THE TWO INTERROGATION FREQUENCIES ARE DIFFERENT, THE BLANKING TIME IS HIGHER THAN THE ACOUSTIC RECURRENCE. IN A SINGLE TRANSPONDER MODE, YOU CANNOT HAVE A BLANKING TIME HIGHER THAN THE ACOUSTIC RECURRENCE. IN THE MMI YOU CANNOT SET UP A BLANKING TIME HIGHER THAN THE RECURRENCE. SO WHEN YOU USE TWO TRANSPONDERS WITH TWO DIFFERENT FREQUENCIES, **MAKE SURE TO HAVE THE CORRECT SETTINGS IN THE TRANSPONDER HARDWARE** AND LET A BLANKING TIME LOWER THAN THE RECURRENCE IN THE MMI. ONLY THE BLANKING TIME SET IN THE HARDWARE IS TAKEN INTO ACCOUNT.

IV.2.2 INITIALIZING GAPS

IF YOU TURN OFF GAPS BY PRESSING THE GAPS POWER SWITCH ON THE ECB, MAKE SURE TO WAIT AT LEAST 20 S BEFORE TURNING IT ON AGAIN.

DO NOT TRANSMIT ACOUSTICALLY WITH GAPS IN THE AIR.

Procedure

Step	Action
1.	Turn the ECB switch to ON.
2.	On the ECB, turn GAPS switch to ON. *GAPS is running its initialization tests. Wait for about 30 s.*
3.	Launch the MMI software on your PC. *MMI scans all the ports of the PC. After completing this communication test successfully, the command button on the upper right corner of the MMI window becomes a “Start tracking” button.*
4.	Press **START tracking** button in the MMI. *This action starts the acoustic cycle of GAPS. The INS needs 5 minutes before being operational.*
5.	Check for end of the alignment inertial sensor alarm message on the MMI software: in the sensor box, check the Inertial Sensor status light: orange during the “coarse alignment”, green during the “fine alignment” (typically 30 minutes but could be longer).
6.	Check for available Data control views in MMI (absolute, relative, depth).
7.	End of procedure.

INS Initialization

- During the first five minutes after powering-on, the inertial system performs its **coarse alignment**:
  - Inertial sensor data (accelerometers and gyrometers) are computed to estimate heading, roll and pitch angles.
  - At sea, it is recommended that the system is kept as steady as possible during coarse alignment: oscillations around a mean position or smooth drift are permitted but accelerations should be avoided. Leaving the vessel adrift for 5 minutes would lead to satisfactory conditions for coarse alignment.
  - No estimation of position or speed, nor errors, are done by the INS during the coarse alignment: the data provided by external sensors (lever arm compensated) are used directly.
- After the coarse alignment phase, the GAPS is ready for navigation. Kalman filter is activated to compute and estimate position and speed with an optimal accuracy. The INS switches to the "**fine alignment**" phase to improve the accuracy of roll, pitch and heading estimations.
  - During the fine alignment phase, movements of the vessel are required. 90 degrees rotations are even recommended so that the Kalman filter assesses the sensors bias on different axes.
  - Error estimations from the INS Kalman filter are improved when optimal trajectories are performed. The optimal trajectory to achieve fast fine alignment is "staircase" shaped, as illustrated in Figure 58, with a typical duration of 3 to 5 minutes for each step. Such a trajectory allows the Kalman filter to assess all sources of errors of the system, to correct them and to achieve optimal performances at the end of the fine alignment process.
  - When a "staircase" shaped trajectory is performed, the fine alignment phase would typically last for less than 20 min.
  - The fine alignment requires the GPS to provide valid data to the system. the INS uses both inertial sensors and external sensors to compute optimal estimates of position, speed, attitude and heading.
  - The fine alignment is ended automatically when the heading covariance is below 0.1 degree.

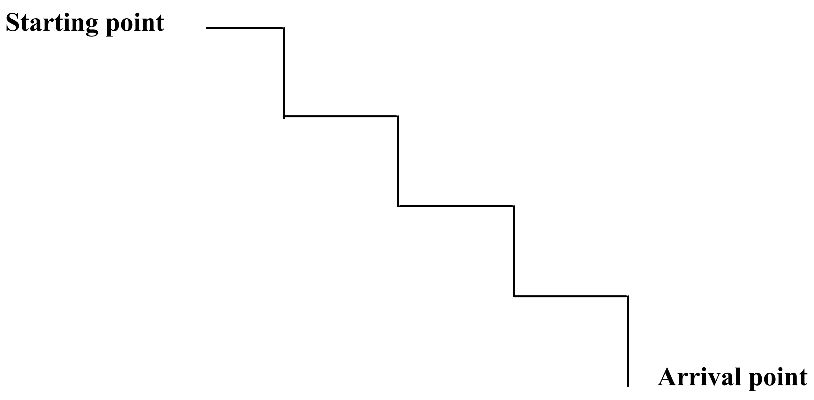


Figure 58 - Illustration of optimal trajectory for fine alignment

The inertial sensor status light turns green at the end of the coarse alignment. You can then start to operate with GAPS. The accuracy of the INS is optimal at the end of the fine alignment. At the end of the fine alignment, the message “fine alignment” disappears from the inertial sensor tool box.

IV.2.3 CONFIGURING THE MISSION PARAMETERS

For more details on these procedures, please refer to section III.3.

Configuring MMI general parameters on a User PC

Step	Action
1.	Under the **Mission** menu, select the **Vessel** tab, enter the ship dimensions.
2.	Under the **Mission** menu, select the **S/Velocity** tab, enter the velocity profile.
3.	Under the **Mission** menu, select the **Supervision** tab, enter the interface parameters: • In the **Serial Link** tool box, choose **GAPS Regular** for the Position protocol and set-up the serial parameters • In the **Output** toolbox, choose the output position protocol if needed
4.	End of procedure.

GPS Lever Arms

In the MMI software, the GPS lever arms, if they exist, have to be entered.

About the GPS antenna, two main configuration cases exist:

- The GPS antenna is vertically above GAPS
- The GPS antenna is NOT above GAPS

Configuring the GPS lever arms when the GPS is vertically above GAPS

Step	Action
1.	Under the **Mission** menu, select the **Vessel** tab, set the GPS X, Y lever arms to zero.
2.	Enter the Z lever arm. • If GAPS is mounted on a pole, GAPS should be placed in a way that the hydrophone H1 is oriented towards the bow of the ship. • If a rigid rope holds GAPS, you always have a slight error induced by the motion of the rope, even if the GPS antenna is put vertically above GAPS.
3.	End of procedure.

Configuring the GPS lever arms when the GPS is NOT vertically above GAPS

Step	Action
1.	Under the **Mission** menu, with the **Vessel** tab selected, set the position offsets X, Y, Z of the GPS antenna with respect to GAPS.
2.	End of procedure.

GPS lever arms must be entered in the GAPS reference frame.

IV.2.4 INSTALLING THE TRANSPONDERS

Procedure

Step	Action
1.	In the MMI software, under the **Transponders** menu, add the transponder to your system and set up its configuration (see Part III.3.10 of this manual).
2.	In the associated toolbox, check **In Use** box to make it operational and set the associated parameters up (at least IIF, MFSK code, transponder/responder mode, turn around time, filter).
3.	In case of a transponder with a remote transducer, connect the remote transducer to the transponder body.
4.	Plug the transponder for power supply to the vehicle carrying it. This connection is used in both transponder (only power supply) and responder mode (power supply and triggering coming from GAPS).
5.	In responder mode, connect the vehicle to the “Synchro Out” BNC plug on the ECB or to your SOURIAU socket if you do use the ECB. For transponders triggered by a TTL signal, plug the responder cable on the rear face of the ECB. For the transponders triggered by a differential signal, plug the responder cable on the front face of the ECB.
6.	End of procedure.

IMPORTANT FOR MT8 AND ET8 TRANSPONDERS

DO NOT FORGET TO SELECT:

- THE RECEPTION CHANNEL FREQUENCY YOU WANT TO USE BY SELECTING IT WITH THE SWITCH LOCATED ON THE BOTTOM END PLATE OF THE TRANSPONDER
- THE CODE, TURN AROUND TIME AND BLANKING TIME BY THE MEAN OF SWITCHES LOCATED INSIDE THE TRANSPONDER

ACTUAL TRANSPONDER SETTINGS HAVE TO MATCH THOSE INTRODUCED INTO THE GAPS MMI

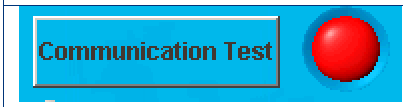
IV.3 Monitoring the Survey

IV.3.1 VISUALIZING THE TRAJECTORY

Refer to section III.4 for a complete description of the control windows in the MMI software.

IV.3.2 LIST OF THE SYSTEM STATUS

System Box

Button/ status light	Meaning
	GAPS is not connected
	GAPS is connected and active. GAPS is pinging.
	GAPS is connected, not acoustically active (but it gives the ship position).

Position and Acoustic lights	Meaning
	Flashing in blue/mauve each time a position is computed and an acoustic ping is sent.

Sensor Box

Status light	Meaning
	**Red** light in case of an alarm
	**Green** light for a normal status
	**Orange** light in case of a warning

Menu Text Label

When you modify some parameters in the different windows or tool boxes, the corresponding menu titles are set to red. This color code means that modifications have been made but not applied yet in the MMI and/or GAPS itself.

IV.3.3 LIST OF THE WARNING MESSAGES AND TROUBLESHOOTING

These messages appear in the tool boxes relative to the processor, the inertial sensor, the acoustic array and the external sensor. For example:

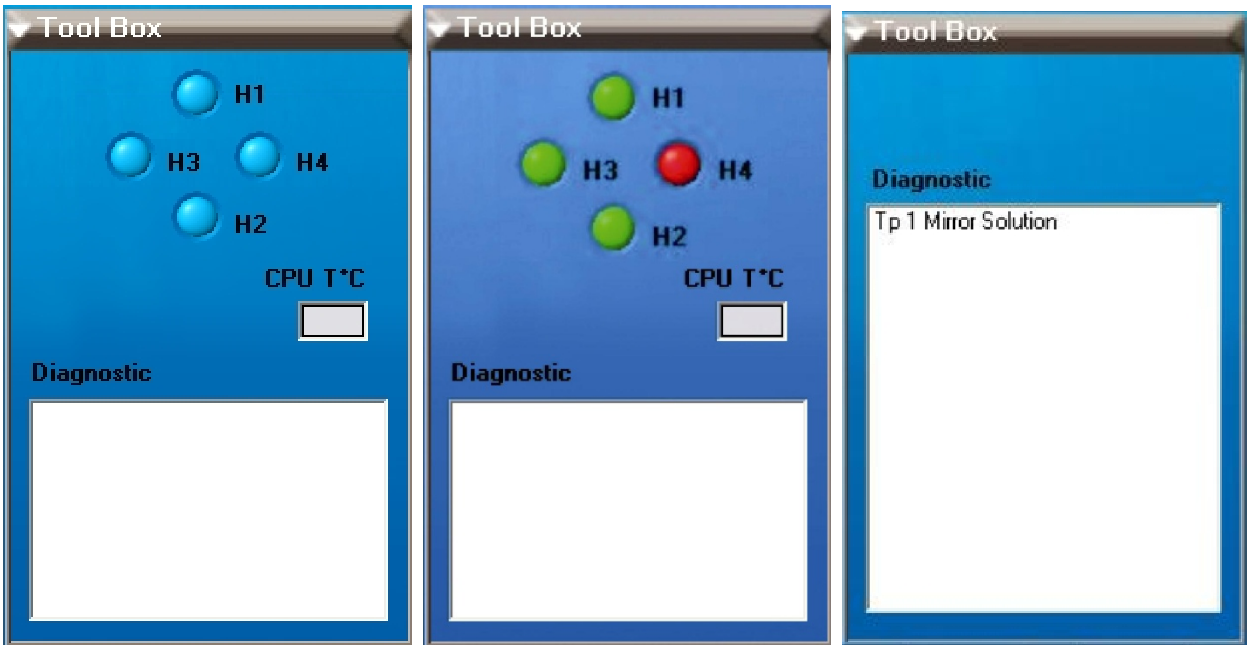


Figure 59 - Diagnostic dialog box in the acoustic array toolbox

Processor

Warning Messages	Meaning	Possible Cause(s)	Checks, possible solutions
Negative Stack Time or Stack Error	Timing error in the attitude data array	CPU overload	Reduce the recurrence
Mirror Solution	Solved ambiguity of two symmetrical positioning solutions	A hydrophone has not delivered useful information (too much noise, out of service …), the three others worked properly. Two positioning solutions are found with three hydrophones. The system has been able to solve the ambiguity.	Check the SNR in the MMI. Check that it is not permanent and that it does not concern always the same hydrophone in the Acoustic Array Status. Reduce the general ambient noise. You can for example reduce the speed or the variable pitch of the propellers.
Filter Attenuation	Position smoothed by the filter so it is accepted	Very noisy raw data that trigger a smoothing and predicting filter (if you have activated this option).	If it happens too often, check the acoustic noise of the ship (see convergence error below).

Inertial System

Warning Messages	Meaning
Alignment	Initialization of the inertial sensor (coarse alignment), it takes 5 minutes after powering of GAPS and before being operational. It is better to let the ship drift during these 5 minutes.
Fine Alignment	End of the initialization of the inertial sensor. It can take 30 minutes before being fully operational. Caution: on a ship that is alongside the wharf, this final initialization can last permanently.

Acoustic Array There are no warning messages available.

External Sensors

Warning Messages	Meaning
Pressure Not Used	Pressure sensor data inconsistent with valid position computation. The pressure sensor data is rejected.
GPS Data Invalid	GPS data is not valid.
GPS Data Noisy	GPS data is noisy.
GPS Data Rejected	GPS data is rejected.

IV.3.4 Error Messages

These messages appear in the tool boxes relative to the processor, the inertial sensor, the acoustic array and the external sensor.

Processor

Error Messages	Meaning	Possible Cause(s) (not exhaustive)	Checks, possible solutions
No Detection.	None of the four hydrophones is receiving any signal	If the message appears alone, the transponder could not transmit. The transponder might be too close to the GAPS antenna in responder mode. Anomaly in the detection process of GAPS.	Check if the transponder transmits (for example try to hear the ping). Move the transponder away from GAPS. Turn off GAPS and after at least 20 seconds turn it on again.
Negative Travel Time	Negative time found in travel time computation	Turn around time of the transponder different from the value in the GAPS MMI and transponder too close to the GAPS antenna.	Check if the values of the turn around time in the MMI and in the transponder are identical. Check the external synchro. Check for unexpected triggering of the transponder due to heavy acoustic noise for example.
Convergence Error	No convergence found in position computation	Noisy raw data	Check the noise recorded by the antenna and try to reduce it (for example slowing down the propeller line shaft)
Velocity profile Error	Error during application of sound velocity profile	The depth of the last layer of the velocity profile is higher than the computed depth of the transponder.	Introduce an additional layer with a greater depth than the actual depth of the transponder.
Not corrected sector jump	Position found in a wrong angular sector below GAPS, NOT corrected.	Acoustic noise conditions specially rough.	Same as Convergence Error (if the problem occurs in a repetitive way)
Corrected sector jump	Position found in a wrong angular sector below GAPS, position is now corrected.	Acoustic noise conditions specially rough.	Same as Convergence Error (if the problem occurs in a repetitive way)

Error Messages	Meaning	Possible Cause(s) (not exhaustive)	Checks, possible solutions
Mirror Ambiguity	The system has entered in a process to solve the ambiguity between two possible solutions. The process has not succeeded.	A hydrophone has not delivered useful information (too much noise, out of service …), the three others worked properly. Two positioning solutions are found with three hydrophones. The system has NOT been able to solve the ambiguity.	Check the SNR value in the MMI. Reduce the general ambient noise. You can for example reduce the speed or the variable pitch of the propellers. Same as in Mirror Solution.
Above Surface	The computed position is above the water surface. The position is rejected.	Most probably the velocity profile is erroneous because the computed position is inconsistent (in the air).	Check the velocity profile. Perform again the acquisition of a velocity profile.
Rejection Filter	This alarm occurs when we know that the computed position is not valid. In this case we do not feed the filter with this position.	Inconsistent value compared to the previous positions has been rightfully rejected.	If this stays an isolated event, there is nothing to do. In the opposite case, consider the presence of reflections and multiple travels of the acoustic wave. Increase the recurrence value. Reduce the general ambient noise as in the convergence error and mirror ambiguity.
Delta T Filter Error	The date of emission of the beacon is older than the date of the position output by the filter.	The internal data flow is late due to CPU overload.	Lower the **Output** rate of the user protocol. Contact iXBlue support

Inertial Sensor

Error Messages	Meaning	Possible Cause(s) (not exhaustive)	Checks, possible solutions
ADC1 Saturation	Overload on the ADC1 of the INS		Contact iXBlue customer support
ADC2 Saturation	Overload on the ADC2 of the INS		Contact iXBlue customer support.
ADC3 Saturation	Overload on the ADC3 of the INS		Contact iXBlue customer support.
Accelerometer X1 Error	Error on the accelerometer X1 of the INS		Contact iXBlue customer support.
Accelerometer X2 Error	Error on the accelerometer X2 of the INS		Contact iXBlue customer support.
Accelerometer X3 Error	Error on the accelerometer X3 of the INS		Contact iXBlue customer support.
Heading Not Valid	Heading data of the INS is not valid	Message appears often after an ADC Overload or accelerometer error.	Wait a few minutes and all should come back in order. If not contact iXBlue customer support.
Attitude Not Valid	Attitude data of the INS is not valid	Message appears often after a ADC Overload or accelerometer error.	Wait a few minutes and all should come back in order. If not contact iXBlue support.

Acoustic Array

There are no error messages available.

External Sensor

Error Messages	Meaning	Possible Cause(s) (not exhaustive)	Checks, possible solutions
GPS Not Received	GPS data expected was not received in input.	GPS not properly connected, defectuous cables (the Y cable or the 10 m GPS cable). Unavailable satellites	Check the cables and connections. Check that the satellites are available.
Pressure Not Received	Pressure data expected was not received in input.	Pressure sensor defectuous, not properly connected, not at the right format or serial port not properly configurated.	Check the input data of the ECB ($PMEVL, NMEA format), serial port configuration …

V MAINTENANCE

V.1 Preventive Maintenance

GAPS has been designed to avoid as much as possible any preventive maintenance operation.

Nevertheless, GAPS has to be used with the usual precautions as for any other underwater equipment.

V.1.1 PRECAUTIONS

- **Rinsing**: Each time GAPS has been used in salted water, it must be thoroughly rinsed with fresh water.
- **Hydrophones caps**: GAPS must be handled with great care, especially concerning the hydrophones. As soon as it is no more in water, the hydrophone protective caps must be put in place.
- **Hydrophones**:
    - Do not paint hydrophones with traditional painting
    - Do not use metallic instruments to clean hydrophones
    - Do not use water with pressure to clean hydrophones
    - Do not use solvent
    - To limit growth on hydrophones we recommend to use International TRILUX 33 or SigmaCoatings blue Sigma-glide (we didn't characterized yet the impact on reception but it should be limited)

AVOID TRANSMITTING ACOUSTICALLY WITH GAPS IN THE AIR, BUT A QUICK TRANSMITTING TEST DOES NOT HARM THE TRANSDUCER.

- **Connector**: Spray silicone grease LOCTITE 8021 must be regularly applied on the male and female part of the SUBCONN connector.
- **Dummy Plug**: When the cable is not connected to GAPS, make sure to use the dummy plug to protect the cable termination.

Figure 60 – GAPS cable dummy plug

- **Handling**: The best way to carry GAPS is to hold it by the upper disc in one hand and one of the longer arms in the other hand.

Figure 61 - Handling GAPS

DO NOT HOLD GAPS BY ITS HYDROPHONES.
WHEN GAPS IS NOT USED, THE FOUR HYDROPHONES MUST KEEP THEIR PROTECTION CAPS.
REMOVE THEM JUST BEFORE PUTTING GAPS INTO WATER.

- The equipment must be placed back in its transport box and stored in a dry area until it is installed. The equipment must always be stored in its packaging. The limits of storage temperature are the following:

Item	Min T°	Max T°
Acoustic Array	- 20°C	+70°C
Acoustic Transponders	- 20°C	+70°C

IMPORTANT

Bad storage conditions may void certain clauses of the guarantee.

V.1.2 Cleaning Hydrophones

Procedure

Step	Action
1.	Clean the hydrophone surface with isopropylic alcohol.
2.	Abrase lightly with 80/100 sand paper.
3.	Clean with isopropylic alcohol.
4.	Wet the surface with aliphatic hydrocarbon solvent (Essence F in French).
5.	Wait 2 minutes for drying.
6.	Apply anti fouling according to the supplier recommendations (thin coat).
7.	Wait 24h.
8.	End of procedure.

V.1.3 TESTING GAPS BEFORE DEPLOYMENT

This section describes the procedure to test the GAPS in the air before operation. This procedure can be carried out in a lab or on the deck of the vessel.

Tests are divided in four different parts that concern the four main functionalities of GAPS:

- STEP 1: Communication
- STEP 2: Transmission
- STEP 3: Reception
- STEP 4: Attitude Monitoring
- STEP 5: GPS Input
- STEP 6: GAPS Output

Integration tests (transponder on the vehicle, GPS, navigation software) are not covered in this section as these tests depend on each specific installation.

If the all six tests are successful, the GAPS is ready to be integrated in its operating environment and to be deployed at sea.

If one test fails, please, contact the iXBlue technical support.

V.1.3.1 Required Equipment

The required equipment to conduct the procedure is described below:

- GAPS acoustic head
- Cable (between GAPS acoustic head and ECB)
- Easy Connect Box (with its 220 V power supply cable)
- Serial link cable (DB9)
- A computer with GAPS MMI software and one serial communication port
- A GPS (with cable)

Figure 62 – Required equipment for the pre-deployment tests

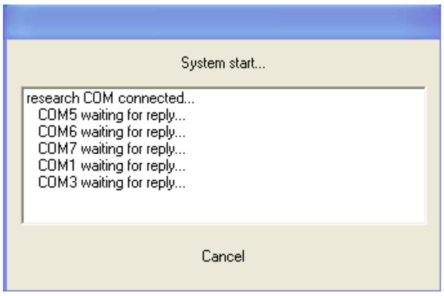
V.1.3.2 Testing Communication

Procedure

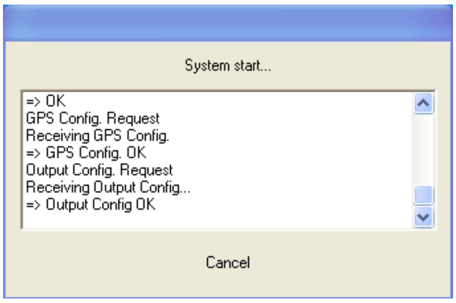
Step	Action

1. Start GAPS MMI Software.

   During launching, GAPS MMI software scans the different communication ports available on the computer for GAPS reply datagrams.



   Once the GAPS communication port is found, the software compares both configurations (from the software and from the GAPS itself) and informs you if there are differences.

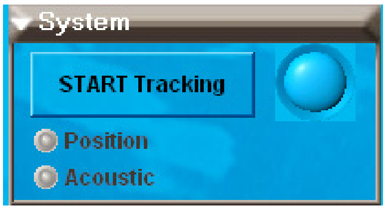


   This test is successful once GAPS has replied a message on its communication port.

2. End of procedure.

V.1.3.3 Testing Transmission

Procedure

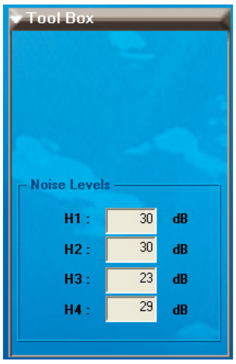
Step	Action
1.	In GAPS MMI software, in the **Transponders** menu, create a MT8 beacon.
2.	Configure the beacon in transponder mode.
3.	Make sure that the transponder is “in use”.
4.	In the **Supervision** menu / processor button, configure the acoustic recurrence: internal fixed, at 1 s.
5.	On the main page, click on **START Tracking.**  *This test is successful if you hear the GAPS pinging at the configured recurrence.*
6.	End of procedure.

Long transmission is the air could damage the transmitter. Perform only a few pings for testing purposes.

V.1.3.4 Testing Reception

Procedure

Step	Action
1.	In GAPS MMI software, create a MT8 beacon, in the **Transponder** menu.
2.	Configure the beacon independently, in responder or transponder mode.
3.	Make sure that the transponder is “in use”.
4.	In the **Supervision** menu / processor button, configure the acoustic recurrence: internal fixed, at 1 s.
5.	On the main page, click on **START Tracking**
6.	In the Supervision menu / Acoustic Array button, check the four noise level measurements.

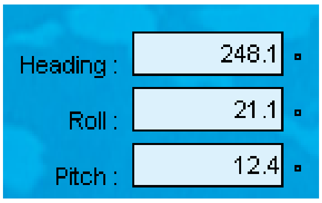


This test is successful if the four noise levels are the same (+/- 3 dB). On the above example, hydrophone n° 3 is damaged (6 to 7 dB difference compare to the 3 other hydrophones).

Step	Action
7.	End of procedure.

V.1.3.5 Testing Monitoring of Heading/Roll/Pitch

Procedure

Step	Action
1.	In GAPS MMI software, select the absolute or relative view (in main menu).
2.	Change, respectively, the heading, roll and pitch of the GAPS head itself.
3.	Check, in the GAPS MMI software that the attitudes are changing, according to the motion of the system.  *This test is successful if you can monitor the heading, roll and pitch in the GAPS MMI software.*
4.	End of procedure.

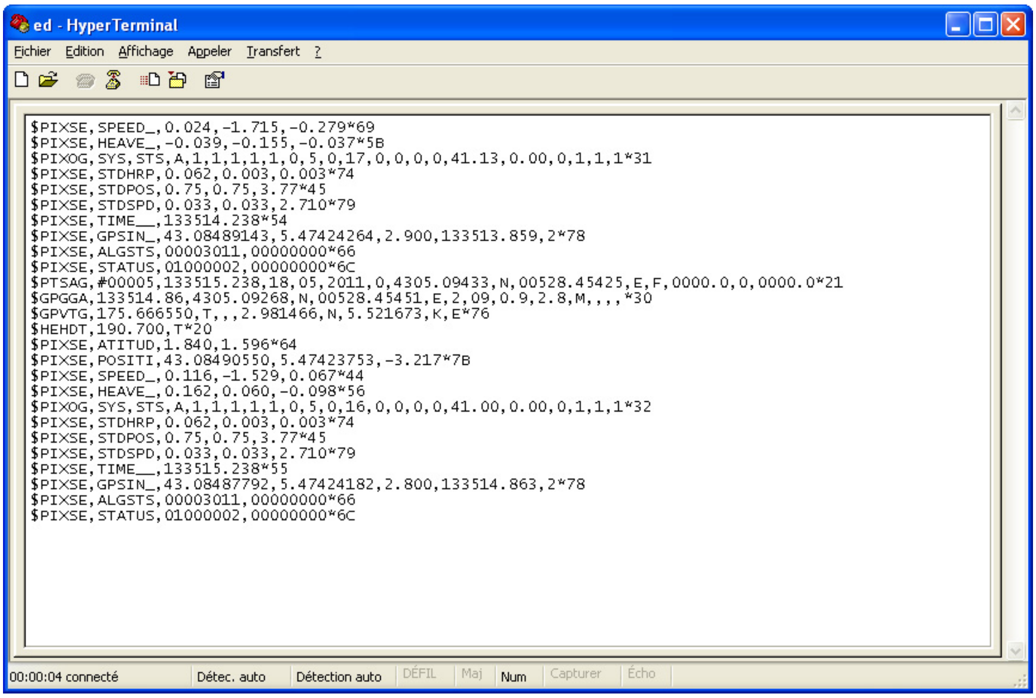
V.1.3.6 Testing GPS Input

Procedure

Step	Action
5.	Connect a GPS onto the GAPS (with Y cable or onto the GPS input, on ECB).
6.	Start the GAPS.
7.	In GAPS MMI software, configure the communication port parameters.
8.	Configure the lever arm between GAPS and GPS in **vessel** menu.
9.	Check that GPS is received (by clicking on **External Sensors Status**). 
10.	Wait for 5 minutes (initial alignment).
11.	After the 5 first minutes, check during 5 minutes that the GAPS is not rejected (by clicking on **External Sensors Status**), in the **Diagnostic** toolbox. *This test is successful if GPS is not rejected after the 5 first minutes.*
12.	End of procedure.

V.1.3.7 Testing GAPS Standard Output

Procedure

Step	Action
1.	In GAPS MMI software, select the GAPS standard protocol on output (in **Supervision** panel) with a 1 s rate.
2.	Connect the ECB output onto a computer serial communication port.
3.	Open a HyperTerminal and configure it with parameters corresponding to the settings already present in the GAPS MMI.
4.	Check that the messages arrive every second on the HyperTerminal.  *This test is successful if you can read GAPS Standard messages on HyperTerminal.*
5.	End of procedure.

V.2 Corrective Maintenance

IMPORTANT

Warranty will be void if GAPS is opened.

In case of a faulty hydrophone, it is possible to change this hydrophone without sending back the equipment to the factory. Follow the procedure **CM01** below to remove an arm of GAPS in order to exchange the faulty hydrophone by a new one.

System: GAPS	**Corrective Maintenance**	
Sub-system: Hydrophone	**Reference:** CM01	**Page:** 1/1
Subject: Clean hydrophone for growth	**Maintenance level:** 1 **Duration:** 5 minutes	

Equipment Soap, fresh water, thin sandpaper

Precaution None

Preliminary Steps None

Procedure

Step	Action
1.	Use soap and fresh water to clean the hydrophone surface.
2.	Apply low pressure with thin sand paper on the hydrophone surface until all growth has been removed.
3.	End of Procedure.

System: GAPS	Corrective Maintenance	
Sub-system: Hydrophone	**Reference:** CM01	**Page:** 1/2
Subject: Exchanging faulty hydrophone	**Maintenance level:** 1 **Duration:** 20 minutes	

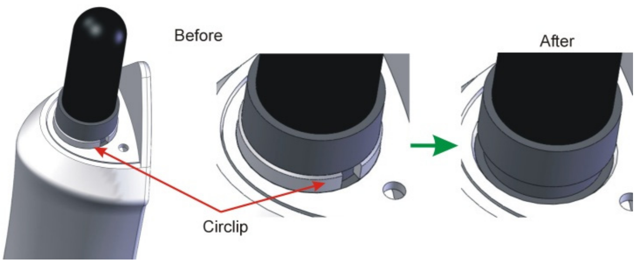
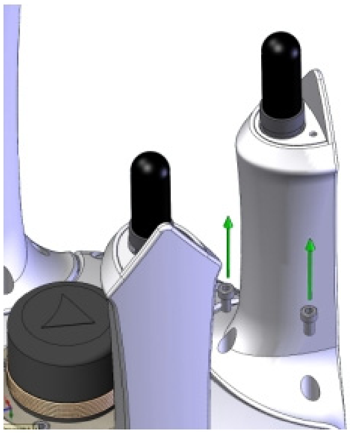
AFTER PERFORMING THIS MAINTENANCE TASK, THE ACCURACY OF YOUR GAPS SYSTEM WILL NOT BE OPTIMAL FOR THE LONG RANGE POSITIONING (> 1,000 M) UNTIL A CALIBRATION OPERATION HAS BEEN PERFORMED.

Equipment Allen key #4, a new hydrophone

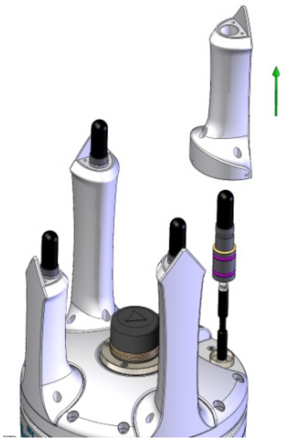
Precaution None

Preliminary Steps None

Procedure

Step	Action	
4.	Set up the GAPS antenna upside down.	
5.	Remove the circlip at the interface between the arm and the hydrophone.	
6.	Use the Allen key to unscrew the three socket head cap screws CHC M5-12 that fasten the arm to the antenna body.	

System: GAPS	Corrective Maintenance	
Sub-system: Hydrophone	**Reference:** CM01	**Page:** 2/2
Subject: Exchanging faulty hydrophone	**Maintenance level:** 1 **Duration:** 20 minutes	

Step	Action
7.	Remove the arm by translating it gently along its own axis. 
8.	Unscrew the hydrophone from its connector. 
9.	Screw the new hydrophone to the connector.
10.	Put some grease on the two rings (pink on the figure) in order to ease the entering of the hydro in the arm.
11.	Replace gently the arm back to its original position.
12.	Fasten the arm to the body with the three screws CHC M5-12.
13.	Insert the circlip at the interface between the hydrophone and the arm.
14.	End of procedure.

V.3 System Upgrade

V.3.1 Purpose

iXBlue provides upgrades of GAPS system firmware. The purpose of this section is to describe the procedures to download the firmware to GAPS by serial link.

V.3.2 Recommendation

If the upgrades include a firmware package, with 4WAYS, INS, CPU and MMI software, iXBlue recommend loading all of them before to use the GAPS. Some functionality should be depending of the different software versions compatibilities.

V.3.3 Upgrading the INS Firmware

Procedure

Step	Action
1.	Connect a direct serial link between the serial port of the computer and the MMI communication port, on the ECB (Easy Connect Box) and, if necessary, disconnect all the other serial connections (GPS, Pressure and Output).

Step	Action
2.	Open the ***comport.ini*** file that is in the INS AutoLoader directory. Change the ComPort that corresponds to the communication port of the computer if necessary.

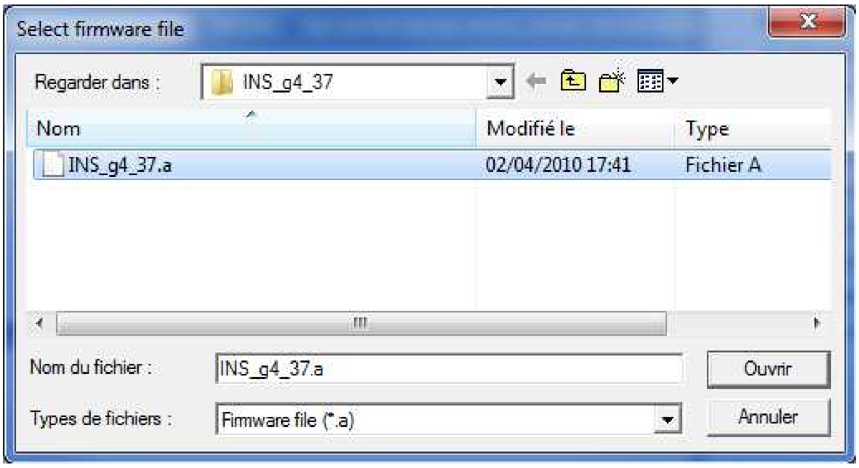
```
[Communication]
ComPort = 1
```

Save the modifications and close the file.

Step	Action
3.	Switch off GAPS.

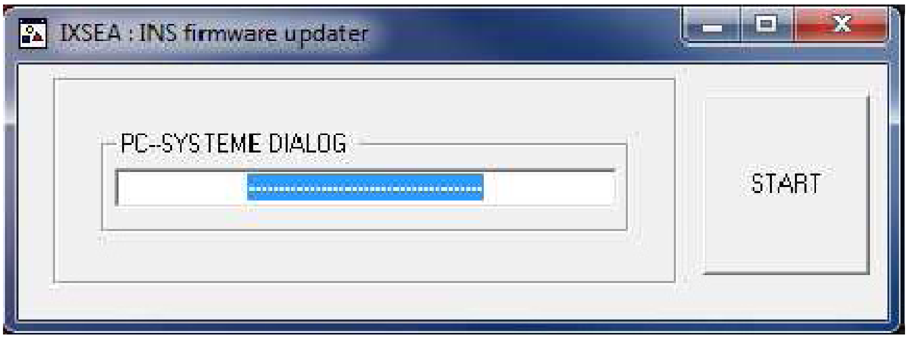
4. Open the `INS_gx_xx` folder and run the InsFirmUpdater.exe software.

   The following window opens:



5. Select the `INS_gx.xx.a` file and open it.

   The following window opens:



6. Switch on GAPS.

   Wait about 10 s.

7. Press on the **START** button.

   The download starts after a few seconds.

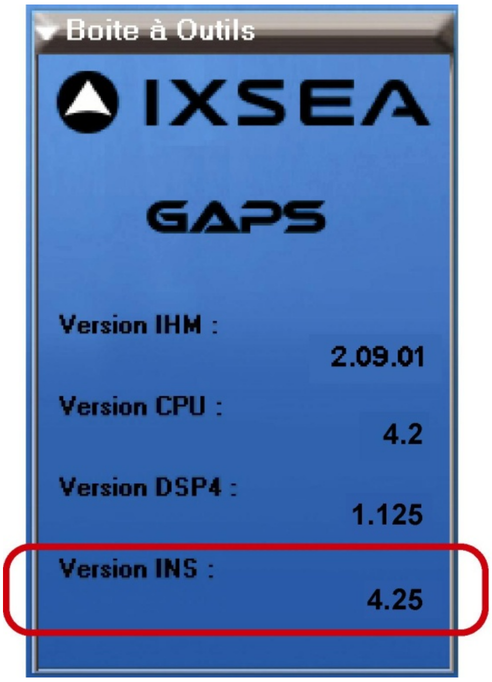
8. Switch off GAPS once the "End of download" message is displayed then exit the program.

9. Switch on the GAPS.

10. Wait 20 s then start the MMI.

11. Download the configuration from MMI to GAPS

    Check the correct INS version number in the Supervision Panel.



12. End of procedure.

V.3.4 UPGRADING THE CPU AND/OR 4WAYS FIRMWARE

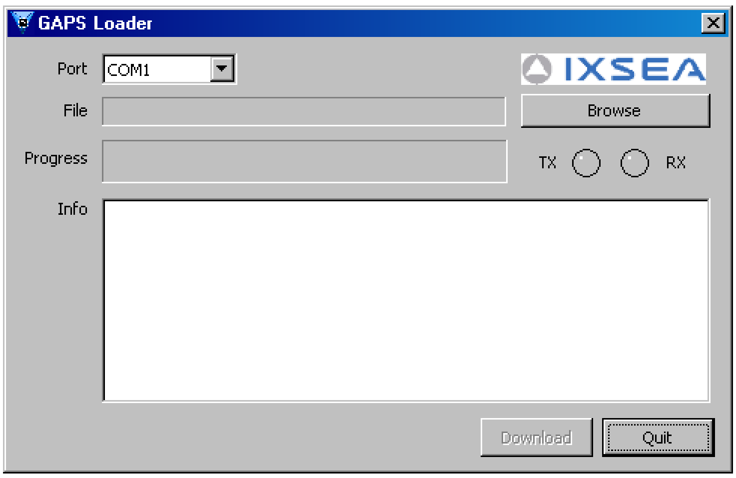
Step	Action
1.	Connect a direct serial link between the serial port of the computer and the MMI communication port, on the ECB (Easy Connect Box) and, if necessary, disconnect all the other serial connections (GPS, Pressure and Output).

2.	Switch GAPS off.

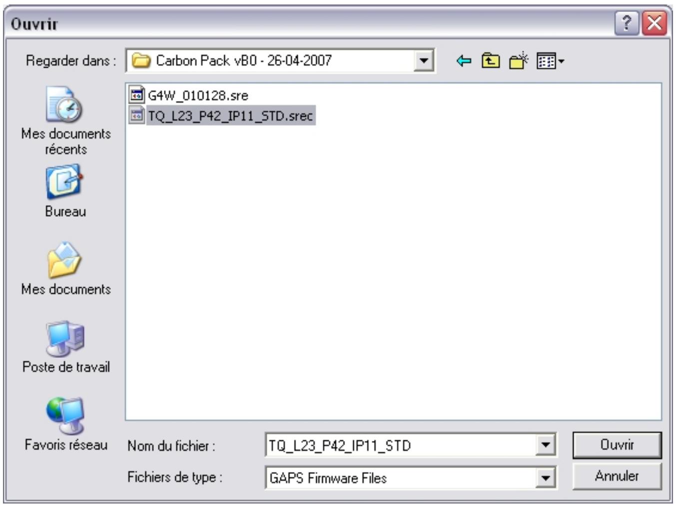
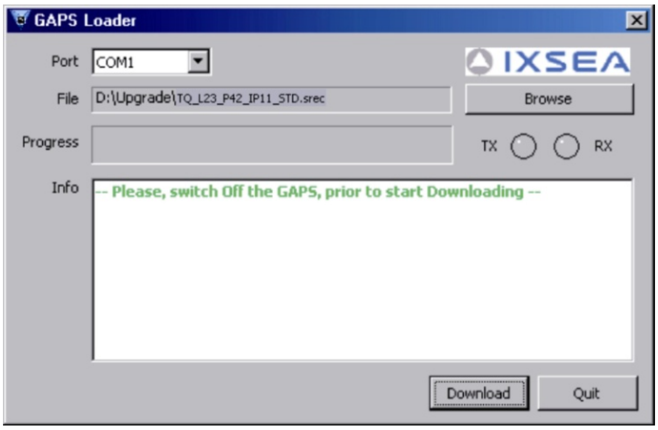
3.	Run the GAPS Loader program provided with GAPS MMI:

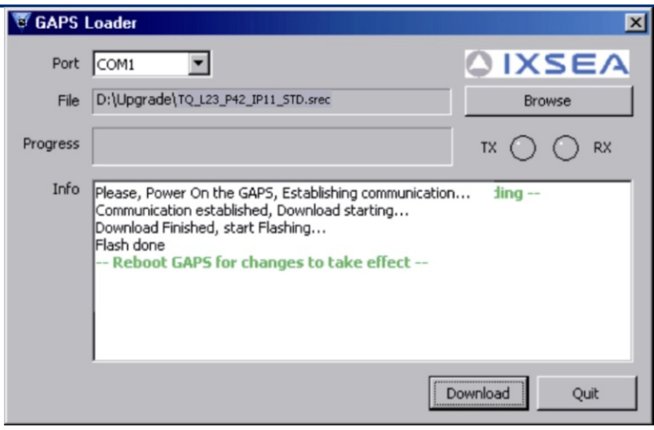
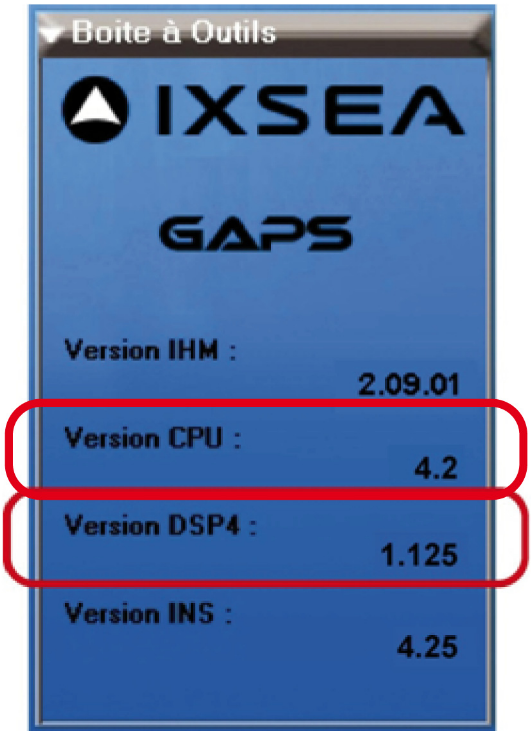
GAPSLoader.exe

The following window opens.



4.	Select the GAPS Com Port.

Step	Action
5.	Press the **Browse** button to select the file to download depending of the upgrade that you have to achieve: • Select the G4W_*XXXXXX*.sre to update the 4Ways firmware or • Select the TQ_L*XX*_P*XX*_IP*XX*_STD.srec to update the CPU • The *XX* in the file names are numbers and identify the firmware version. 
6.	Press the **Download** button 
7.	Switch GAPS on.
8.	Exit the program once the download is finished and switch off GAPS.

Step	Action
	
9.	Switch GAPS on and wait for 20 s then launch the MMI.
10.	Choose to download the configuration from MMI to GAPS and check the 4Ways and or the CPU version number in the Supervision Panel. 
11.	End of procedure.

VI LIBRARY INTERFACE

VI.1 Input Protocols

VI.1.1 xxGGA

"xx" means that the first two letters of the format name can be any letter.

- Data received: Latitude, Longitude, GPS quality
- Data frame:

$xxGGA,hhmmss.ss,llll.ll,a,yyyyy.yy,b,q,ss,...,…,.,…,.,…,….*hh<CR><LF>		
Where:	hhmmss.ss	is the UTC of position
	llll.ll	is the latitude in degrees (two first l) and in minutes (four last l)
	a	is the hemisphere N: North S: South
	yyyyy.yy	is the longitude in degrees (3 first y) and in minutes (4 last y)
	b	is longitude sign E: East W: West
	q	is the GPS quality indicator • 0 Fix not valid • 1 GPS SPS Mode fix valid • 2 Differential Mode, SPS Mode, fix valid • 3 GPS PPS Mode, fix valid • 4 RTK • 5 Float RTK
	ss	is the number of satellites
	*hh	is optional

VI.1.2 xxZDA

"xx" means that the first two letters of the format name can be any letter.

- Data received: the Universal Time information
- Data frame:

$xxZDA,hhmmss.ss,dd,mm,yyyy,xx,yy*cc<CR><LF>		
Where:	hhmmss.ss	is the UTC time in hours, minutes, seconds of the GPS position
	dd	is the day
		dd = 0 to 31
	mm	is the month
		mm =1 to 12
	yyyy	is the year
	xx	is the local zone description in hours
		xx = -13 to 13
	yy	is the local zone description in minutes
		yy = 0 to 59
	*cc	is the checksum

VI.1.3 PMEVL

- Data received: Pressure value
- Data frame:

$PMEVL,XP,MEA,C,VVVVV*cc<CR><LF>		
Where:	XP	is the transponder ID (from 001 up o 128)
	MEA	is a mnemonic
	C	is the analog channel, C = 8
	VVVVV	is the Pressure value
		VVVVV = 0 to 65535 dBars (integer)
	*cc	or VVVV.V = 0.0 to 9999.9 dbars (float)
		is the checksum

VI.2 Output Protocols

The protocols listed in this section are sorted between the protocols that contain the position of the transponder and those that do not.

The protocols, listed in sections VI.2.1, VI.2.2, VI.2.3, VI.2.4, VI.2.5, VI.2.6 and VI.2.7, contain the position of the transponder(s).

The protocols listed in VI.2.8, VI.2.9, VI.2.10, VI.2.11, VI.2.12, VI.2.13, VI.2.14 and VI.2.15 contain information about the GAPS antenna. They DO NOT contain the position of the transponder.

VI.2.1 GAPS STANDARD

The GAPS Standard protocol is composed of the three iXBlue POSIDONIA positioning messages $PTSAG, $PTSAX and $PTSAY plus all the messages of the PHINS Standard protocol.

Transponder Absolute Positioning Message (geographical coordinates and depth)

$PTSAG,#NNNNN, hhmmss.sss,jj,mm,aaaa,BBB,DDMM.MMMMM,H,DDDMM.MMMMM,D,A,MMMM.M,A, MMMM.M *CK		
where:	#NNNNN	Recurrence frame Number
	hhmmss.sss	is the time in hours, minutes, seconds ,milliseconds
	jj	is the day (jj = 1 to 31)
	mm	is the month (mm =1 to 12)
	aaaa	is the year
	BBB	is the Transponder No. or ship's No 0: GAPS antenna 1 to 128: Transponder -128 to –1: Unknown Transponder
	DDMM.MMMMM	is the latitude degrees, minutes and 1/100000
	H	is the hemisphere (N: North, S: South)
	DDDMM.MMMMM	is the longitude degrees, minutes and 1/100000
	D	is the longitude direction (E: East, W: West)
	A	is the validity of the four reception channels 0 to F: binary coding of acoustic hydrophone validity
	MMMM.M	is the calculated depth in meters
	A	is the depth validity 0: None 1: Calculated 2: Sensor
	MMMM.M	is the sensor depth in meters

- Position validity: The value represents the acoustic hydrophone validity on 4 bits (from 0000 to 1111). 0 means that the channel is not valid and 1 that the hydrophone operates properly. GAPS can still output valid positions even if the validity is not 1111 (three channels are enough). All output positions are valid.
- Calculated depth / Sensor depth: The GAPS know only one depth that is the fusion of both depths (Calculated and sensor). This "optimized" depth is in the "Calculated depth" field.

- Sensor depth: if the Acoustic Transponder has no sensor, the value is 9999.
- In case of ship, the three last fields are set to zero.

Transponder relative Positioning Message relative to the GAPS array - GAPS orientation (Relative coordinates and depth)

$PTSAX,#NNNNN, hhmmss.sss,jj,mm,aaaa,BBB, XXXXX.X, YYYYY.Y,A,PPPP.P,A,CCCC.C *CK		
where:	#NNNNN	Recurrence frame Number
	hhmmss.sss	is the time in hours, minutes, seconds ,milliseconds
	jj	is the day
		jj = 1 to 31
	mm	is the month
		mm =1 to 12
	aaaa	is the year
	BBB	is the Transponder No.
		1 to 128: Transponder
		-128 to –1: Unknown Transponder
	XXXXX.X	is the X coordinate (+ forward) in meters
	YYYYY.Y	is the Y coordinate (+ starboard) in meters
	A	is the position validity (X, Y, Z)
		0 to F: binary coding of acoustic channel validity
	PPPP.P	is the calculated depth in meters
	A	is the depth validity
		0: None 1: Calculated 2: Sensor
	CCCC.C	is the sensor depth in meters

- Position validity: The value represents the acoustic Channel validity on 4 bits (from 0000 to 1111). 0 means that the channel is not valid and 1 that the channel operates properly.
- Calculated depth / Sensor depth: The GAPS know only one depth that is the fusion of both depths (Calculated and sensor). This “optimized” depth is in the “Calculated depth” field.
- Sensor depth: if the Acoustic Transponder has no sensor, the value transmitted is 9999.

THE X AND Y POSITIONS ARE RELATIVE TO THE GAPS ACOUSTIC ARRAY.

Transponder Relative Positioning Message relative to GAPS – NORTH orientation (Relative coordinates and depth)

$PTSAY,#NNNNN, hhmmss.sss,jj,mm,aaaa,BBB,XXXXX.X, YYYYY.Y,A,PPPP.P,A,CCCC.C *CK		
where:	#NNNNN	Recurrence frame Number
	hhmmss.sss	is the time in hours, minutes, seconds ,milliseconds
	jj	is the day
		jj = 1 to 31
	mm	is the month
		mm =1 to 12
	aaaa	is the year
	BBB	is the Transponder No.
		1 to 128: Transponder
		-128 to –1: Unknown Transponder
	XXXXX.X	is the X coordinates (positive northwards) in meters
	YYYYY.Y	is the Y coordinates (positive eastwards) in meters
	A	is the position validity (X,Y, Z)
		0 to F: binary coding of acoustic channel validity
	PPPP.P	is the calculated depth in meters
	A	is the depth validity
		0: None 1: Calculated 2: Sensor
	CCCC.C	is the sensor depth in meters

- Position validity: The value represents the acoustic Channel validity on 4 bits (from 0000 to 1111). 0 means that the channel is not valid and 1 that the channel operates properly.
- Calculated depth / Sensor depth: The GAPS know only one depth that is the fusion of both depths (Calculated and sensor). This “optimized” depth is in the “Calculated depth” field.
- Sensor depth: if the Acoustic Transponder has no sensor, the value transmitted is 9999.

THE X AND Y POSITIONS ARE RELATIVE TO THE GAPS ACOUSTIC ARRAY

- Data sent: Latitude, Longitude of the ship or GAPS, GPS quality
- Data frame:

$GPGGA,hhmmss.ss,ddmm.mmmmm,a,dddmm.mmmmm,b,q,ss,...,…,.,…,.,…,….*hh<CR><LF>		
where:	hhmmss.ss	is the UTC of position
	ddmm.mmmmm	is the latitude in degrees and in minutes and 1/100000
	a	is the hemisphere N: North S: South
	dddmm.mmmmm	is the longitude in degrees and in minutes and 1/100000
	b	is longitude sign (E: East, W: West)
	q	is the GPS quality indicator • 0 Fix not valid • 1 GPS SPS Mode fix valid • 2 Differential Mode, SPS Mode, fix valid • 3 GPS PPS Mode, fix valid • 4 RTK • 5 Float RTK
	ss	is the number of satellites
	*hh	is optional

- Data sent: Course Over Ground and Ground Speed
- Data frame:

$GPVTG,x.x,T,x.x,M,x.x,N,x.x,K,a*hh<CR><LF>		
where:	x.x,T	Course over ground, degrees True
	x.x,M	Course over ground, degrees Magnetic
	x.x,N	Speed over ground, knots
	x.x,K	Speed over ground, km/h
	a	Mode Indicator (A autonomous mode, D differential mode, E estimated mode, M manual input mode, S simulator mode, N Data not valid, never null)
	*hh	Checksum

All the strings of the GAPS Standard format (sent on the Output serial link) are also present in the GAPS Regular (sent on the MMI serial link). The GAPS Regular strings are transmitted at a rate of 1 Hz. GAPS Regular contains other strings dedicated to an iXBlue internal use and are thus not described in this manual.

VI.2.2 HIPAP HPR 418 BCD (REV C) MOBILE OR FIXED

Please refer to the Kongberg document HPR418BCD_revC.doc.

Transponder position message: the frame contains 32 bytes in binary format.

Example data:

X=1234.56m Y=-987.65m Depth 1234.5m Heading 59.9° Pos. to ROV 15. Training mode

The difference between the **mobile** and **fixed** protocols is made in the Byte 3 Bit 5. The bit is equal to 1 in the mobile case and 0 in the fixed case.

Message		Example		
Byte 0	0xDF	DF	Start of message	
Byte 1	0x01		Head byte 1- SSBL position	
Byte 2	0xSS		Status Byte 1 Bit 0: Position Measurement OK Bit 1: Position measurement filtered Bit 2: Position measurement predicted (always 0 for GAPS) Bit 3: Optional data SSBL OK (pressure sensor only for GAPS TP) Bit 4-6: Always 0 Bit 7: Transceiver error (opposite of Bit 0)	
Byte 3	0x20		Status Byte 2 Bit 0-1: Transducer number (MSB s/n GAPS) Bit 2-3: Transceiver number (LSB s/n GAPS) Bit 4: Training mode (always 0 for GAPS) Bit 5: Mobil TP (SSBL) Rov TP (LBL) (0 fixed, 1 mobile) Bit 6: LBL co-ordinates in UTM (always 0 for GAPS) Bit 7: Master 0, Slave 1 (always 0 for GAPS)	
Byte 4	0x01		TP. Inf. 0 - TP (Transponder) 1 - Depth TP Optional Data 1 2 - Inclinometer TP Optional Data 1&2 /* not used for GAPS 3 - Diff.in.TP Optional Data 1&2 /*not used for GAPS 4 - Compass TP Optional Data 1 /* not used for GAPS 5 - Acoustic control transponder /* not used for GAPS 6 - Beacon /* not used for GAPS 7 - Depth Beacon /* not used for GAPS 10 -Responder driver 1 /* not used for GAPS 13 - Responder driver 4	
Byte 5 Byte 6	0x00 0xTT		TP ID	From 0 to 99
Byte 7 Byte 8 Byte 9	0xsY 0xYY 0xYY		Y position	s = 0 if Y positive (Y HIPAP) s = D if Y negative BCD coded, LSB = 1/10 of unit
Byte 10 Byte 11 Byte 12	0xsX 0xXX 0xXX		X position	s = 0 if X positive (X HIPAP) s = D if X negative BCD coded, LSB = 1/10 of unit
Byte 13 Byte 14 Byte 15	0xsZ 0xZZ 0xZZ		Z position	s = 0 if Z positive s = D if Z negative BCD coded, LSB = 1/10 of unit

Byte 16 Byte 17	0xHH 0xHH		Heading LSB Heading MSB	0° to 359.9° LSB=0.1° BCD coded
Byte 18 Byte 19 Byte 20	XsD 0xDD 0xDD		Sensor Depth Optional Data 1	Meters S = 0 BCD coded
Byte 21 Byte 22 Byte 23	0x00 0x00 0x00		Optional Data 2	
Byte 24 Byte 25	0x00 0x00		Horizontal error Ellipse direction	
Byte 26 Byte 27	0x00 0x00		Horizontal error Ellipse major	
Byte 28 Byte 29	0x00 0x00		Horizontal error Ellipse minor	
Byte 30	0xXX	XX	Checksum	
Byte 31	0xFF	FF	End of frame	

Transponder position message: the frame contains 32 bytes in binary format.

Message			
Byte 0	0xDF	Start of message	
Byte 1	0x03	Head byte	TP sequence Telegram
Byte 2	0xSS	Number of transponder in use	From 1 to 13
Byte 3 Byte 4	0xTT 0xTT	Number of TP 1	From 1 to 999
Byte 5 Byte 6	0xTT 0xTT	Number of TP 2	From 1 to 999
Byte 7 Byte 8	0xTT 0xTT	Number of TP 3	From 1 to 999
Byte 9 Byte 10	0xTT 0xTT	Number of TP 4	From 1 to 999
Byte 11 Byte 12	0xTT 0xTT	Number of TP 5	From 1 to 999
Byte 13 Byte 14	0xTT 0xTT	Number of TP 6	From 1 to 999
Byte 15 Byte 16	0xTT 0xTT	Number of TP 7	From 1 to 999
Byte 17 Byte 18	0xTT 0xTT	Number of TP 8	From 1 to 999
Byte 19 Byte 20	0xTT 0xTT	Number of TP 9	From 1 to 999
Byte 21 Byte 22	0xTT 0xTT	Number of TP 10	From 1 to 999
Byte 23 Byte 24	0xTT 0xTT	Number of TP 11	From 1 to 999
Byte 25 Byte 26	0xTT 0xTT	Number of TP 12	From 1 to 999
Byte 27 Byte 28	0xTT 0xTT	Number of TP 13	From 1 to 999
Byte 29	0x00	Dummy byte	Filled with 0
Byte 30	0xXX	Checksum	Bytes OR exclusive (except Checksum and End of frame). Bit 7 of the Checksum is always 0.
Byte 31	0xFF	End of frame	

VI.2.3 HIPAP HPR 400

Field	Name	Kongsberg Explanation	
$	Start Character		$
PSIMSSB	Address	Prop. Simrad address for SSBL	PSMSSB
,hhmmss.ss	Time	Empty or Time of reception	
,cc	Tp_code	Example: B01, B33, B47	%03d
,A	Status	A for OK and V for not OK	A/V
,cc	Error_code	Empty or a three character error code	ExD/ExM
,a	Coordinate_system	C for Cartesian, P for Polar, U for UTM coordinates	C
,a	Orientation	H for Vessel head up, N for North, E for East	N
,a	SW_filter	M means Measured, F Filtered, P Predicted	M
,x.x	X_coordinate	See separate explanation below	Northing
,x.x	Y_coordinate	See separate explanation below	Easting
,x.x	Depth	Depth in meters	depth
,x.x	Expected_accuracy	The expected accuracy of the position	Sqrt(Tx2+ty2)
,a	Additional_info	N for None, C Compass, I inclimeter, D Depth, T Time	
,x.x	First_add_value	Empty, Tp compass or Tp x inclination	
,x.x	Second_add_value	Empty or Tp y inclination	
*hh	Checksum	Empty or Checksum	*ck
CRLF	Termination		CRLF

Example: `$PSIMSSB,,B01,A,,P,H,M,111.80,63.43,48.50,0.00,N,,*5E`

VI.2.4 NAUTRONIX ATS II

Message	**Date Time B: Transp E: Status X: PosX Y: PosY D: PosZ H: Heading P: pitch R: roll <CR><LF>**	
Field 1	Date	dd month AAAA
Field 2	Time	HH:MM:SS:mmm
Field 3	Transponder number	From 1 to 127
Field 4	Status	0
Field 5	X coordinate	In meters ('+' when directed to starboard)
Field 6	Y coordinate	In meters ('+' when directed to the bow)
Field 7	Z coordinate	In meters ('+' when directed to the bottom)
Field 8	Heading	In degrees ('+' clockwise)
Field 9	Pitch	In degrees ('+' when bow up)
Field 10	Roll	In degrees ('+' when starboard up)

VI.2.5 POSIDONIA 6000

- Data sent: Transponder number, Transponder latitude, Transponder longitude, Transponder depth, Latitude standard deviation, Longitude standard deviation, Depth standard deviation, Delay
- Data frame: Binary format (32 bytes)

Message	**<Sync><F1><F2>…..<F8><Ch1Ch2>**	
Byte 0	0x24	Synchronization byte
Data Field 1 Byte 1	Transponder number	Warning: The first received number is used as a synchronization byte for all the other inputs
Data Field 2 Bytes 2 to 5	Transponder latitude	$+/-2^{32}$ = +/-Pi signed 32 bits
Data Field 3 Bytes 6 to 9	Transponder longitude	$+/-2^{32}$ = +/-Pi signed 32 bits
Data Field 4 Bytes 10 to 11	Transponder depth	IEEE floating point format , meters Warning: Not used by the INS
Data Field 5 Bytes 12 to 17	Latitude standard deviation	IEEE floating point format , meters
Data Field 6 Bytes 18 to 21	Longitude standard deviation	IEEE floating point format , meters
Data Field 7 Bytes 22 to 25	Depth standard deviation	IEEE floating point format , meters
Data Field 8 Bytes 26 to 29	Delay	IEEE floating point format , seconds
Bytes 30 to 31	Checksum	Addition of all the bytes from 0 to 29. Warning: 2 characters

VI.2.6 IXSEA USBL INS 1

Byte Nb	Field	Nb of bits	definition	Value		
				LSB	Min Value	Max Value
1	GG_{hex}	8	header	55_{hex}		
2	Bits 2 to 0	3	Message number	001_{bin}		
	Bits 7 to 3	5	Transponder ID	NA	0	31
3, 4, 5, 6	$LLLLLLLL_{hex}$	32	Latitude (deg) (Two-complement coded)	$180/2^{32}$	- 90 °	$90x(1\text{-}2^{32})$ °
7, 8, 9, 10	$NNNNNNNN_{hex}$	32	Longitude (deg)	$360/2^{32}$	0 °	$360.(1\text{-}2^{32})$ °
11 to 12	$ZZZZZ_{hex}$ (8+8+4 bits: - byte11, - byte12, - bits 3 to 0 of byte 13)	20	Z (m), immersion	0,01 m	0 m (00000_{hex})	+10485,75 m ($FFFFF_{hex}$)
13	Bit 4	1	Reserved			
	Bits 7 to 5	3	Major axe XY: long axe (in m) of the error ellipse representing the standard deviation on the position in the XY plane 000: 0 m < standard deviation < 0,5 m 001: 0,5 m < standard deviation < 1,5 m 010: 1,5 m < standard deviation < 3 m 011: 3 m < standard deviation < 6 m 100: 6 m < standard deviation < 12 m 101: 12 m < standard deviation < 25 m 110: 25 m < standard deviation < 50 m 111: standard deviation > 50 m			
14	Bit 0	1	Reserved			
	Bits 3 to 1	3	Minor axe XY: small axe (in m) of the error ellipse representing the standard deviation of the position in the XY plane 000: 0 m < standard deviation < 0,5 m 001: 0,5 m < standard deviation < 1,5 m 010: 1,5 m < standard deviation < 3 m 011: 3 m < standard deviation < 6 m 100: 6 m < standard deviation < 12 m 101: 12 m < standard deviation < 25 m 110: 25 m < standard deviation < 50 m 111: standard deviation > 50 m			
	Bits 7 to 4	4	Angle between the North and the major axe of the XY error ellipse l	$180/2^4$	0 °	15/16 x180 °
15	Bit 0	1	Reserved			

Byte Nb	Field	Nb of bits	definition	Value		
				LSB	Min Value	Max Value
	Bits 3 to 1	3	Standard deviation of the Z(m) position 000: 0 m < standard deviation < 0,5 m 001: 0,5 m < standard deviation < 1,5 m 010: 1,5 m < standard deviation < 3 m 011: 3 m < standard deviation < 6 m 100: 6 m < standard deviation < 12 m 101: 12 m < standard deviation < 25 m 110: 25 m < standard deviation < 50 m 111: standard deviation > 50 m			
	Bits 7 to 4	4	Reserved			
16	PP_{hex}	8	Reserved			
17, 18 19	$rrrrrrrrrrrrrrrrrrrrrr_{bin}$ (8+8+6 bits of: - byte 17, - byte 18, - bits 5 to 0 of byte 19)	22	It is the truncation of the absolute time provided by the GPS to the GAPS, keeping only the minutes, seconds, and milliseconds. It is coded in milliseconds number.	1 ms	0 ms	(3 599 999 ms, i.e. 1h - 1ms The largest values of this field do not have any meaning
	Bits 7 and 6 of byte19	2	Reserved			
20	KK_{hex}	8	Status byte Bits 0 to 8 - Reserved			
21	SS_{hex}	8	Checksum exclusive OR by byte for the whole 20 first bytes thus header included.			

Immersion definition

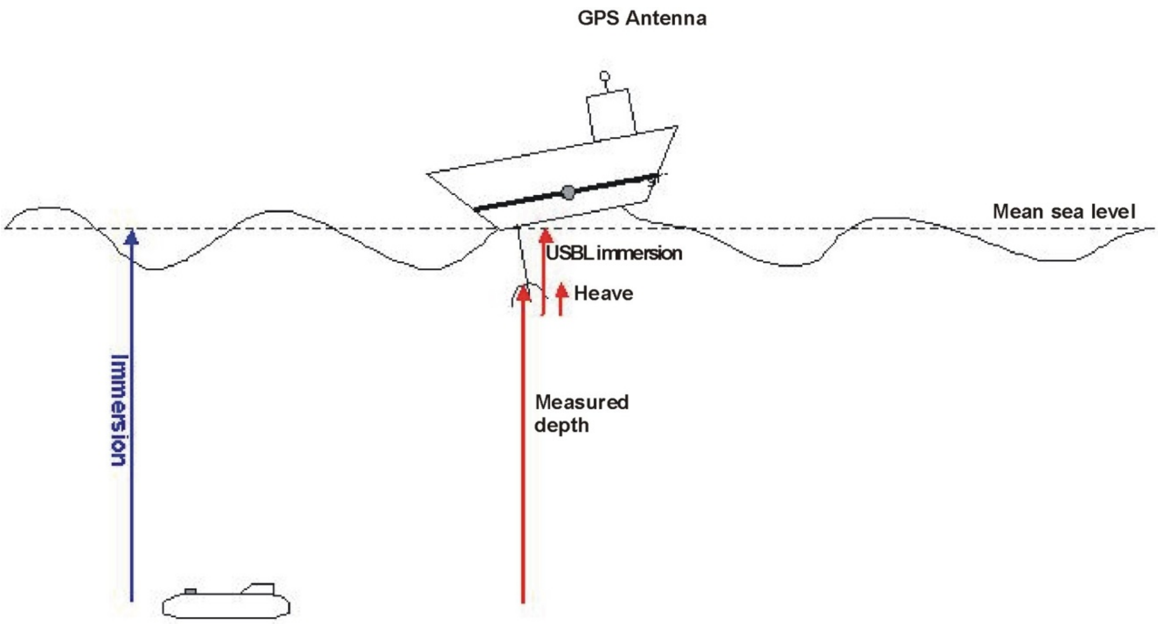
The immersion corresponds to the mobile depth with respect to the mean sea level (thus heave corrected). This data is coherent with the one that would be given by a depth sensor on the underwater mobile. But it does not allow to deduce the absolute position as there is no compensation for tide.

VI.2.7 IXSEA USBL INS 2

Message	$PXUI2,id,lat,lon,imm,maj,min,ang,dev,tim*CK	
Field 1	Transponder ID	
Field 2	Latitude (deg)	Resolution: $180/2^{32}$ Domain: $[-90 .. 90 \times (1-2^{32})]$
Field 3	longitude (deg)	Resolution: $360/2^{32}$ Domain: $[-90 .. 360 \times (1-2^{32})]$
Field 4	Immersion (m)	Resolution: 0,01 m Domain: [0 .. +10485,75]

Field 5	Major axe XY (m) Long axe of the error ellipse representing the standard deviation on the position in the XY plane	0: 0 m < standard deviation < 0,5 m 1: 0,5 m < standard deviation < 1,5 m 2: 1,5 m < standard deviation < 3 m 3: 3 m < standard deviation < 6 m 4: 6 m < standard deviation < 12 m 5: 12 m < standard deviation < 25 m 6: 25 m < standard deviation < 50 m 7: standard deviation > 50 m
Field 6	Minor axe XY (m) Small axe of the error ellipse representing the standard deviation of the position in the XY plane	0: 0 m < standard deviation < 0,5 m 1: 0,5 m < standard deviation < 1,5 m 2: 1,5 m < standard deviation < 3 m 3: 3 m < standard deviation < 6 m 4: 6 m < standard deviation < 12 m 5: 12 m < standard deviation < 25 m 6: 25 m < standard deviation < 50 m 7: standard deviation > 50 m
Field 7	Angle between the North and the major axe of the XY error ellipse	Resolution: $180/2^4$ Domain: [0 .. 15/16 x 180]
Field 8	Standard deviation of the Z(m) position	0: 0 m < standard deviation < 0,5 m 1: 0,5 m < standard deviation < 1,5 m 2: 1,5 m < standard deviation < 3 m 3: 3 m < standard deviation < 6 m 4: 6 m < standard deviation < 12 m 5: 12 m < standard deviation < 25 m 6: 25 m < standard deviation < 50 m 7: standard deviation > 50 m
Field 9	Truncation of the absolute time provided by the GPS to the GAPS, keeping only the minutes, seconds, and milliseconds. It is coded in milliseconds number.	Resolution: 1ms Domain: [0 .. 3 599 999] (The largest values of this field do not have any meaning)

Immersion The immersion corresponds to the mobile depth with respect to the mean sea level (thus heave corrected). This data is coherent with the one that would be given by a depth sensor on the underwater mobile. But it does not allow to deduce the absolute position as there is no compensation for tide.



Immersion	=	Measured depth (by the USBL acoustic array)
	-	Heave
	+	USBL immersion

VI.2.8 PHINS STANDARD MESSAGE

- Data sent: Heading, Attitude, Position, Speed, Standard deviations, Sensors input, Status
- Data frame:

$TIME__, hhmmss.sss*hh<CR><LF>		
Where:	**hhmmss.sss**	is the UTC of the data
	hh	is the checksum

$HEHDT,x.xxx,T*hh<CR><LF>		
Where:	**x.xxx**	is the true heading in degrees
	hh	is the checksum

$PIXSE,ATITUD,x.xxx,y.yyy*hh<CR><LF>		
Where:	**x.xxx**	is the roll in degrees
	y.yyy	is the pitch in degrees
	hh	is the checksum

$PIXSE,ALGSTS,hhhhhhhh,llllllll *hh<CR><LF>		
Where:	**hhhhhhhh**	is the hexadecimal value of INS algo status (LSB)
	llllllll	is the hexadecimal value of INS algo status (MSB)
	hh	is the checksum

$PIXSE,STATUS,hhhhhhhh,llllllll *hh<CR><LF>		
Where:	**hhhhhhhh**	is the hexadecimal value of INS status (LSB)
	llllllll	is the hexadecimal value of INS status (MSB)
	hh	is the checksum

$PIXSE,POSITI,x.xxxxxxx,y.yyyyyyy,z.zzz*hh<CR><LF>		
Where:	**x.xxxxxxx**	is the latitude in degrees
	y.yyyyyyy	is the longitude in degrees
	z.zzz	is the altitude in meters
	hh	is the checksum

$PIXSE,HEAVE_,x.xxx,y.yyy,z.zzz*hh<CR><LF>		
Where:	**x.xxx** **y.yyy** **z.zzz** **hh**	is the surge in meters is the sway in meters is the heave in meters is the checksum

$PIXSE,GPSIN_,x.xxxxxxx,y.yyyyyyy,z.zzz,hhmmss.sss*hh<CR><LF>		
Last data received from the GPS 1 sensor		
Where:	**x.xxxxxxx** **y.yyyyyyy** **z.zzz** **hhmmss.sss** **hh**	Is the latitude in degrees is the longitude in degrees is the altitude in meters is the time of the data last update is the checksum

$PIXSE,STDPOS,x.xx,y.yy,z.zz*hh<CR><LF>		
Where:	**x.xx** **y.yy** **z.zz** **hh**	is the latitude std dev is the longitude std dev is the altitude std dev is the checksum

$PIXSE,STDSPD,x.xxx,y.yyy,z.zzz*hh<CR><LF>		
Where:	**x.xxx** **y.yyy** **z.zzz** **hh**	is the north speed std dev is the east speed std dev is the vertical speed std dev is the checksum

$PIXSE,STDHRP,x.xxx,y.yyy,z.zzz*hh<CR><LF>		
Where:	**x.xxx** **y.yyy** **z.zzz** **hh**	is the heading std dev is the roll std dev is the pitch std dev is the checksum

$PIXSE,SPEED_,x.xxx,y.yyy,z.zzz*hh<CR><LF>		
Where :	**x.xxx** **y.yyy** **z.zzz** **hh**	is the north speed in m/s is the east speed in m/s is the vertical speed in m/s is the checksum

Some data frames as GPSIN are sent only if new data arrived from an external sensor since last output (DDRECK if dead reckoning mode is turned on).

VI.2.9 HEHDT

- Data sent: Heading
- Data frame:

$HEHDT,x.xxx,T*hh<CR><LF>		
Where:	**x.xxx**	is the true heading in degrees
	hh	is the checksum

VI.2.10 HALLIBURTON

- Data sent: Position, Atitude, Standard deviations, Status
- Data frame:

$PIXSE,HSPOS_,hhmmss.ss,llmm.mmmmm,H,LLLmm.mmmmm,D,d.dd,a.aa,x.xx,y.yy,z.zz,d.dd,nn,c,e.e,n.n,m.mmmm,s.ssss,vvvv.v<CR><LF>		
Where:	hhmmss.ss	is the UTC absolute time
	llmm.mmmmm	is the latitude in deg, decimal in min
	H	N: north, S: south
	LLLmm.mmmmm	is the longitude in deg, decimal in min
	D	E: east, W: west
	d.dd	is the depth in meters
	a.aa	is the altitude in meters (from DVL)
	x.xx	is the latitude Std (meters)
	y.yy	is the longitude Std (meters)
	z.zz	is the latitude longitude covariance (meters)
	d.dd	is the depth Std (meters)
	nn	is the UTM zone integer
	c	is the UTM zone character
	e.e	is the easting projection
	n.n	is the northing projection
	m.mmmm	is the log misalignment estimation in degrees
	s.ssss	is the log scale factor error estimation in %
	vvvv.v	is the compensation sound velocity in m/s

$PIXSE,HSATIT,h.hhh,r.rrr,p.ppp,h.h,a.aaa,b.bbb,c.ccc,d.ddd,e.eee,f.fff,g.ggg,h.hhh,i.ii,j.jj,k.kk,l.ll,m.mm,n.nn<CR><LF>		
Where:	h.hhh	is the heading in deg
	r.rrr	is the roll in deg
	p.ppp	is the pitch in deg
	h.h	is the heave in meters
	a.aaa*	is the heading rate* in deg/s
	b.bbb*	is the roll rate* in deg/s
	c.ccc*	is the pitch rate* in deg/s
	d.ddd	is the course made good in deg
	e.eee	is the speed over ground
	f.fff	is the longitudinal velocity in m/s
	g.ggg	is the transverse velocity in m/s
	h.hhh	is the vertical velocity in m/s
	i.ii	is the heading Std in deg
	j.jj	is the roll Std in deg
	k.kk	is the pitch Std in deg
	l.ll	is the north speed Std in m/s
	m.mm	is the east speed Std in m/s
	n.nn	is the vertical speed Std in m/s

* The precision of all rotation rate data is limited to 3°/h in order to be compliant to exportation regulation.

$PIXSE,HSSTAT,FFAAVVQQ<CR><LF>		
Where:	FF	is system failure word
		Bit 0 FOG error
		Bit 1 Accelerometer error
		Bit 2 Serial In A error
		Bit 3 Serial In B error
		Bit 4 Serial In C error
	AA	is INS aiding word
		Bit 0 GPS aiding
		Bit 1 DVL aiding
		Bit 2 USBL aiding
	VV	is valid word
		Bit 0 GPS valid
		Bit 1 DVL valid
		Bit 2 USBL valid
		Bit 3 Bathy valid
		Bit 4 Serial in A activity
		Bit 5 Serial in B activity
		Bit 6 Serial in C activity
	QQ	is overall QC ('0' - 'F')
		Bit 0 Alignment mode
		Bit 1 1->Fine alignment mode, 0->ready to dive
		Bit 2 Kalman On

VI.2.11 NAVIGATION

- Data sent: Heading, Attitude, Position, Status
- Data frame:

$HEHDT,x.xxx,T*hh<CR><LF>		
Where:	**x.xxx**	is the true heading in degrees
	hh	is the checksum

$PIXSE,ATITUD,x.xxx,y.yyy*hh<CR><LF>		
Where:	**x.xxx**	is the roll in degrees
	y.yyy	is the pitch in degrees
	hh	is the checksum

$PIXSE,POSITI,x.xxxxxxx,y.yyyyyyy,z.zzz*hh<CR><LF>		
Where:	**x.xxxxxxx**	is the latitude in degrees
	y.yyyyyyy	is the longitude in degrees
	z.zzz	is the altitude in meters
	hh	is the checksum

$PIXSE,STATUS,hhhhhhhh,llllllll *hh<CR><LF>		
Where:	**hhhhhhhh**	is the hexadecimal value of PHINS status LSB
	llllllll	is the hexadecimal value of PHINS status MSB
	hh	is the checksum

VI.2.12 SIMRAD EM

- Data sent: Heading, Roll, Pitch, Heave, Status
- Data frame:

Message	**SS 90 RRRR PPPP hhhh HHHH**		
Byte 0	0xSS	Sensor status	0x90 ⇒ OK 0x9A ⇒ alignment
Byte 1	0x90	Sync byte	
Byte 2	0xRRRR	Roll LSB	Roll ± 180° LSB: 0.01° Sign "+" when port up
Byte 3		Roll MSB	
Byte 4	0xPPPP	Pitch LSB	Pitch ± 180° LSB: 0.01° <u>Warning:</u> Opposite sign of Octans usual convention Sign "+" when bow up
Byte 5		Pitch MSB	
Byte 6	0xhhhh	Heave LSB	Heave ± 10 m LSB: 0.01m Sign "+" when Octans goes up
Byte 7		Heave MSB	
Byte 8	0xHHHH	Heading LSB	Heading 0° to 360° LSB: 0.01°
Byte 9		Heading MSB	

Each data is "two complemented" coded except Heading.

VI.2.13 SOC AUTOSUB

Standard: Output SOC custom protocol

Data sent: Status, Heading, Attitude, Rotation rates, Depth, Speeds, Position, Log misalignment

Data frame: The frame contains 18 fields - 61 bytes - MSB are sent first.

Message <F0><F1><F2>…..<F17>			
Field 0	Byte 0	'$'	Synchronization byte
Field 1	Byte 1	Status	1 if Alignment
Field 2	Bytes 2 to 5	Heading	Radians IEEE floating point format
Field 3	Bytes 6 to 9	Roll	Radians IEEE floating point format Sign "+" when port up
Field 4	Bytes 10 to 13	Pitch	Radians IEEE floating point format Sign "+" when bow down
Field 5	Bytes 14 to 17	XV3 rotation rate*	Rad/s IEEE floating point format
Field 6	Bytes 18 to 21	XV1 rotation rate*	Rad/s IEEE floating point format
Field 7	Bytes 22 to 25	-XV2 rotation rate*	Rad/s IEEE floating point format **Warning:** Opposite sign of PHINS 6000 usual convention
Field 8	Bytes 26 to 29	Depth	Meters IEEE floating point format
Field 9	Bytes 30 to 33	Down speed	M/s IEEE floating point format
Field 10	Bytes 34 to 37	East speed	M/s IEEE floating point format
Field 11	Bytes 38 to 41	South speed	M/s IEEE floating point format
Field 12	Bytes 42 to 45	Latitude	+/-2^{31} = +/-Pi Signed 32 bits
Field 13	Bytes 46 to 49	Longitude	+/-2^{31} = +/-Pi Signed 32 bits
Field 14	Bytes 50 to 53	Log misalignment	Radians IEEE floating point format
Field 15	Bytes 54 to 57	Spare fields	**4 bytes**
Field 16	Bytes 58 to 59	Counter	Incremented by 1 Unsigned 16 bits
Field 17	Byte 60	Checksum	Addition of all the bytes for 0 to 59

* The resolution of rotation rate data is limited to 3.6 deg/h to comply with export regulation.

VI.2.14 GPGGA SHIP

- Data sent: Latitude, Longitude of the ship or GAPS, GPS quality
- Data frame:

$GPGGA,hhmmss.ss,ddmm.mmmmm,a,dddmm.mmmmm,b,q,ss,...,...,.,...,.,...,....*hh<CR><LF>		
where:	hhmmss.ss	is the UTC of position
	ddmm.mmmmm	is the latitude in degrees and in minutes and 1/100000
	a	is the hemisphere
		N: North
		S: South
	dddmm.mmmmm	is the longitude in degrees and in minutes and 1/100000
	b	is longitude sign (E: East, W: West)
	q	is the GPS quality indicator
		0 Fix not valid
		1 GPS SPS Mode fix valid
		2 Differential Mode, SPS Mode, fix valid
		3 GPS PPS Mode, fix valid
		4 RTK
	ss	5 Float RTK
	*hh	is the number of satellites
		is optional

VI.2.15 GYROCOMPASS

- Standard: Output NMEA 0183 compatible
- Data sent: Heading, Attitude, Status
- Data frame

$HEHDT,x.xxx,T*hh<CR><LF>		
where:	**x.xxx**	is the true heading in degrees
	hh	is the checksum

$PIXSE,ATITUD,x.xxx,y.yyy*hh<CR><LF>		
where:	**x.xxx**	is the roll in degrees
	y.yyy	is the pitch in degrees
	hh	is the checksum

$PIXSE,STATUS,hhhhhhhh,llllllll *hh<CR><LF>		
where:	**hhhhhhhh**	is the hexadecimal value of PHINS status LSB
	llllllll	is the hexadecimal value of PHINS status MSB
	hh	is the checksum

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