SIXTH FRAMEWORK PROGRAMME

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Project acronym: **VENUS**

Project title: **Virtual ExploratioN of Underwater Sites**

Instrument: SPECIFIC TARGETED RESEARCH OR INNOVATION PROJECT

Thematic Priority [2.5.10] [Access to and preservation of cultural and scientific resources]

D6.5 Marseille: Photogrammetric and Bathymetric sonar survey.

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EXECUTIVE SUMMARY

This report start by a description of the archaeological site in Marseille, description mainly extracted from the site presentation written in Deliverable 5.2, and then describes the experimental activities related to the third sea trial of the Venus project in Marseille, October 2008. Three main activities have taken place:

- Photogrammetric data acquisition by Submarine Remora 2000 linked with record of accurate navigation data and multibeam survey.
- Multibeam survey of the wreck
- Data validity check during the mission

In addition to the working procedure and diary of events, the report includes archaeological interpretation, methodologies at the base of the photogrammetric process, calibration procedures, data storage information and preliminary data processing.

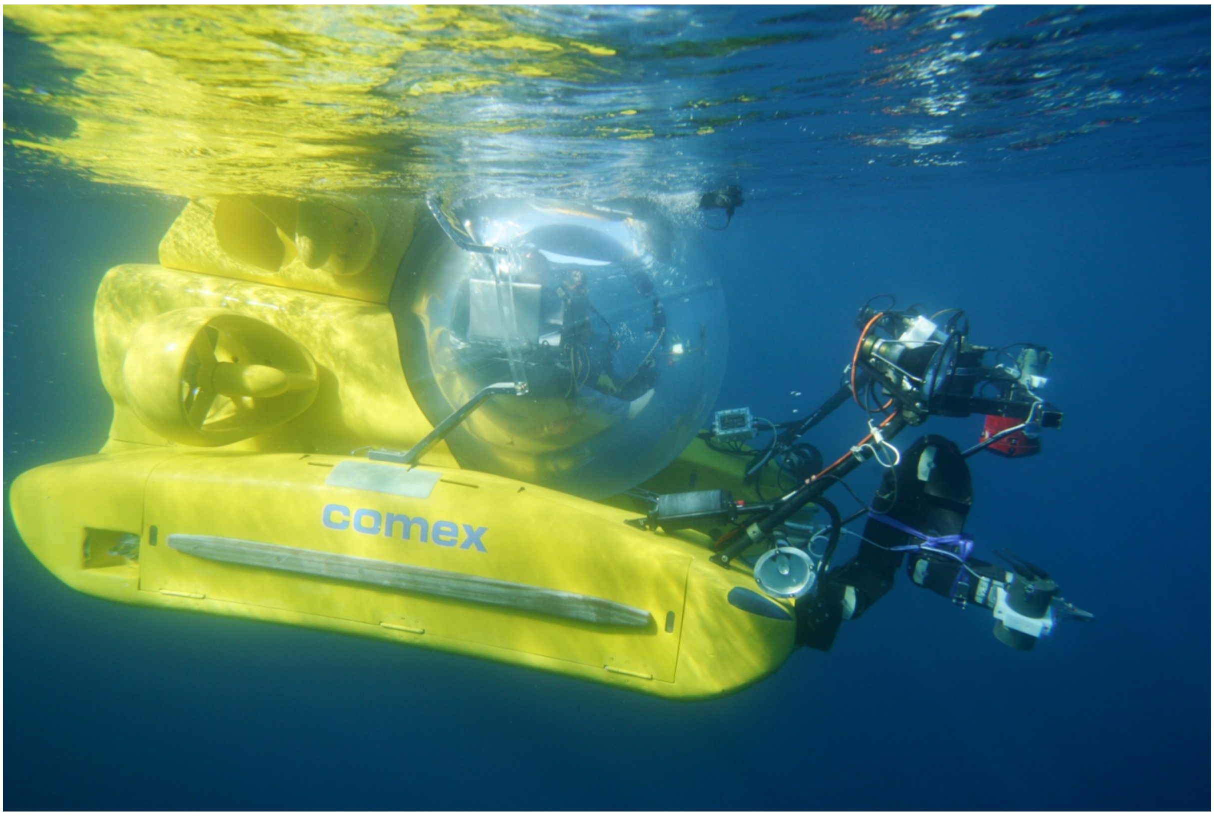


Figure 1. The Remora 2000, during the mission in Marseille.

1 Introduction

This roman shipwreck was discovered in October 1998 by Henri-Germain Delauze, Comex Cie president, during a Remora submarine's diving. It lies by 105 m deep in front of the limestone coast of the Calanques, between Marseilles and Cassis, in the south of France (Bouches-du-Rhône). Two short expertises carried by the Department of Sub-aquatic and Sub-marine Archaeological Research (DRASSM, France), were planned with the same Comex submarine, in 1999 and 2001.

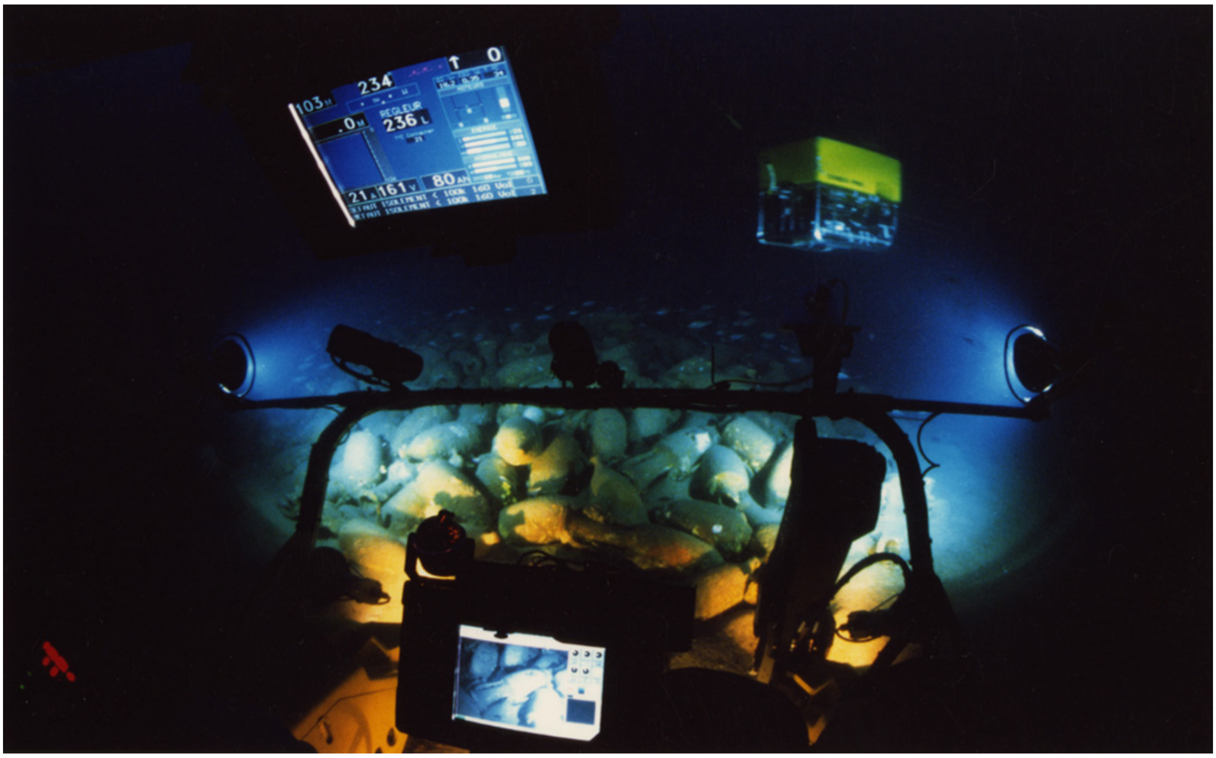


Figure 2. Port-Miou C wreck seen from the submarine Remora 2000, COMEX.

The wreck is located in open sea at 4 km in front of the Port-Miou calanque and 9 km from the east part of Riou island, in a vast area where six others roman wrecks were found by Comex. In this large area, among seven others roman wreck recently declared by Comex, between 90 and 110 m deep, four of them are totally destroyed by the repeated trawlers passage. These trawlers today equipped with extremely sophisticated instruments and geo-positionment-system, in order to recording shipwrecks position in order to lucrative recuperations, can touch several times the same site and ravage completely the archaeological layer of surface.

In conclusion, the site is lying in the sand but may be was preserved from the danger of fishing marine by a group of rocks all around, making trawlers in the obligation to avoid the danger and change of way.

1.1 Description:

The shipwreck looks like a large tumulus of roman amphorae of Dressel 1 type. It is about 24 m long, 12 m wide and 2 m high, and it is just a little inclinated on a smooth slope. We distinguished perfectly in the center of the tumulus the superimposing at least of two layers of jars. The cargo is composed of almost 1500 or 2000 visible amphorae and contains may be a total of 3000 or 3500 jars, may be more. For example, a roman trade ship of 40 m. long could carry 10 000 amphorae, like on Albenga shipwreck in Italy or Madrague de Giens in France.

On the Port-Miou C wreck, a part of the amphorae still in place in the original cargo organisation, which appear closely imbricates, are inclinated together toward the same direction. If usually the deep amphorae do not have numerous natural concretions, all of them are at least covered by a thin pulverulent mud film which parasite the images and impose a short cleaning before photos. Fishes and their shade thrown on the sea bead will be maybe also a problem for the reading and the understanding of photos.

These amphorae are belonging to the Dressel 1A type, studied by the German epigraphist Heinrich Dressel at the end of the XIXth century, in Roma, who proposed a first typology always used today.

Figure 3. Port-Miou C wreck : Amphorae lying on the seabed (detail).

They are all slender shape, for wine, with a short and inclinated lip which recall the amphorae the second half of the second century or early in the first century BC. They can be compared to the amphorae of the wreck Chrétienne A (Saint-Raphael, France), or Pointe Moussure and Bon-Porté 2 (Saint-Tropez).

Roman Dressel 1 amphoras for wine were produced on the Tyrrhenian coast of Italy during forty or fifty years, between the end of the 2nd century and the beginning of the 1st century BC. Exported to Gaul from Italy by maritime routes, this kind of homogeneous cargo is today very well known in France. By its character, Port-Miou C ship belongs to a group of at least 120 roman contemporary ships loaded with this same amphora type. Elsewhere, millions of others Dressel 1 amphorae are recorded in terrestrial excavations in all French territory.

For this reason, the first great underwater archaeological excavations in France and in Italy concerned this type of cargo: Albenga (1950), Grand Congloué 1 and 2 (1952), Chrétienne A (1960), Drammont A (1960), Madrague de Giens (1975), Pointe du Brouil (1982)... Elsewhere, millions others Dressel 1 amphorae are recorded in terrestrial excavations in all French territory.

Indeed, deep gisements present a new interest for the archaeology today because they are generally the best preserved than the others. It is necessary to clarify that, except rare exceptions, the wrecks the depth of which is superior to 100 m are frequently situated off shore, far from the destructive reefs. So, not deteriorated by clandestine divers and still almost intact, Port-Miou C shipwreck, which is in open sea has escaped to reefs and can bring us irreplaceable datas on the organization of the loading, crew material, boarding equipment and form of the ship.

This type of amphora can present some stamps of potter printed in the clay before to cook the amphora in the kiln. These stamps could be printed on the rim of the amphora, in the middle of the neck, may be also on the shoulder (Fig 8 & 9). But, this category of ship could transport in the same time big complementary cargo of black glazed campanian ware, used to drink wine, or many common potteries. For instance, the Grand Congloué wreck, sank near Marseilles and was excavated in 1952 by Cdt Cousteau with the Calypso while the official archaeologist Fernand Benoit stayed on surface on the back deck of the Calypso. With its amphorae, this wreck contained itself thousands of black Campanian potteries.

1.2 Originality of the Port-Miou C wreck:

Port-Miou C shipwreck belongs to the deep archaeological remains. It is necessary, to clarify that we consider that a wreck is deep when it is inaccessible by diving with standard air mixes. In line with the strict regulations in France deep diving begins beyond sixty metres of depth.

Today, if we take the case of the French Mediterranean Sea where are listed at least six hundred archaeological remains of roman shipwrecks, the number of deep sites including Port-Miou C shipwreck, represents approximately 13 % of the total. Naturally the most numerous, discovered by coral-divers or rash divers, by air scuba, are included in the slice between 60 and 80 m. In this slice, the incursion dive with mixed-gas is possible for the best formed and best pulled archaeologists, in other words that they are very few in France.

But the exhaustive archaeological excavation would require the implementation of an industrial-platform equipped with recompression-chambers and with a diving-bell for the saturation-diving. These operations are very expensive and their cost is generally more than renting of submarine and robots. Besides, in that case, very rare are the archaeologists who could dive on the wreck within the framework of the saturation-diving. They would thus leave their place to professional, industrial or military divers, who would take their place, by proxy. It was already the case 50 years ago, close to Marseille, when Cdt Cousteau and his team was excavating the remains of Grand Congloué wreck and when Fernand Benoît, the official archaeologist, stayed on surface on the back deck of the Calypso.

Different experiences carried out in France by Drassm over twenty years on 8 or 10 deep wrecks have contributed to develop and validate some repetitive technical procedures in the domain of studying wrecks in situ. This work has firstly involved the documenting information, notably by photogrammetry, then during the automated desilting of artefacts, their numbering and finally their recovery, still without the aid of the divers.

1.3 Main goals of the mission Port-Miou C 2008:

Usually, the underwater archaeologists have to apply under the water, on the site that they are studying, the principles and method of terrestrial archaeology. There is no absolved knowledge about remains of wreck but knowledge split up, made by fragments. They want to know the precise dimensions, the nature, and the origin of the port of trade, the final destination of the ship, the chronology and state of preservation of the wreck. We have been asked if it was really necessary to map within several centimetres the positions of hundred of wine jars in a cargo. Perhaps the exact placement of jars in the middle of the wreck was unimportant, but there was no way of knowing this during the excavation. For example, in 1952, near Marseilles, Cdt Cousteau and his team inaugurating underwater archaeology, have excavated two superimposed wrecks without realizing it. But once the ended excavation it was too late to check the problem in the field.

For this reason, underwater archaeologists must record and analyze in the three dimensions the spatial distribution of artefacts in the wreckage and understand the relationship between these artefacts with each other.

In fact, they want to recognize the initial order of the cargo under the current disorder caused by the wreck and possibly separate objects or things considered as exogenous intrusions, which were mixed at the site after the shipwreck.

1.4 Archaeological study of a virtual site:

Archaeologists need to keep various representations of the wrecks they are studying. These representations can be plans, sections and different kinds of views. Since the last fifteen years, the study of deep wrecks led by DRASSM allowed to access and creates various types of representations that have evolved with technological advances and computer.

These very diverse representations, by synthesis images accessible on a computer of common type must be easy to use for searchers. They must allow archaeologists to read the organization of the wreck and recognize the diverse compartments which constitute the group of things. The wreck of a Roman ship should be understood as a means of transport with its load, a functional set an economic system (or military), and a closed community with its own conventions and objects. Naturally the complex study of the ship itself cannot be envisaged within the framework of a short mission concerning mainly the study of surface of the site. It requires a detailed excavation which is not still possible today on deep wrecks.

1.5 Conclusion

The ambition of VENUS team on the wreck Port-Miou C is to create and keep somewhere a precise three-dimensional image of the surface layer of the wreckage. This representation will allow the archaeologists to observe and study the site without being obliged to rent an expensive submarine. She will have to be the most resembling possible of the real wreck.

This kind of virtual reality may be increased knowledge of cultural and scientific annexes useful in the interpretation of the remains.

But with the threat of trawlers, this representation of the surface layer may become already a reality of the past, an anterior reality. However, this representation will become perhaps the only trace of the high part of the wreck, promised to the destruction in the future.

2 Survey: underwater exploration

Figure 4. The Remora seen from the ROV.during the mission in Marseille.

2.1 Introduction

The VENUS Operations take place during the week 41, from the 5th of October to the 11th of October 2008.

This section describes all preliminary works, instruments and technical's choices, technical configurations required to realize the Photogrammetry of the Port Miou C Wreck and Bathymetry results.

It's also explained all the calibration needs to permit the instruments integration for acquisition data.

Figure 5. The Remora2000 embedded in the Minibex vessel.

2.2 Technical choices

VENUS project need, in addition of the photogrammetry, a good 3D image of the wreck. Such 3D images can only be done using multibeam bathymetric echosounders and that's what we are going to do but not in a usual way.

Multibeam bathymetry needs very high accurate positioning system. Usually, this kind of bathymetry is performed from the surface, with a hull mounted transducer, coupled with very high accurate GPS and inertial unit to compensate yaw, roll and pitch and to have the best position of the acoustic 3D image that take the multibeam system.

Unfortunately this type of fine bathymetric system is only perfomant for shallow water. In VENUS and mainly for Port-Miou C Wreck, the wreck is too deep to acquire a good 3D image from the surface with a hull-mounted multibeam bathymetric system. The only solution is so to operate the multibeam from an underwater vehicle, and to be able to position the underwater in real time with the best accuracy (centimetric – relative positioning- to be comparable to surface bathymetry from the surface).

The choice is so the following:

- Integrate the multibeam on the Submarine REMORA 2000 (for some reasons of volume, weight, power supply, it's not actually possible to integrate it on the ROV).
- Obtain a real time / very accurate positioning of the submarine during multibeam acquisition.

The technical choice is resumed by the following synoptic:

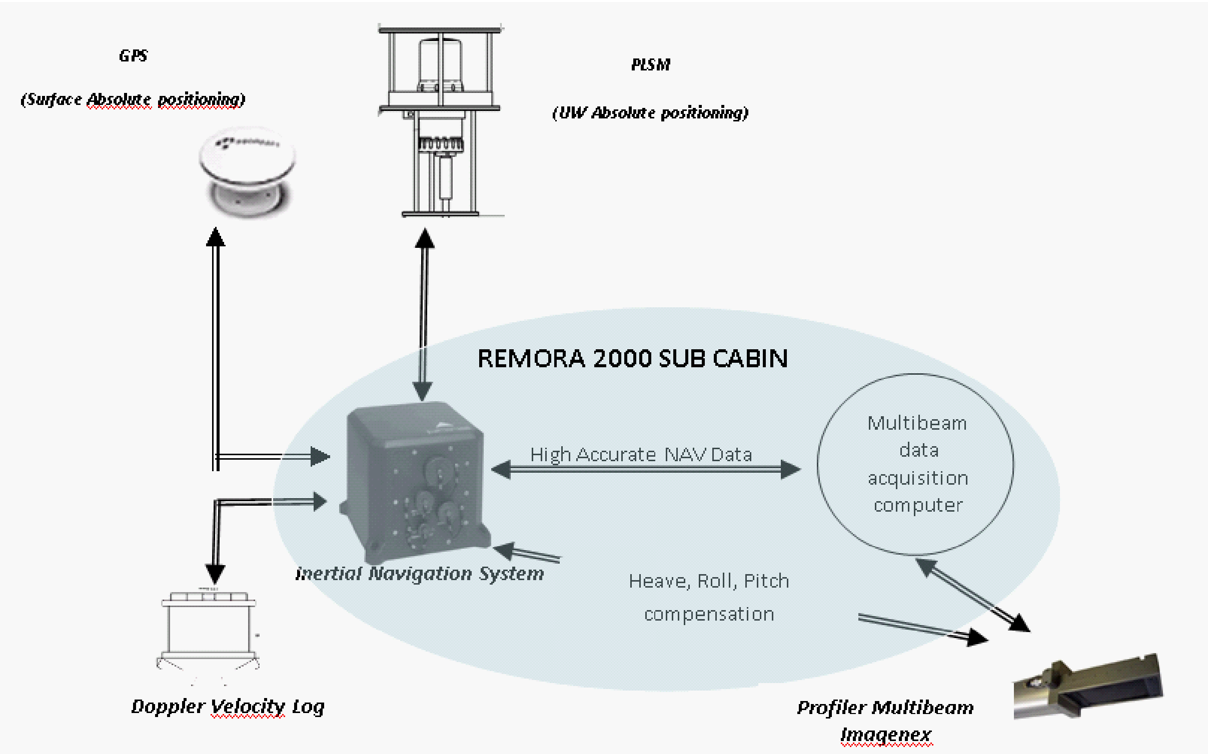


Figure 6. Synoptic tools schema.

First trials have been done in September for a final mission on Port-Miou C wreck in October. REMORA 2000 will be the first submarine able to provide multibeam bathymetry with this kind of accuracy in the acquisition of bathymetric and position data.

We are aware that the future is not with manned sub-marine, but with ROV. But for the time of this project it wasn't realizable to integrate all equipments for some reason of weight, volume and power supply.

With the Marseille mission we experiment the general purposes capability of the builded tools to collect photos and data for photogrammetry acquisition. In Particolar, we use the experience gained in the previous missions, to finish the tools for acquire generic navigation data, to synchronize them by internal software that can be distribute in a lot of navigation PC unit and to log all needed data inside the D300 NIKON Camera mountable in a lot of underwater robot types..

Hereafter the description of the chosen instruments will permitted to precise all configuration and calibration.

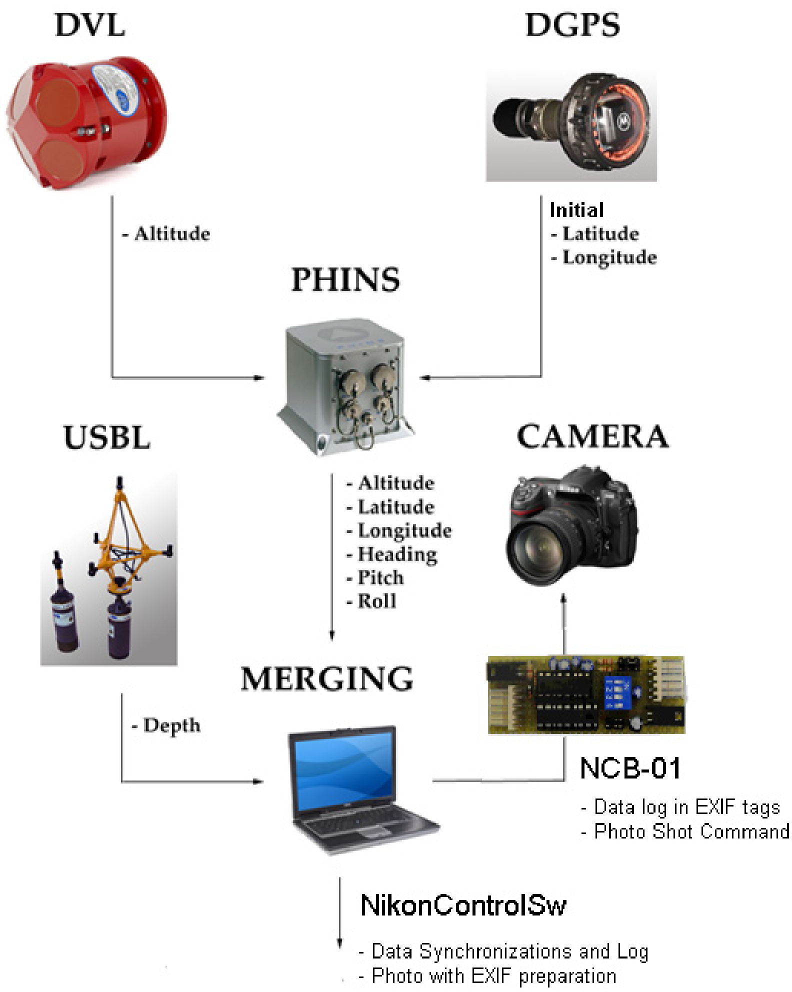


Figure 7. Data Acquisition Chain.

2.2.1 REMORA 2000

The use of the REMORA2000 asks a precise preparation, because when the engine is in dive, it is autonomous and only linked to the surface support by acoustic-phone.

All procedure need to be clear and adapted.

All instruments are fitted on sub-marine and interfaced on laptops in the submarine cabin.

Figure 8. From the Remora2000 cabin.

2.2.2 Phins: Inertial navigation system

PHINS, Photonic Inertial Navigation System is the central instrument used for the 3D-Positioning for surface and subsea. It is an inertial navigation system from Ixsea outputs position and depth, heading, roll, pitch, 3-axis velocity, and heave, surge and sway. Its high accuracy inertial measurement unit is based on IXSEA's Fiber Optic Gyroscope technology coupled with an embedded digital signal processor that runs an advanced Kalman filter. Depending on the required application, PHINS may be connected to different aiding sensors:

- GPS receiver (any type, single antenna),
- Doppler Velocity Log (DVL),

Whatever the number of sensors, the system will select the aiding data whenever they are available and optimize its settings accordingly.

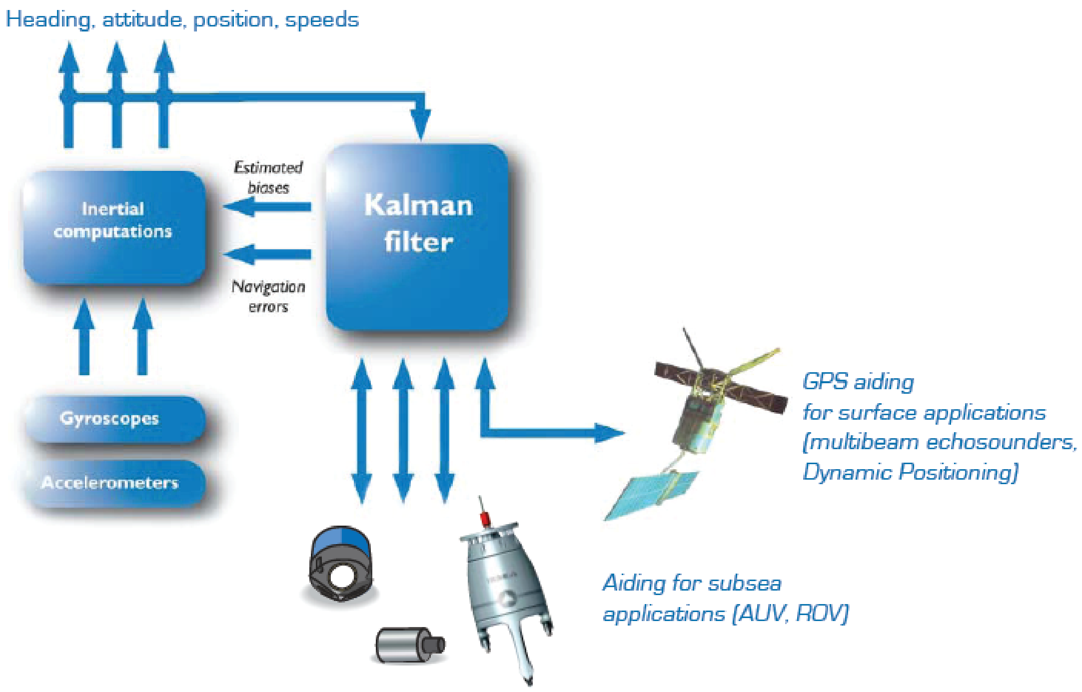


Figure 9. www.dynamic-positioning.co.uk

To resume the INS give:

- Heading
- Pitch, Roll and Heave
- Partially integration of DGPS and DVL data
- Dead reckoning when there is no data from DGPS and DVL

Figure 10. The PHINS is installed in the REMORA 2000 cabin..

Special thanks to IXSEA for gracious loan of this expensive and issued from new high technology instruments.

PHINS includes a rejection filter to check and reject low quality data from the aiding sensors. This may occur for example with GPS data in the event of multipath, which may also occur with DVL aiding.

The PHINS is the central information core that allows us to have a lot of additional data from the navigation of the Submarine.

It give to the merging process Altitude provided by the DVL and the LONGITUDE and LATITUDE coordinates provided by the DGPS when we are on surface and when we are subsea by the inertial computation aiding by DVL motion data (Bottom track velocity).

The PHINS provides others important information for the rapid mosaicing and Multibeam bathymetry like HEADING, PITCH and ROLL.

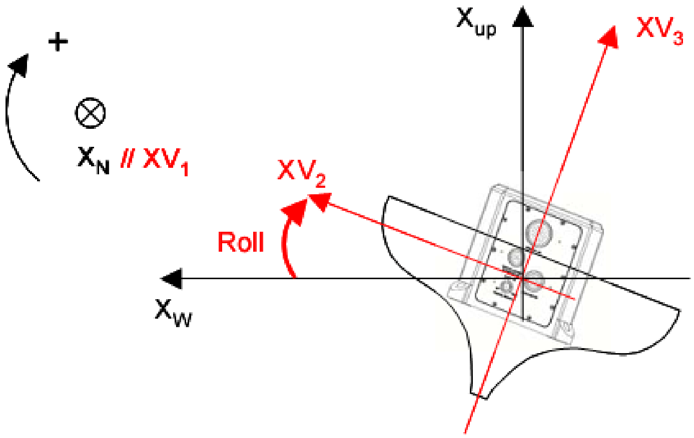


Figure 11. Definition of the roll angle in case of null heading and pitch, and no misalignment.

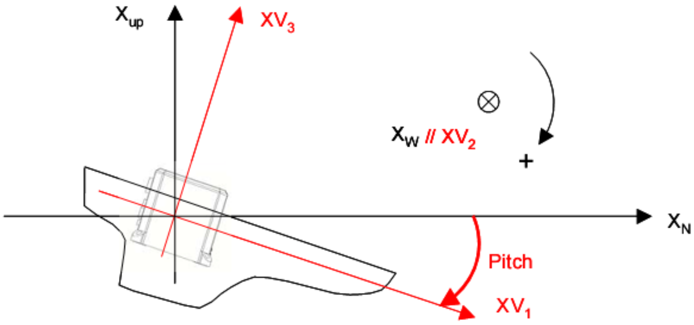


Figure 12. Definition of pitch angle in case of null heading and roll, and no misalignment.

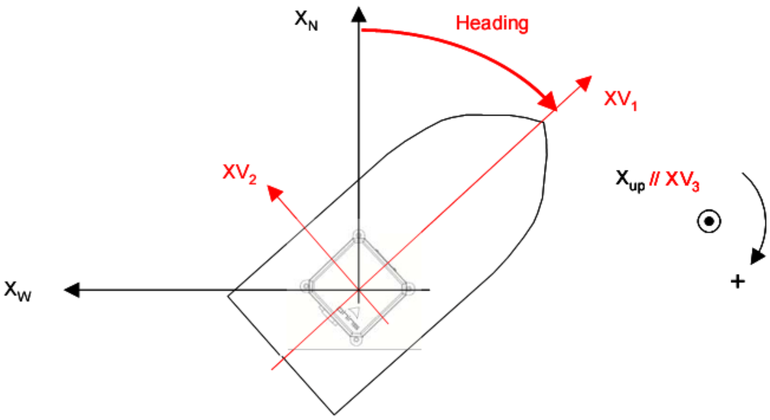


Figure 13.Definition of heading angle in case of null pitch and roll, and no misalignment.

2.2.3 DGPS

The SOSI Series GPSR-X015G Satellite Differential GPS Receivers are designed for use with deep diving AUVs, buoys or other autonomous systems that are required to operate at depth but periodically surface to determine position and reset their navigation system.

These receivers are designed to receive GPS satellite data only while on the surface, but can survive routine submergence to depth. The GPSR-X015G is available in depth ratings of 1000, 3000, or 6000 meters.

The rugged 12 channel GPS engine is compatible with WAAS, EGNOS, JCAB and RTCM Differential Correction Systems.

Their proven housing, antenna, and receiver element designs insure reliable operation that you can depend upon.

The DGPS is interfaced to initialize the Navigation with an absolute position.

Figure 14. SOSI Series GPSR-X015G Satellite Differential GPS Receiver mounted on the Remora 2000.

The DGPS pass the latitude and longitude information to the PHINS while the Submarine is on the surface of the sea.

2.2.4 DVL – doppler velocity log

For this operation, DVL RDI PD6 WH 300 has been used.

Teledyne RDI’s DVLs provide high rate, precision navigation data utilizing patented BroadBand bottom-tracking algorithms. These frequent navigation updates can be used stand-alone, or can be integrated into an existing navigation system to provide user with confidence in their exact underwater location, even in deep water. DVL measures ocean currents, vehicle speed over ground, and altimetry all in one affordable package.

It provides a full suite of sensors including:

- Bottom track velocity: Bottom-tracking information and a data quality factor are continuously output from the DVL. When the DVL's range to the bottom exceeds the maximum, this is indicated by the data quality factor. The maximum bottom-tracking range is dependent upon system frequency and local environmental conditions.

- Water track velocity: outputs 3D water velocity information in either XYZ coordinates (referenced to the DVL itself) or East-North-Up coordinates (referenced to Magnetic North). The DVL measures water velocity from within a user-programmable sampling volume that extends away from the instrument.
- Altitude: 4 individual measurements: As the DVL is bottom-tracking, it also records the distance to the bottom for each of the three beams. These three values are then cosine-corrected and are reported independently and as an average in the data output. This feature helps reduce vehicle instrumentation costs as the need for a separate altimeter is not necessary.
- Error velocity (data quality indicator)
- Temperature
- Heading/Tilt
- Acoustic echo intensity

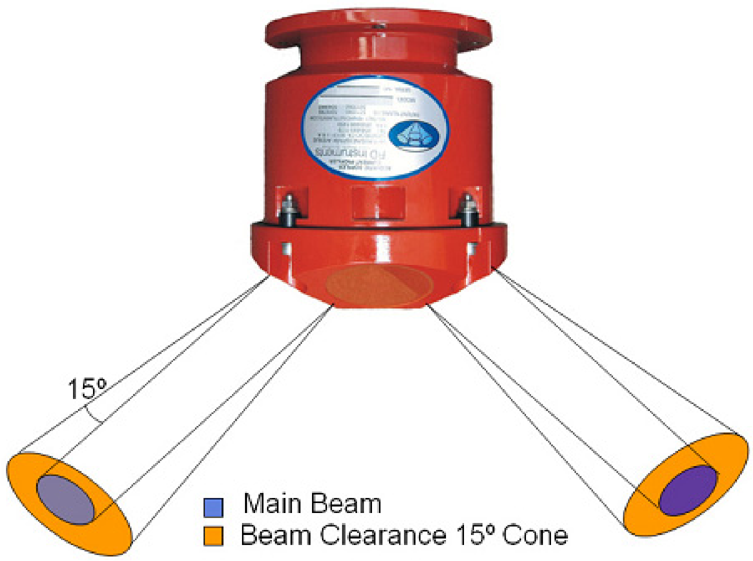


Figure 15. Teledyne RDI's DVL.

The DVL @ 300kHz permit to keep data from surface to the sea bottom (until 200m). So the dead reckoning mode of the PHINS isn't used.

Moreover, this instrument can work to minimum 1 m altitude from sea bottom.

This data are sent into the PHINS, all DVL data permit the alimentation of PHINS filter.

The association of these instruments permitted an accurate positioning of the submarine during all this operation.

The DVL pass the ALTITUDE data (as distance from camera to ground (seabed)) to the PHINS that no re-elaborate it and finally send it to the merging data process.

Normally DVL send the DEPTH information for the mosaicing but it's no good for our interest. The dept sensor is used for high depth and it works in a discrete way with 2 meters of sensibility.

For a good use of this configuration, a calibration is necessary. This part is described in a following section.

2.2.5 PLSM – Underwater positioning system

The **AQUA-METRE R300** is a local underwater positioning system based on an acoustical interferometric scheme (mainly known as Ultra Short Base Line or USBL).

It is particularly well suited to accurate local 3D locating within the range of up to 150 meters (500 feet) from the reference point.

The system may be ROV operated and managed from the surface using acoustical networking features.

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

– The measurement Base, which constitutes the local reference Cartesian coordinate system {0,0,0}),
– At least one Pointer which replies to Base interrogations.

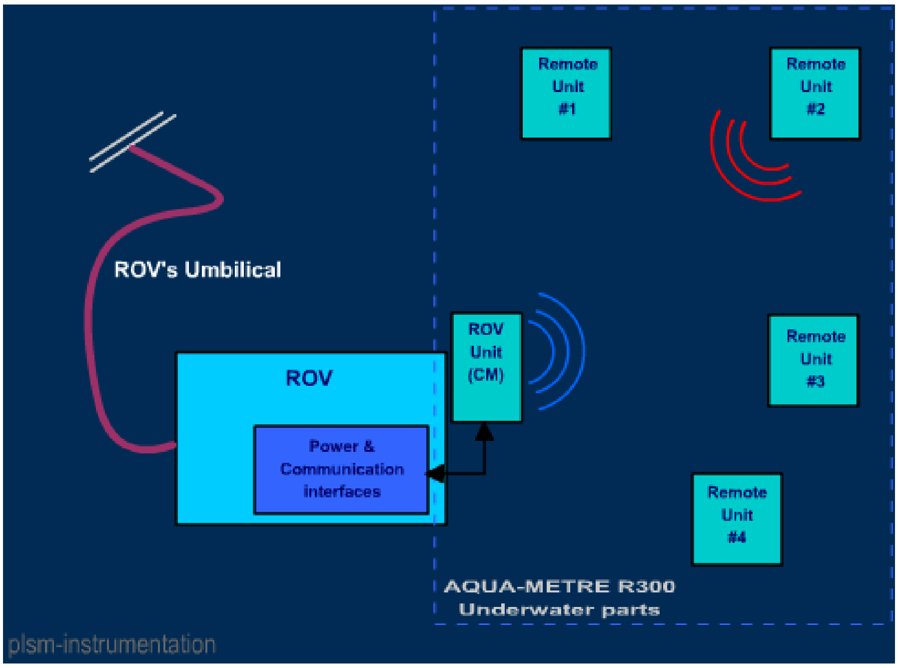


Figure 16.A typical ROV operated configuration.

Basically, the system is intended for 3D measurement of Pointer(s) location in the local coordinate system(s) defined by the Base(s).

Thus, with only one unit, lets say a Pointer, it is possible to monitor heading and inclination of an underwater ROV or structure for instance (in case of construction). More sophisticated configuration will require two Bases and two Pointers like a full pipe connection metrology. The configurations are not limited and may be adapted to specific needs.

It is then possible to manage the system from the surface and get measurement (3D location, inclination, heading, temperature…) of every underwater unit using a simple communication terminal.

In order to control and to have an idea of the real time photo coverage, we decide to use an Acoustic short Base system.

Moreover from this installation, the Z value is extract from PLSM data (the pressure sensor of DVL isn't enough accurate). And the PLSM data are used to navigate during the photogrammetry, in fact a rectangle with theoretical dimension of photo is projected at minimum 2.5 sec. (recurrence time), this representation permitted to provide an idea of photo coverage during acquisition.

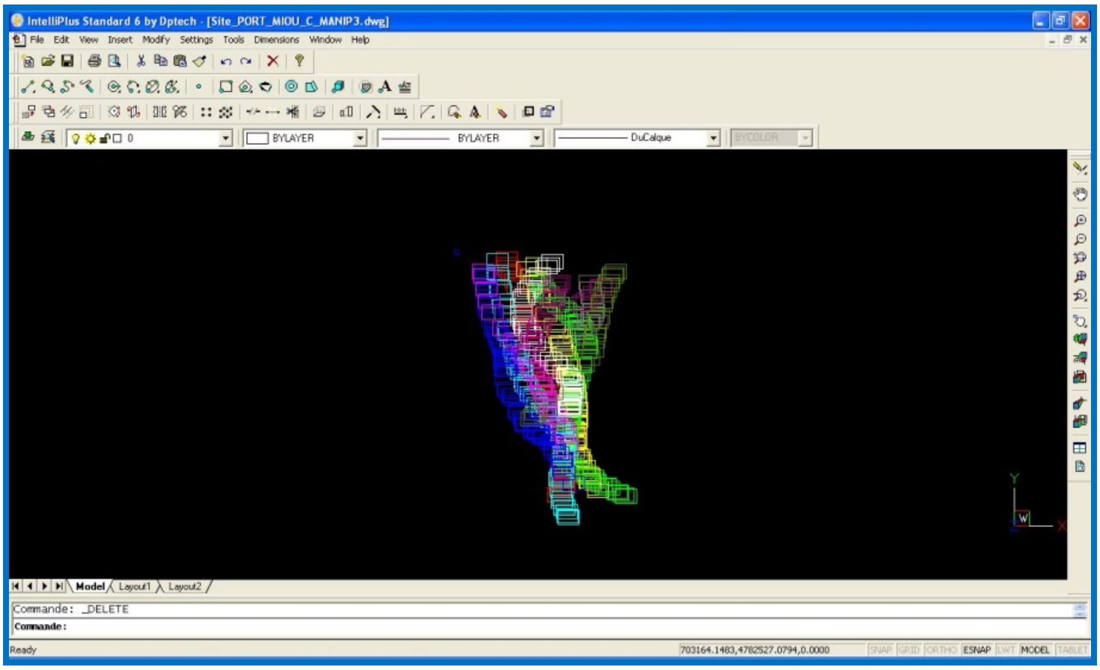


Figure 17. View of real time PLSM representation data.

The system includes four components:

- An acoustic base
- A positioning system PC with AQUACAD and Intellicad V5 software installed.
- A transponder attached to the ROV with perfectly know 3D offsets from the reference survey point (about 20 cm in front of the main camera)
- A PC USB Interface Unit that communicate with the Base and interfaces it with the computer (PC) as well as the video overlay.

Figure 18. PLSM, Transponder & Base.

We use PLSM for providing information about z coordinate instead DVL DEPTH information for the mosaicing. The only problem with the PLSM USBL is that it needs 2.5 sec of minimum sampling period.

2.2.5.1 System setup:

The Mobile Pointer must be mechanically installed, such as its hydrophone remains unmasked and always "visible" from the Base during all the operations.

Figure 19. Special Pointer fixed on Submarine REMORA 2000.

Depends on the case, there are many ways to position the Base, among others:

- The Base is installed on a support and laying on the site.
- The Beacon installed on Submarine is the communication Master of the system. It's linked in the cabin by cable.

2.2.6 Profiler imagenex delta t 837a

Figure 20. The Imagenex Model 837A "Delta T".

The Imagenex Model 837A "Delta T" is a multiple receiver sonar system designed to provide video-like imaging with all the advantages of underwater sonar.

Innovative digital signal processing is used to optimize data usage from all channels to achieve the best possible resolution at every point in the field of view. Recent advances in computing power have made it possible to transfer and process this data at resolutions equal to computer monitor resolution, and with image frame rates of better than 20 frames per second.

The Delta T system has been designed from the ground up with the most advanced, high accuracy, low power electronic components available to provide breakthroughs in system power consumption, package size, and price. This advanced electronics package has built in flexibility and programmability to accommodate a wide range of transducer arrays. Thus, the Delta T is the first in a family of new technology products which will have imaging and profiling capabilities to suit your underwater application. Imagenex sonars: advancing underwater imaging capability for the everyday user.

We decide to use this instrument because:

- It's light and mechanically easily fitted on the sub-marine
- The data communication has done through Ethernet cable to laptop.
- It's low voltage equipment (submarine safety regulation)

Ideally, the higher frequency is more adapted, but there was no availability of this equipment in rental at this period.

2.2.7 Camera Nikon D300

Figure 21. Camera Nikon D300.

For the previous operation the camera used was a Nikon D2HS. This camera was chosen by Comex and CNRS to respond to the previous request:

- Light sensitive
- Quick response between command and picture record
- Usable with ITTL flash system.
- Availability and price

The housing was from Comex equipment and designed originally for a Nikon D1, the size and design of this housing make easier adaptation of new device.

Further in the project; CNRS and ISME choose to work with Nikon D200 and then D300.

Those camera still responds to original request but offer better resolution (10,2 mega pixels and 12, mega pixels) allows to write more data's in the Exif area of the photos files via GPS signal input by a UART port and offer a TTL remote control possibility. Underwater housing for divers is available on the shelf for affordable price.

As mechanical designs of these cameras are not the same, Comex has designed and machine a new bracket to mount them in the submarine housing. The new bracket allows installation of D200 or D300 and still permit to replace battery without dismantle the assembly.

The lens stays the same along the project, a Sigma 14mm.

Some more functionality has been developed around the camera:

One USB link to control camera settings through Nikon control software

Serial link from computer to ISME Microcontroller board (NCB01) to send navigation data's from submarine cabin to camera (for Exif file writing)

A special junction box as been designed and manufactured to allows installation of additional bulkhead connectors on the camera housing.

2.2.8 Nikon Control Board

The Nikon Reflex Digital Cameras present one general connector to remote control the photo acquisition and to input to the internal microcontroller the GPS data. The Team of ISME developed a special board to embed navigation data and general useful submarine status directly on the photographs in the time it has been taken. This small board has been designed to receive data directly from a software that run on navigation PC and enter in a general underwater case present today in the market.

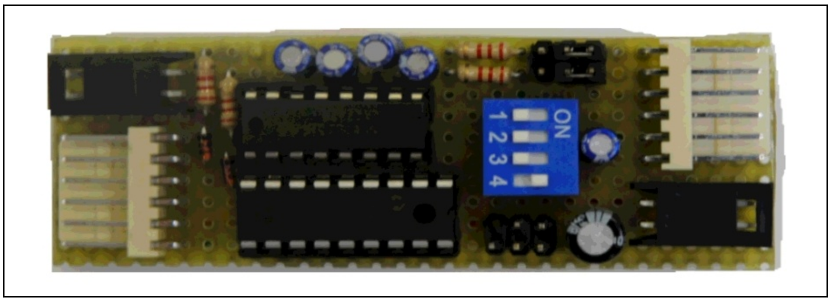


Figure 22 - Top view of the NCB01, rev 1.0B

NCB01 (see Figure 22) acts as an interface between general installed NIKON Reflex Digital Camera (I.e. NIKON D200, D300) and a remote control unit with a serial RS232 interface.

NCB01 receives commands and data from the serial device, unpacks them and sends them to the NIKON camera.

2.2.8.1 Description of the board

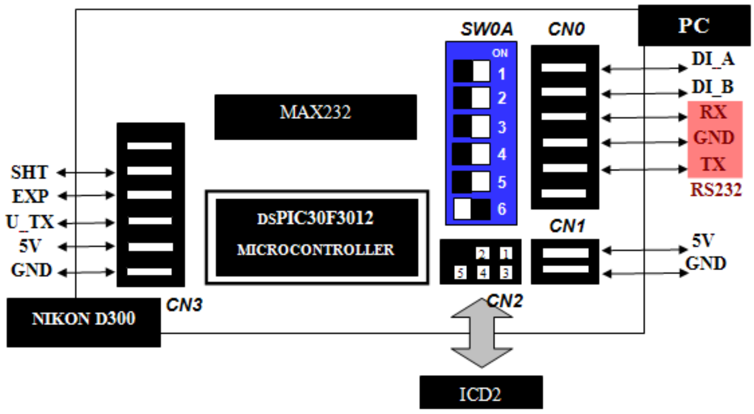


Figure 23- Overview of the NCB01, rev 1.0A

CONNECTIONS

CN0 – Remote control connector

DI-A	**Digital input A controls SHT output if SW0x pos. 1 is turned on**
DI_B	**Digital input A controls EXP output if SW0x pos. 2 is turned on**
RX	**RS-232 compatible RX input to MCU**
GND	**RS-232 ground in**
TX	**RS-232 compatible TX output from MCU**
NC	**NO USE**

CN1 – External power supply

5V	**External 5V supply to the circuit if SW0A pos. 6 (SW0B pos. 4) is turned on**
GND	**Circuit ground (shorted with CN0 and CN3 GNDs)**

CN2 – ICD2 connector

1	**GND**
2	**EMUC2/PCG**
3	**5V**
4	**EMUD2/PGD**
5	**MCLR**

CN3 – NIKON connector

NC	**NO USE**
SHT	
EXP	
U_TX	**UART TX to Nikon**
5V	**5V supply to the circuit from Nikon if SW0A pos. 5 (SW0B pos. 3) is turned on**
GND	**Circuit ground (shorted with CN0 and CN1 GNDs)**

CN4 – I²C connector

SDA	**I²C SDA compatible with onboard pull-up resisotr**
SCL	**I²C SCL compatible with onboard pull-up resisotr**

SW0A

1	**OFF: MCU controls SHT. ON: DI_A controls SHT**
2	**OFF: MCU controls EXP. ON: DI_B controls EXP**
3	**NO USE**
4	**NO USE**
5	**OFF: open circuit. ON: 5V supply from CN3**
6	**OFF: open circuit. ON: 5V supply from CN1**

WARNING: never turn ON 5 & 6 switches together to avoid short circuit between external supply and Nikon supply.

SW0B

1	**OFF: MCU controls SHT. ON: DI_A controls SHT**
2	**OFF: MCU controls EXP. ON: DI_B controls EXP**
3	**OFF: open circuit. ON: 5V supply from CN3**
4	**OFF: open circuit. ON: 5V supply from CN1**

WARNING: never turn ON 3 & 4 switches together to avoid short circuit between external supply and Nikon supply.

JP0

1-2	**ICD2 programmer position**
2-3	**I²C - CN4 enable**

NCB01 is designed as general purposes device for drive a Nikon D300 during survey for photogrammetry. It can works stand alone with starting configuration commands or drown by supervisor software.

When it acts alone can manage directly information coming from I²C sensors and write all camera positioning data to the EXIF area.

In Marseille mission we chose needed data for the EXIF area from more accurate REMORA 2000 onboard sensors.

The dimensions of NCB01 are (9x3x1)cm, space for connectors included.

2.2.8.2 Communication between PC and NCB01 board

The NCB01 receives commands and data from PC RS232 port, and sends them to the Nikon camera.

$NIKON,210908,16563011,4338.9061,N,01320.3933,E,05620,1800,1800,1730,99,2,200,02*4DEND

Figure24 - Example command string

The communication is over a simple RS232 protocol with the following hardware settings:

- **BAUD RATE**: 4800 bps
- **DATA BITS:** 8
- **PARITY:** None
- **STOP BITS:** 1
- **FLOW CONTROL:** None

NOTE: the format of the command string (Figure24) is very strict, i.e. position and length of each field is fixed and unchangeable. The following strings must be separated by a comma ",".

Following there's the meaning of the each field present in the command string:

- **"$NIKON"** head ► Each command row must begin with this sequence, otherwise it won't be recognized by the unpacking routine.
- **"210908"** date ► Day **08**, Month **09**, Year **2008**
- **"16563011"** timestamp ► Hour **16**, Min **56**, Sec **30.11**
- **"4338.9061,N"** latitude ► **43° 38.9061' North** of latitude
- **"01320.3933,E"** longitude ► **13° 20.3933' East** of longitude
- **"05620"** depth ► **56.20 meters**, depth from the sea surface
- **"1800"** pitch ► **180.0 degree**
- **"1800"** roll ► **180.0 degree**
- **"1730"** heading ► **173.0 degree**
- **"99"** altitude ► **9.9 m**, altitude from the sea bottom
- **"2"** photo mode ► **"2" continuous**, camera will take one photo automatically every "delay time" seconds

  "1" one shot, camera will take one photo

  "0" stop the continuous mode
- **"200"** exp time ► **exposure time**, varying between 1 and 999 msec
- **"02"** delay time ► **delay time**, in the continuous mode, is the time between two consecutive photos
- **"*4D"** checksum ► It's not been implemented yet
- **"END"** tail ► It lets the routine understand that the command string is terminated

2.2.9 NikonControlSw tool

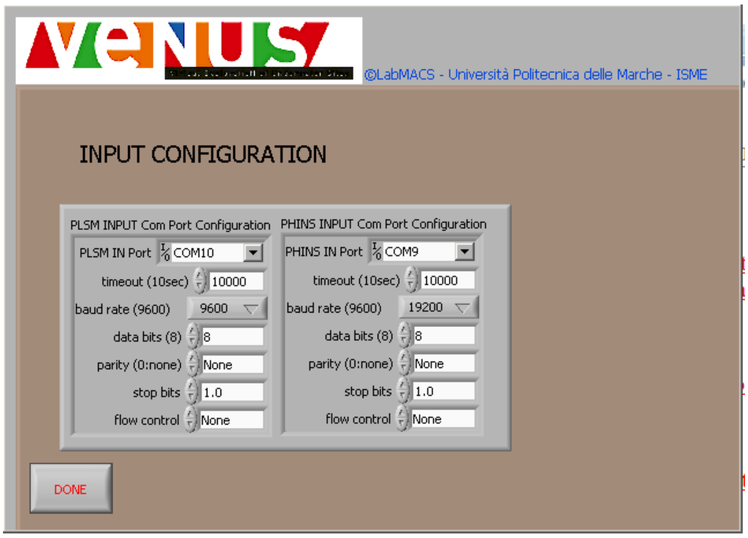
The NikonControlSw tool is a management software developed for photogrammetric underwater data acquisition. Generally it runs on the navigation computer of the underwater robot and takes care of:

- Logging data coming from all sensors installed
- Prepare data to send information needed for photogrammetry to the Nikon
- Commanding the photo shot
- Recording the time synchronization signals.

The tool presents three Graphical User Interfaces (GUIs) two of configuration and one operative.

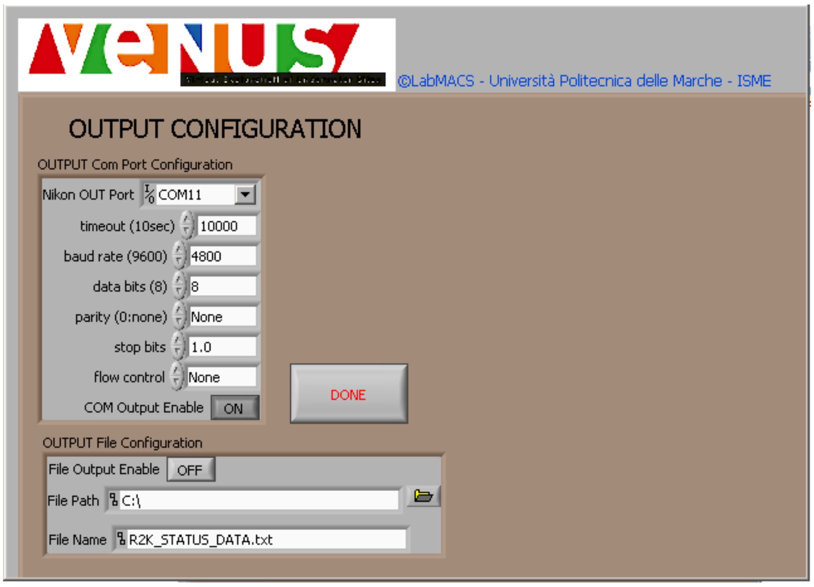
EXIF Nikon Reflex Digital Cameras present one general connector to remote control the photo acquisition and to input to the internal microcontroller the GPS data. The Team of ISME

2.2.9.1 Input Configuration GUI



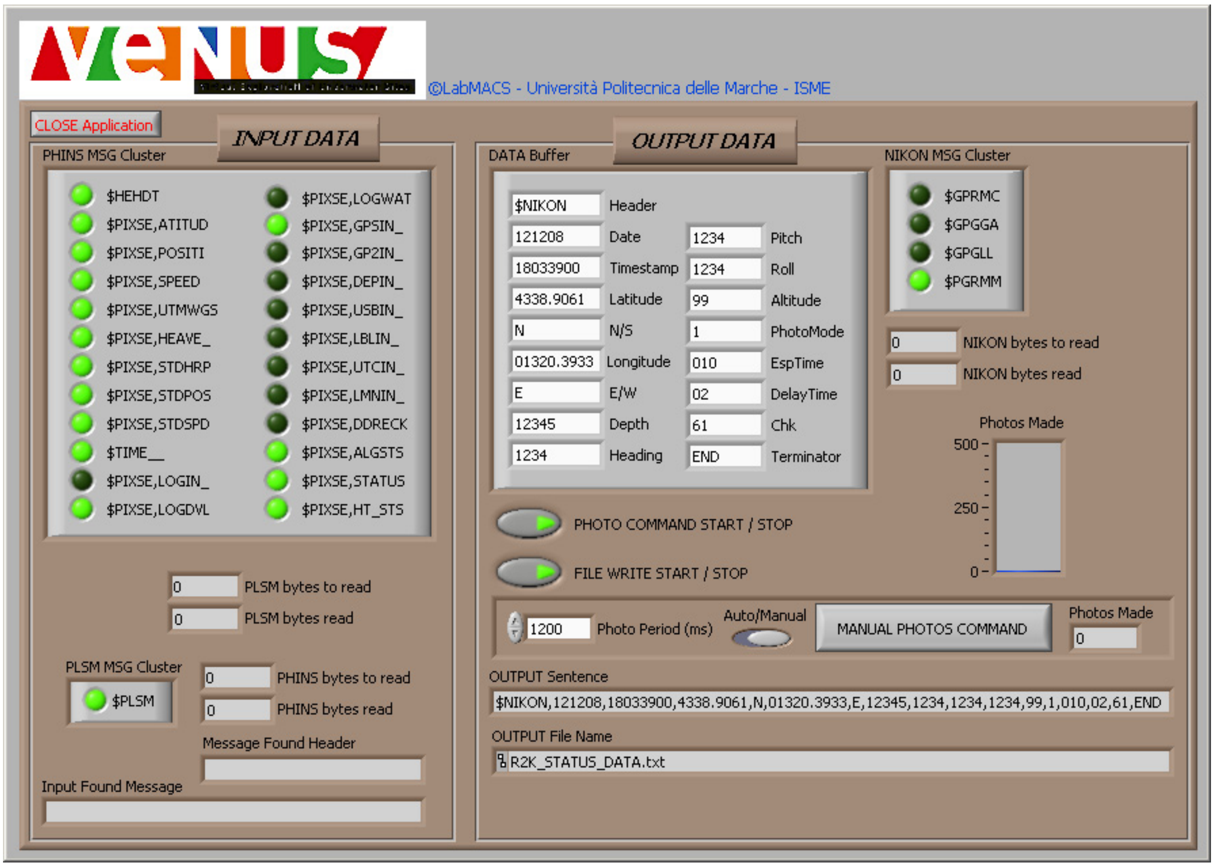
In this GUI the user can describes the sensor devices connected to the tool and the ports used.

2.2.9.2 Output Configuration GUI



In this GUI the user can indicates the output port where the nikon is connected and the filename for the log.

2.2.9.3 Operative GUI



In this GUI the user can indicates the data to log in the file and have the control for photo camera. During the survey, user can choose to control the camera in manual way or in auto shot choosing the time between one shot and the other.

2.2.9.4 Output log file

The application, if file logging button is enable, write all the recognized sentences in a file.

The file is named automatically with the follow name yymmdd_DVL_DATA.txt. In the file name the yymmdd represent respectively year, month and day of the date of logging automatically read from pc internal date.

In the file each input recognized sentences is added with data and time of log.

Below in blue is an example of a part of log coming from com port monitoring.

```
08;09;23;19;27;00;.250#:TS,94020323000508,35.0,+15.4,1.4,1508.0,0
08;09;23;19;27;01;.250#:TS,94020323000508,35.0,+15.4,1.4,1508.0,0
08;09;23;19;27;02;.156#:BI,+1,+2,+1,-1,A
08;09;23;19;27;02;.250#:SA,+0.41,+3.66,8.03
08;09;23;19;27;02;.250#:TS,94020323000508,35.0,+15.4,1.4,1508.0,0
08;09;23;19;27;02;.250#:BI,+1,+2,+1,-1,A
08;09;23;19;27;02;.703#:BS,+2,+1,+1,A
08;09;23;19;27;03;.093#:BE,+2,+0,+1,A
08;09;23;19;27;03;.250#:SA,+0.41,+3.66,8.03
08;09;23;19;27;03;.250#:TS,94020323000508,35.0,+15.4,1.4,1508.0,0
08;09;23;19;27;03;.250#:BI,+1,+2,+1,-1,A
08;09;23;19;27;03;.250#:BS,+2,+1,+1,A
08;09;23;19;27;03;.250#:BE,+2,+0,+1,A
08;09;23;19;27;03;.421#:BD,+0.04,-0.03,+0.01,3.54,1.00
08;09;23;19;27;04;.250#:SA,+0.41,+3.66,8.03
08;09;23;19;27;04;.250#:TS,94020323000508,35.0,+15.4,1.4,1508.0,0
08;09;23;19;27;04;.250#:BI,+1,+2,+1,-1,A
08;09;23;19;27;04;.250#:BS,+2,+1,+1,A
08;09;23;19;27;04;.250#:BE,+2,+0,+1,A
08;09;23;19;27;04;.250#:BD,+0.04,-0.03,+0.01,3.54,1.00
08;09;23;19;27;05;.250#:SA,+0.41,+3.66,8.03
08;09;23;19;27;05;.250#:TS,94020323000508,35.0,+15.4,1.4,1508.0,0
08;09;23;19;27;05;.250#:BI,+1,+2,+1,-1,A
08;09;23;19;27;05;.250#:BS,+2,+1,+1,A
08;09;23;19;27;05;.250#:BE,+2,+0,+1,A
08;09;23;19;27;05;.250#:BD,+0.04,-0.03,+0.01,3.54,1.00
08;09;23;19;27;06;.250#:SA,+0.41,+3.66,8.03
```

Date and time fields are separated by semicolon, different type of data fields are separated by symbol #.

2.2.10 Flashes

The flash are the same since the start of the project, Nikon SB800 installed in Comex designed housing.

Improvement of optical link between Master and Remote as been conducted as described below.

2.2.10.1 Upgrade of flash system

2.2.10.1.1 Context:

In the Venus framework the photographic equipment consist of one reflex digital camera and two Nikon SB800 speedlight.

Submarines housing have been specially designed for these equipment.

The particularity of the shooting in this project is that the focus setting must be locked at a fix value for optical calibration reason. Thus in order to increase the depth of field we have to close the diaphragm and we need a powerful lighting system The SB800 flash gun associated with the camera allows normally a good illumination. The two flashes, one master and one Slave are spreading together and with the camera in order to obtain the better lighting. This type of operation called Advanced Wireless Lighting" is only available in optical mode (optical link between flashes). The master flash fires a pre lightning containing the information of power setting for the slave. To receive this information the slave speed light is fitted with a light sensor on his side.

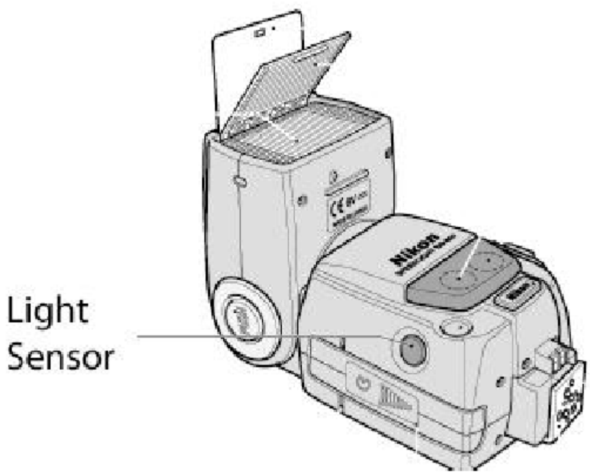


Figure 22. SB800 Nikon Flashes.

The underwater housing designed for the speed light are fitted with a light guide permitting the access of the transmitted power setting to the sensor. But practical tests have demonstrate that the optical link was not obtained in the project context The camera housing installed in between the two flash housing avoid direct optical link and the medium attenuation added to the guide attenuation is to much. The slave is not firing. The test has been performed with a cable link but this mode does not permit advanced shooting. Slave flash is preset to a fixed power. The result is that the lighting is unbalanced and photos are over or under expose depending of the shooting distance.

In order to solve this problem and to be able to use the Advanced Wireless Lighting in the medium of the project we must settle a correct link between Master and slave. Plastic fibers are used. The optical cable is formed of seven 1mm fiber. A connecting part is designed for each side of the cable, one adapted to the master and the other to the slave. A plastic sheath protects and keeps together the fibbers. The length is set at 6 meters for an installation on the Remora Submarine.

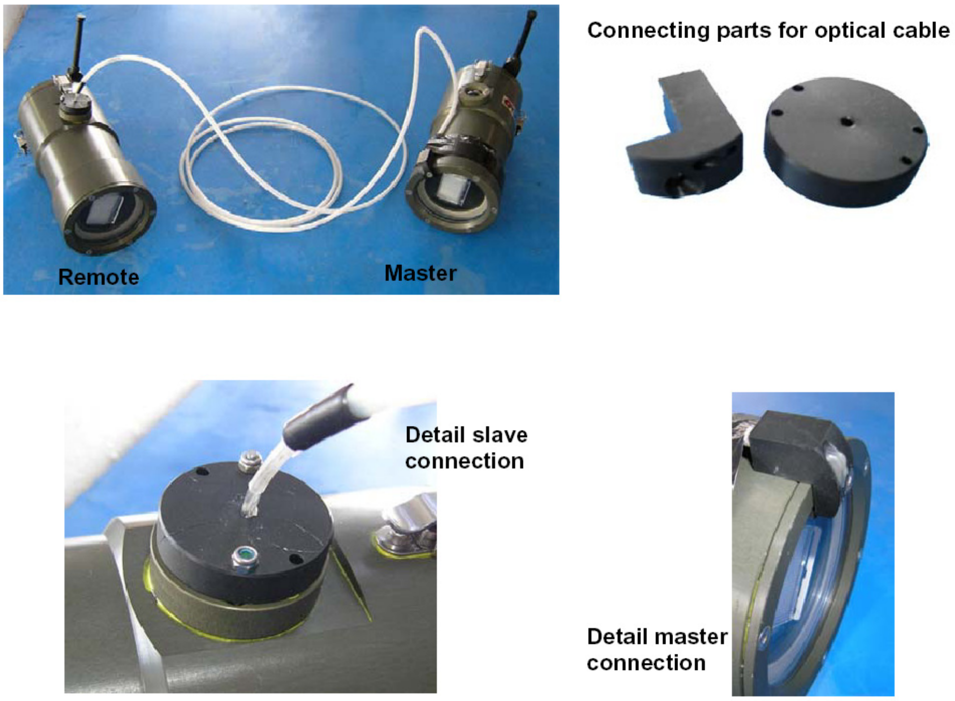


Figure 23. Flashes link.

Test of the system at surface give good result. Sub surface test have been realized during workshop in September.

2.2.10.1.2 Barrel System, study in progress:

In the framework, the shooting rate has to be as fast as possible in a way to guaranty the overlap between photos despite the moving speed of the underwater vehicle. This speed is inevitable for navigation purpose. The rate of shooting is limited by the recycle time of the speed light. This recycle time is generally 3 seconds for common equipment when firing at full power. One could imagine that increasing the number of flash for the same lighting will reduce the firing power and then the recycle time. This is the truth but not in ratio, doubling the number of speed light will not reduce twice the firing power.

The solution studied is to use in turn several pair of speed light. After the first shooting with the first pair, the second pair is used during the recycle time of the first. Using two pair allows to double the rate, three pair to triple the rate ….

The difficulty is then a wiring problem. For each pair we need a master and a slave. The master is electrically connected to the camera and the slave is connected optically to his master. A slave flash must not fire with any master. The Nikon system had a channel selector who permits to associate a master and a slave and avoid confusion. 4 channels are available. The actual state of the study is the design of an electronic device that will connect in turn a master flash to the camera. The devices as to detect the firing trigger and then to switch all line between flash and camera to the next flash.

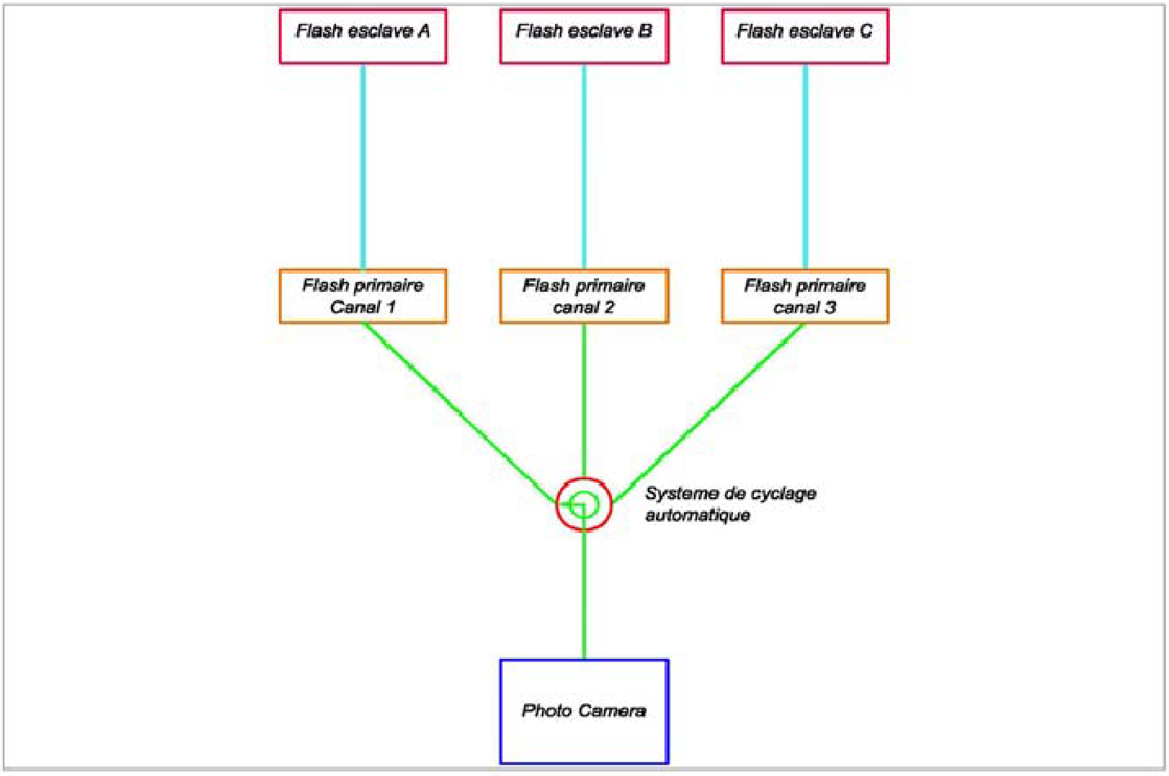


Figure 24. Flashes connexion shema.

2.2.11 Navigation software: hypack / hysweep

A navigation software permit to interface all navigation instruments and record and follow all motion in real time.

"HYPACK® provides all of the tools necessary to complete your hydrographic, side scan and magnetometer survey requirements. With over 4,000 users around the world, HYPACK® provides you with the tools necessary to meet almost any hydrographic survey requirement. It provides tools to design your survey, collect your data, apply corrections to soundings, remove outliers, plot field sheets, export data to CAD, compute volume quantities, generate contours, create side scan mosaics and create/modify electronic charts.

HYSWEEP® is an optional module that provides for the calibration, data collection and data processing of multibeam sonar data inside the HYPACK® package. HYSWEEP® has been integrated to almost all multibeam systems, including those from Odom, Reson, Konigsberg/Simrad, Elac/Seabeam, and GeoAcoustics. With over 500 HYSWEEP® users on six continents, HYSWEEP® has proven to be powerful, cost effect and easy to learn."

We decide to use HYPACK/ HYSWEEP because:

- The Delta T837 Profiler is compatible, which is not the case of all navigation software.
- COMEX have an experience on.
- It can be installed on laptop

2.3 *Preliminary works*

In order to insure the realization of PORT MIOU C works, COMEX works during several weeks, to test instruments, to perform trials, to adapt procedure to the configuration envisaged for final works.

This section describes all this weeks and presents the results of all trials.

2.3.1 PLSM accuracy trials

In order to improve future underwater positioning, we decided to test the equipment of PLSM which would enable us to have a more accurate and more stable positioning for ROV and Submarine diving.

These trials have been realized from 25 to 27 of April 2007 on board Minibex.

During these trials, one year and half ago, the PLSM will be used alone for the positioning of the sub-marine, in the final configuration the PLSM is used for the elevation data, and to realize the navigation during the photogrammetry.

2.3.1.1 Installation of the site

Initially, a team of 2 divers guided by a ROV disposed on the seabed metric reference mark.

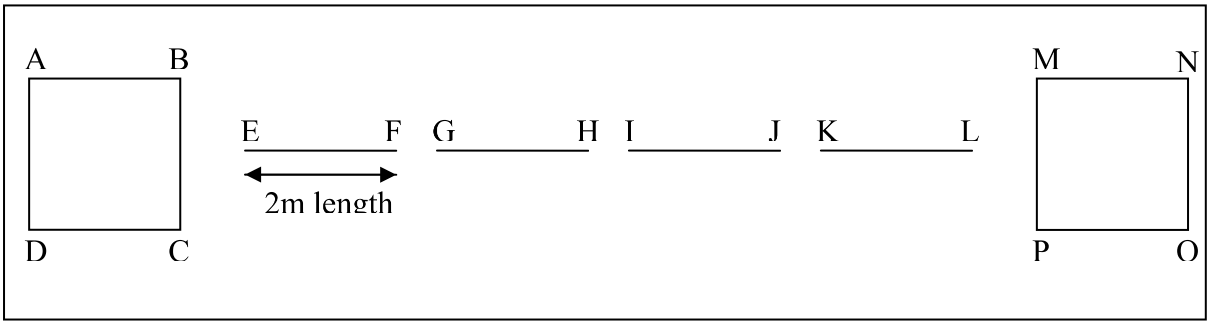


Figure 25. Schema of the metric reference mark positioning.

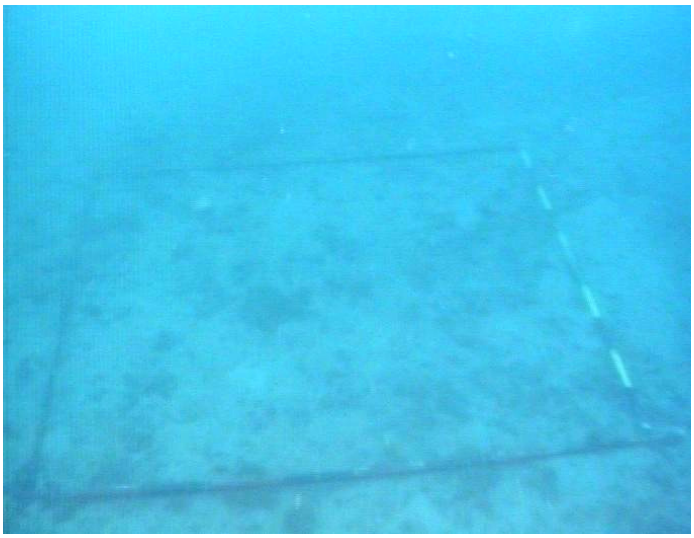


Figure 26. ROV Snapshot of Square.

A transponder (corresponding at the ORE Trackpoint USBL System installed on the Minibex) has been fixed on ROV, the coordinates of the trials site have been notified.

The Inteferometric Base mounted on a appropriate structure, permitting direct acoustic path between the Base and the Pointer (mounted on the ROV or on the Submarine) has been launched using the Minibex crane, and the ROV for the laying on the seabed.

The Base is laying approximately at 25m of the metric reference mark site previously layed.

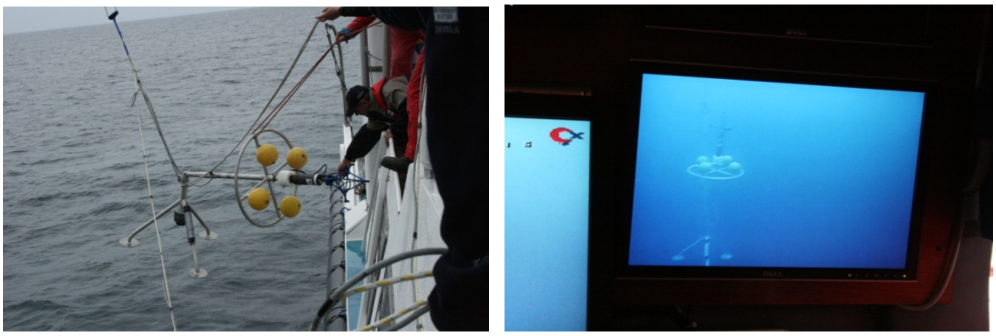


Figure 27. On the left, launched of the Base. On the right: Base on the seabed

2.3.1.2 Description of operation

The trials have been realized in 3 times.

As explain in the instruments descriptions, the system need to be linked by cable, it can be to the pointer or to the Base.

In a first time, the pointer has been linked at the surface Unit via the ROV umbilical. The pointer has been fixed on the ROV, the purpose being the positioning of ROV moving. A converter (RS 232 / RS 485) has been installed to boost the communication along the ROV umbilical. The communications acoustics and by cable are tested in this configuration.

In a second time, the link cable has been installed on the Base. The acoustic communication with the pointer mounted on ROV is tested.

And finally, the pointer has been installed on the submarine "REMORA 2000", especially to test if the noise produced by the submarine doesn't obstruct the acoustics communications between the Base and the pointer.

2.3.1.3 Software

2.3.1.3.1 Aquacad

AQUACAD is the software developed by PLSM, this software permit all the communication with the underwater positioning system, and the management of data.

In the first time, from the software, the cable communication with the system needs to be established.

The id of the Base and Pointer are specified.

And the inclination compensation needs to be tick, to correct the inclination angle of the Base create by the seabed slope.

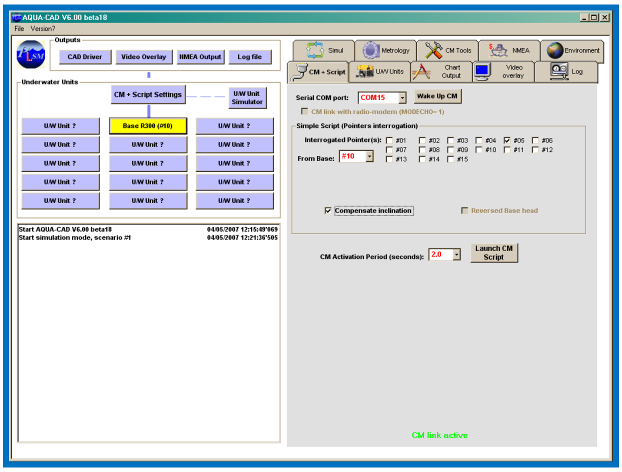


Figure 28. Aquacad main window.

In second time, the Base need to be wake up and initialized. (In this way, the Base measured its parameters: Celerity, heading…)

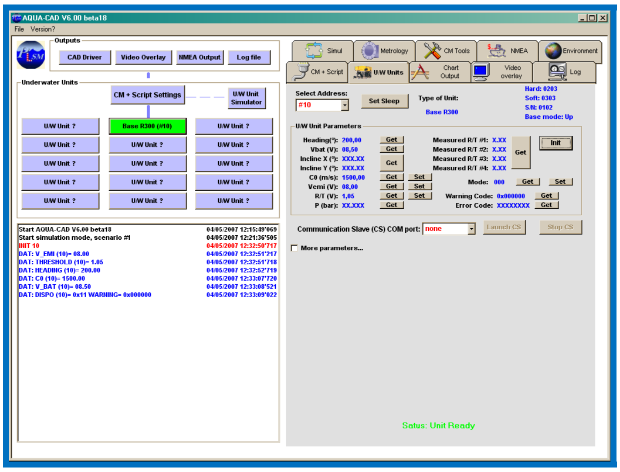


Figure 29. Aquacad

The pointer needs to wake up and initialized too.

It is possible to enter here the offsets between the pointer and the ROV point from measure.

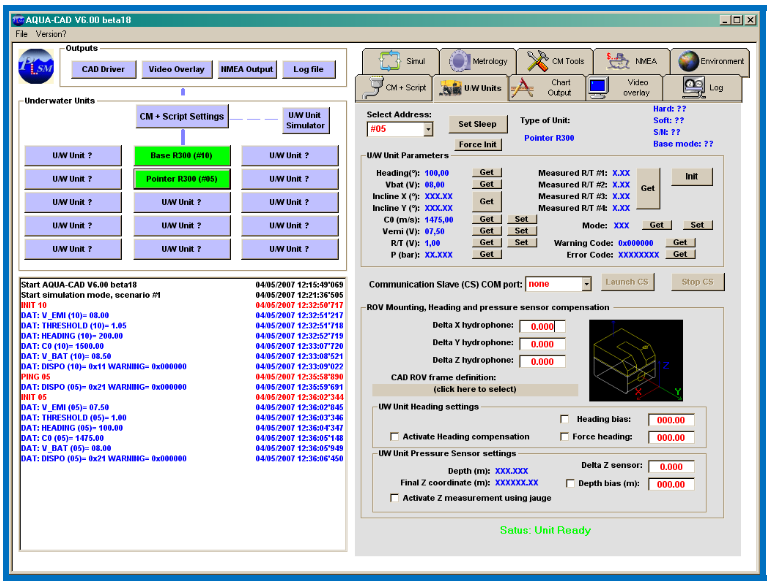


Figure 30. Aquacad.

In the third time, the configuration of chart output needs to be configured.

The system gives relative positions (x,y,z) between the Base and the Pointeur. It's possible to refer the system, there 3 options:

- Pure relative mode
- Rough attachment: we can enter a specific point for the position of base, this point can be determinate by a USBL system.

But the heading is measured by the compass in the base. This mode permit to work in a absolute location but, the error induce by the compass measure is too important

- Pivot and Lever cartographic attachment, for this one we need de have two known point on the site.

The mode of referencement must be selected with this stage.

And the connection between AQUACAD and IntelliCAD (for the cartographic representation) must be done here.

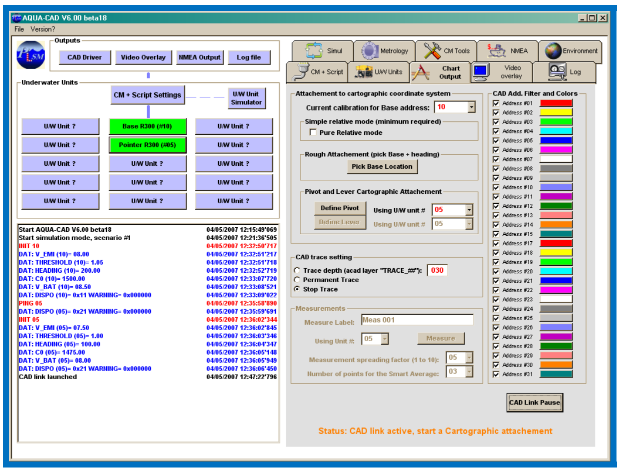


Figure 31. Aquacad.

At this stage, we just need to launch the communication master to send the instruction of the acoustic interrogation beginning.

2.3.1.3.2 Intellicad

After the link established between the AQUACAD software, and IntelliCAD, all the (x,y,z) positioning are represented in real time on IntelliCAD Software.

IntelliCAD is compatible with the AutoCAD format (DWG).

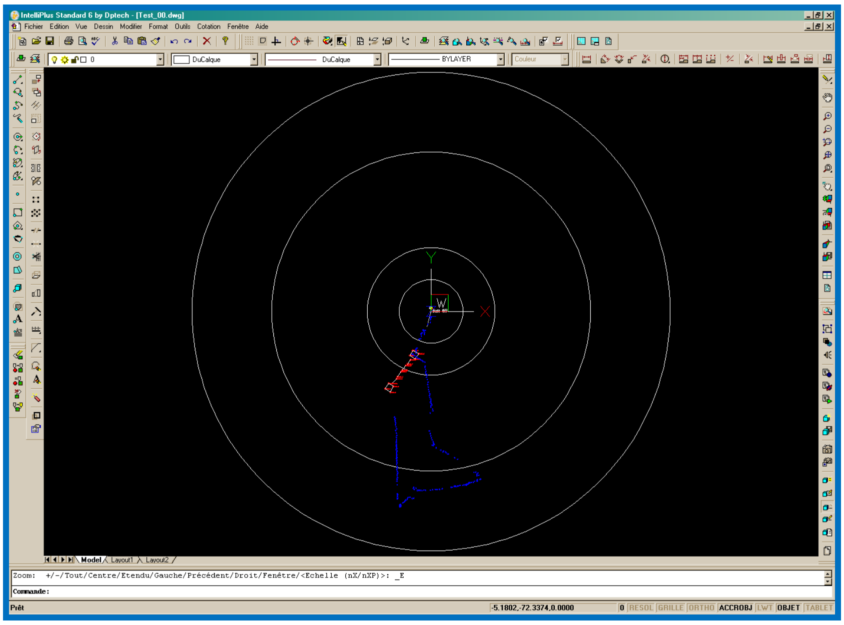


Figure 32. Intellicad.

2.3.1.4 Results

We have realized 3 series of different tests to appreciate the quality of the system.

2.3.1.4.1 Accuracy test

Figure 33. Accuracy test.

The references mark measure 2m length and visually marked every 20 cm.

The test consists to realise one measure every 20 cm.

An offset have been measure between the extremity of the grip and the pointer.

Results : Average: 0.204m / Standard Deviation: 0.026

Mark (1-2)	Mark (2-3)	Mark (3-4)	Mark (4-5)	Mark (5-6)	Mark (6-7)	Mark (7-8)	Mark (8-9)	Mark (9-10)
0.22m	0.20m	0.15m	0.21m	0.22m	0.19m	0.19m	0.23m	0.23m

2.3.1.4.2 Reference mark way test

Figure 34. Reference mark way test.

As described above the References Mark were placed according to a certain way.

The purpose of this test is to point with the ROV grip each angle of the site.

This test has been realized twice, with two different calibrations.

IntelliCAD manage this test.

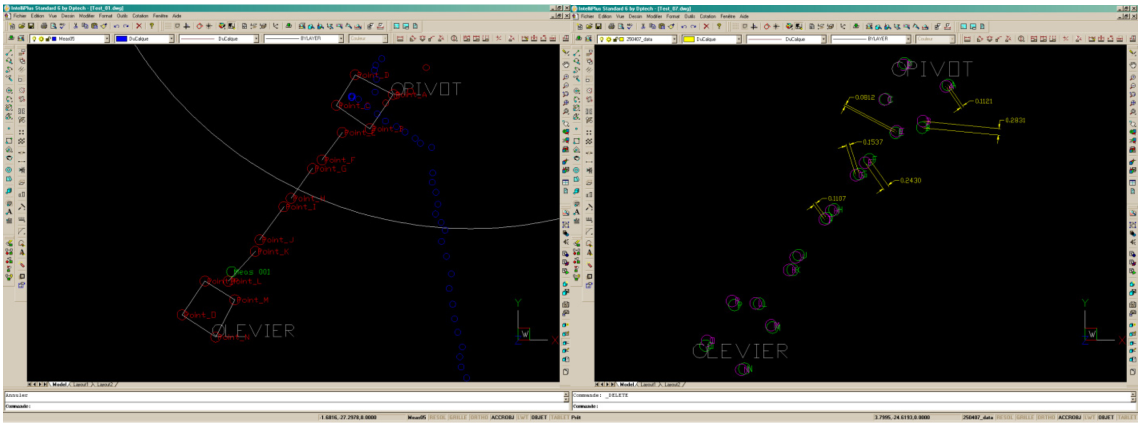


Figure 35. On the right: in the first time, the ROV has drawn the site, on the Left: in second time, this test has been realized twice, with two different calibrations.

The two calibrations are Pivot and Lever calibrations.

The Green and Magenta Circles represent the 2 different set of data.

Results:

Average: 0.150 m / **Standard Deviation**: 0.061

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
0.076	0.0462	0.1121	0.2831	0.0812	0.1537	0.243	0.1411	0.1107	0.1655	0.1515	0.1604	0.1157	0.2042	0.2154	0.1409

2.3.1.4.3 Elevation test

The ROV grip measure the x,y,z on it cage, to appreciate the quality of elevation data.

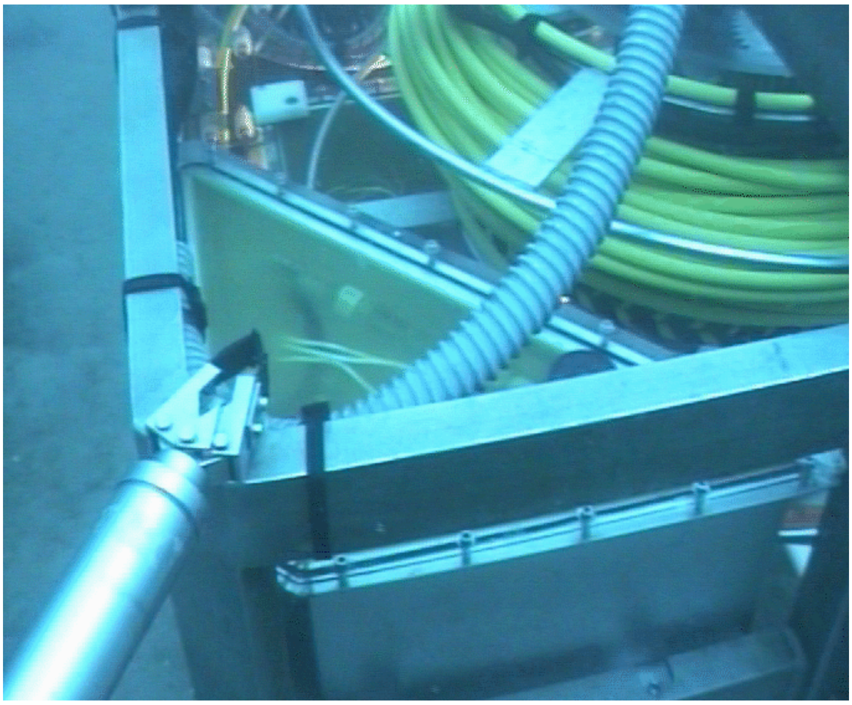


Figure 36. Elevation test.

Results:

Delta Z	ROV Measure	On board Measure	Error

TOP CAGE / SUPPORT	1.102	1.190	0.09
SUPPORT / BOTTOM CAGE	0.32	0.30	0.02

2.3.1.5 Conclusion

These trials demonstrate that the PLSM Underwater Positioning System is:

- Stable and Accurate in relative mode
- Not Obstruct by the Submarine noise
- Efficient in the 2 possibilities of communications by cable (on ROV or on Base)

2.3.2 Trials during week 35-36

From the 25th of August to the 5th of September 2008, several trials of configuration to prepare the Venus Final operation have been done.

This trials concern:

- The PHINS/ DVL Calibration, and the possibility of modification of the previous Ixsea procedure.
- The Multibeam chosen for Venus final operation

This document presents all configurations of PHINS and Navigation Software to anticipate the problems we can meet during the final operation.

Figure 37. Microsurvex mobilisation for trials.

2.3.2.1 Calibration IXSEA Procedure

Extract of ixsea documentation:

"Calibration can be performed with a GPS at the surface or using USBL positioning system if the calibration cannot be done at the surface.

Enter DVL lever arms with an accuracy of 5 cm. Refer to ANNEX 0 for lever arm values of PHINS ready" systems.

Enter GPS or USBL lever arms with an accuracy of 10 cm.

DVL must be in "bottom track" in "always false".

GPS or USBL must be in "automatic reacquisition"

Optional (for metrology verification only): Primary lever arms must be set with values identical to GPS USBL transponder lever arms. This will enable position of PHINS+DVL and GPS or USBL transponder defined at the same location during the verification phase

PHINS alignment process

PHINS must be "aligned". This procedure enables the system to evaluate the sensor biases to *minimize the navigation drift.*

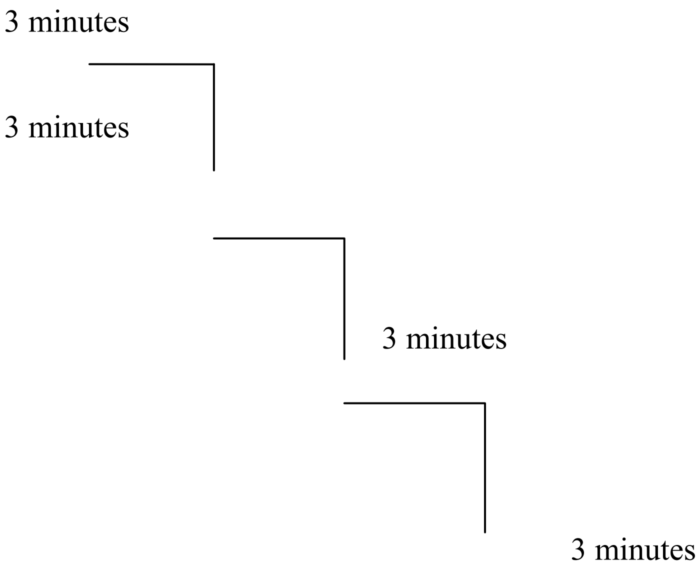
« Alignment » of PHINS is optimum when standard deviation on heading is inferior to 0.1°. You can check this in the expert view of the PHINS repeater. A message will also indicate this in the repeater

Alignment can be done by different methods

- On the deck with GPS input.

- Under water using USBL positioning

- Alignment time will decrease with GPS or USBL accuracy or when performing direction modifications in navigation as described hereafter.



Cross calibration from point A to B

2 virtual points A and B are referenced on the maritime navigation. Travelled distance must 1000 times the

GPS or USBL accuracy so that PHINS+DVL specification can be met3. For example, distance between

these points must be greater than 5 km for a GPS that has an accuracy better or close to 5 m (i.e : DGPS).

To enable bottom track, the depth of water from A to B must be :

< 200 m for a DVL 300 kHz

< 90m for a DVL 600 kHz

< 30 m for a DVL 1200 kHz

1. Set GPS or USBL in "automatic reacquisition" and click on "send"
2. Set DVL in "always false" and click on "send"
3. Go to point A and point vessel in direction of point B.
4. Go to lever arm configuration and open DVL lever arm and misalignment menu
5. Start logging data with the repeater (200 ms with file size set to 60000)
6. click on "Calibration" button
7. The ship or Subsea vehicle must sail now to point B . Sailing speed is not critical only travelled

   distance is important. Speed can be faster than 5 knots if system can withstand this.
8. 1 minute before arriving at point B click once more on "Calibration"
9. A message will appear : "do you want to save the calibration values". Answer yes.
10. switch logging of data off
11. Note the values found in your calibration Form

If DVL axis are aligned with PHINS axis the heading misalignment should be approximately -45°. If you are using an SVP and scale factor close to 0%.

Fine calibration from point B to point A

Put the vessel at point B facing direction of point A

1. Open lever arm configuration menu and open DVL lever arm and misalignment menu
2. Start logging data with the repeater (200 ms with file size set to 60000)
3. Click on "calibration" button
4. The ship must sail know to point B. Sailing speed is not critical only travelled distance is important. Speed can be faster than 5 knots if system can withstand this.
5. 1 minute before arriving at point A click once more on "Calibration"
6. A message will appear: "do you want to save the calibration values". Answer yes
7. Switch logging of data off
8. Note the values found in your calibration Form

Verification of calibration

1. Switch off PHINS.

2. Proceed to an alignment phase

3. Check that primary lever arms are identical to GPS lever arms

4. Launch repeater recording. (i.e: 500 ms period and file size 60000 to have one record file)

5. Set the DVL Bottom speed to “automatic reacquisition”. Check Watermass speed is still in

“always false”. Click on “send” button.

6. Set the GPS or USBL to “always false” mode. Click on “send” button.

7. Start logging data with the repeater (200 ms with file size set to 60000)

8. Start sailing at 5 knots for example for 3 km between point C and D.

9. At point D leave the ship drifting for a minute or two so that position of GPS or USBL can be easily compared to position of PHINS+DVL with the repeater data4

10. Switch recording off. Switch PHINS off.”

COMEX realized trials to test the results with a shorter calibration procedure. Indeed, apply this complete procedure to the submarine isn’t safe. COMEX need to reduce the distance traveled where the submarine is towed by the vessel.

2.3.2.2 Full Calibration Results

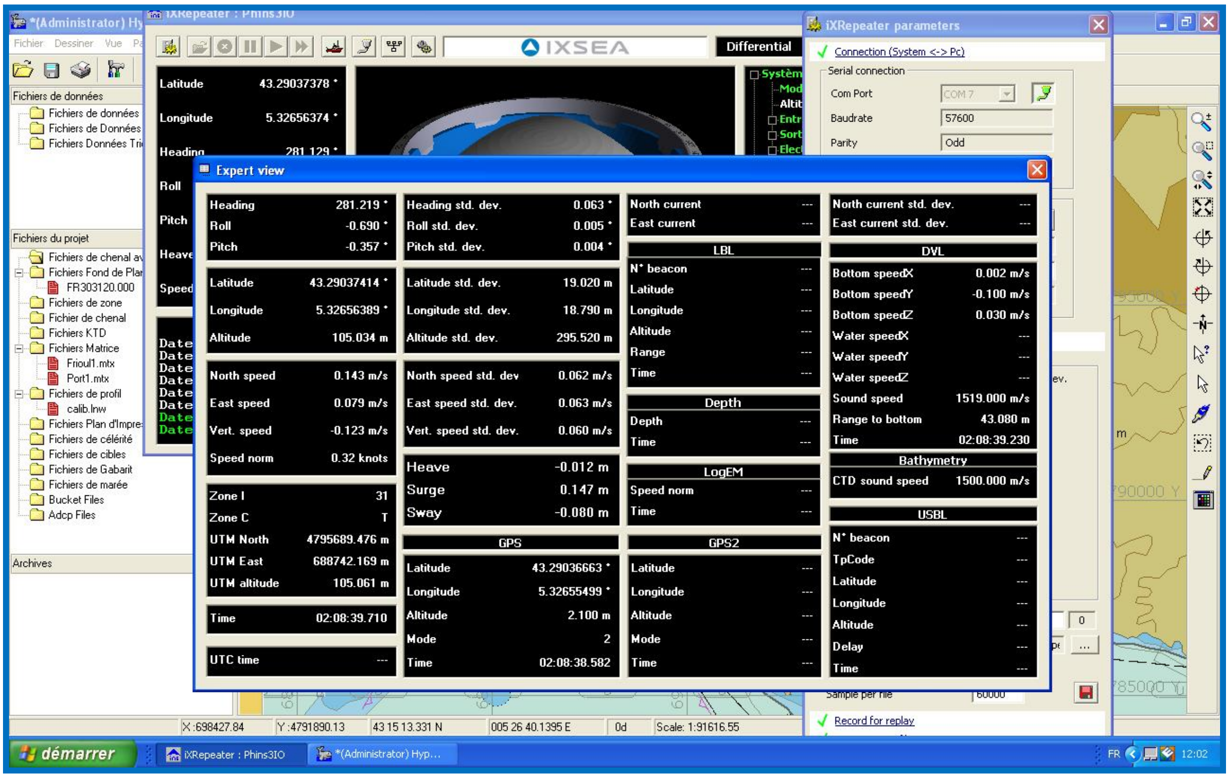


Figure 38. calibration result: IXSEAmain frame.

Then, the result after a full calibration procedure and 3km approx for the verification phase:

PHINS Results: Easting : 688 742.13m Northing : 4 795 689.54m	RESULTS Delta Easting= 0.7m Delta Northing = 0.85m Delta Position= 1.1m
DGPS Results : Easting : 688 741.43m Northing : 4 795 688.69m	

2.3.2.3 1 km Calibration / results trials

If we want to follow the full procedure for the PHINS – DVL Calibration the distance to run with the sub marine is too important, then for this reason we want to realize calibration test with shorter distance.

After a calibration realize on 1km long the results are:

Speed 3.6 knots.

Several trials runs have been realized.

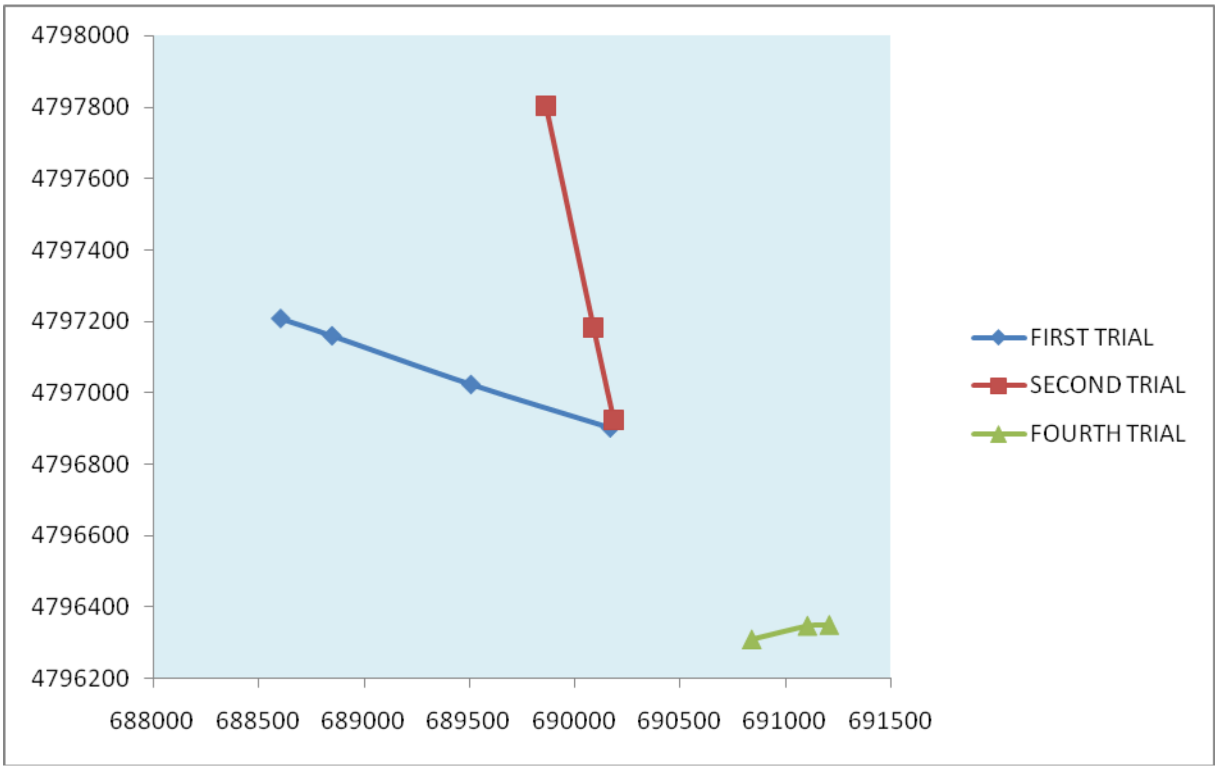


Figure 39. Calibration IXSEA .

FIRST TRIAL (value in meters)

		Easting	Northing	Difference Easting	Difference Northing	Total Distance error	Running distance
RUN1	PHINS	690168.01	4796902.95				
	DGPS	690165.55	4796902.59	2.46	0.36	2.49	Approx 200m
RUN2	PHINS	689512.80	4797024.53				
	DGPS	689506.10	4797023.97	6.70	0.56	6.72	671
RUN3	PHINS	688857.94	4797157.15				
	DGPS	688847.50	4797159.88	10.44	-2.73	10.79	1343
RUN4	PHINS	688616.71	4797197.386				
	DGPS	688604.13	4797208.12	12.58	-10.73	16.54	1591

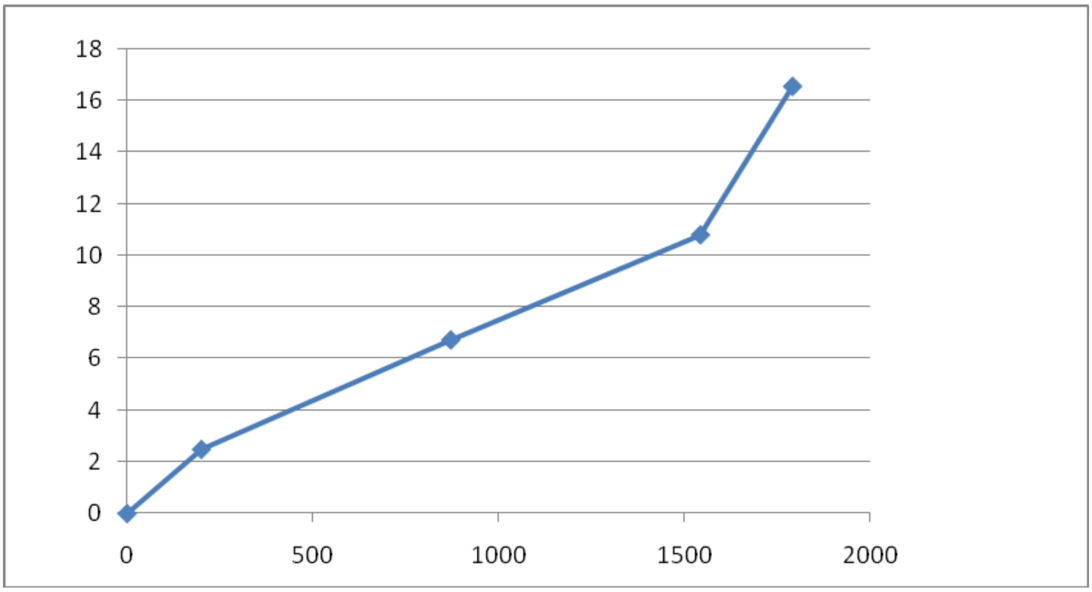


Figure 40.First trial Error in relation with running distance

SECOND TRIAL

		Easting	Northing	Difference Easting	Difference Northing	Total Distance error	Running distance
RUN1	PHINS	690188.17	4796921.35				
	DGPS	690187.04	4796922.65	1.13	-1.30	1.72	Approx 200m
RUN2	PHINS	690090.05	4797180.83				
	DGPS	690090.22	4797181.126	-0.17	-0.30	0.34	476
RUN3	PHINS	689861.14	4797796.72				
	DGPS	689862.28	4797802.52	-1.14	-5.80	5.91	1138

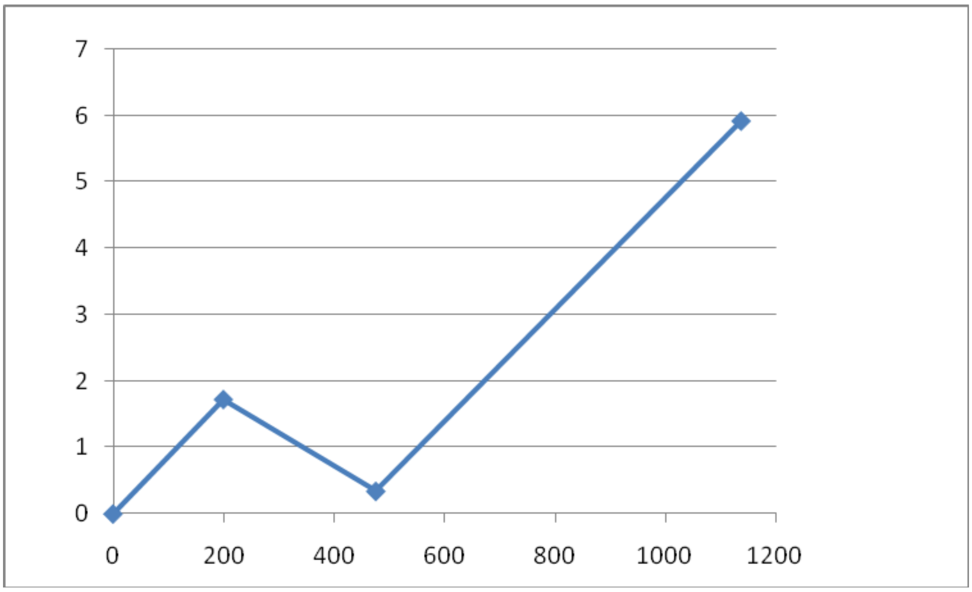


Figure 41. Second trial Error in relation with running distance

THIRD TRIAL

		Easting	Northing	Difference Easting	Difference Northing	Total Distance error	Running distance
RUN1	PHINS	690462.80	4796789.85				
	DGPS	690463.93	4796789.83	-1.13	0.02	1.13	Approx 200m

FOURTH TRIAL

		Easting	Northing	Difference Easting	Difference Northing	Total Distance error	Running distance
RUN1	PHINS	690839.39	4796311.23				
	DGPS	690839.88	4796311.54	-0.49	-0.31	0.58	Approx 200m
RUN2	PHINS	691103.80	4796348.74				
	DGPS	691105.64	4796349.42	-1.84	-0.68	1.96	468
RUN3	PHINS	691206.20	4796350.47				
	DGPS	691210.03	4796351.62	-3.83	-1.15	4.00	573

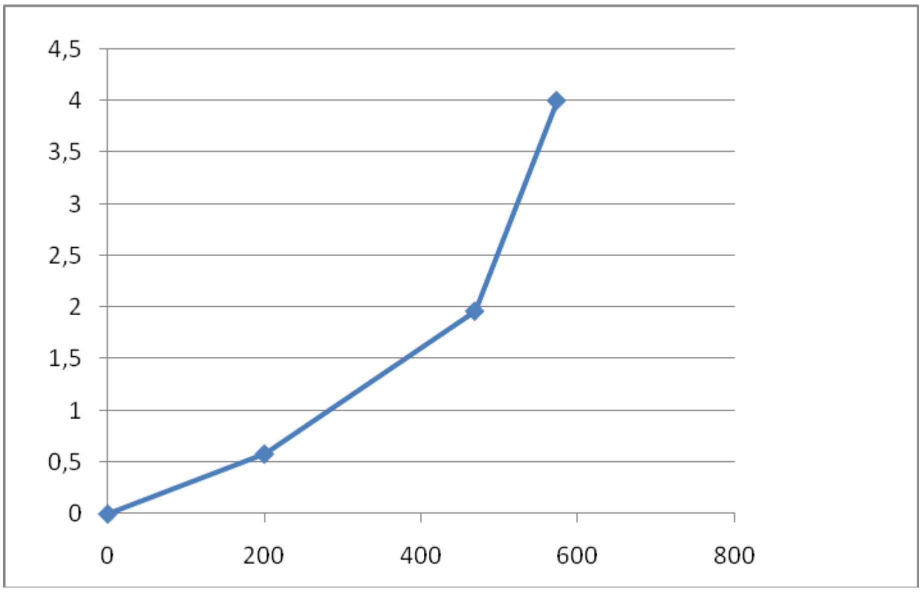


Figure 42. Fourth trial Error in relation with running distance.

2.3.2.4 Conclusion

All this trials underlined that we can planned a Calibration PHINS-DVL on 1km traveled distance.

2.3.3 Sensor setup

We will describe here all the work done to install the equipment on the Submarine.

The work is divided in 3 parts: mechanical interface, Electrical wiring, and weight adjustment.

2.3.3.1 Mechanical interfaces

Supports of instruments are defined in order to make correct use of the equipment and permit standard launch and recovery of the submarine.

- Doppler Velocity Log (DVL) has to be installed in a position where it will be always at more than 1.5m of sea bottom. This is to be sure to never lose the DVL signal and to never enter in a dead reckoning phase that will generate some drift. More over acoustic beams should not encounter obstacle giving mask or multi-path to acoustic signal.
- Position of Multibeam echo sounder has to follow the same recommendation except for distance to sea bottom.
- Position of camera must permit to take picture without submarine parts in the field. Camera must be at 1.7 metres above bottom during survey. At this position the pilot of submarine must be able to see the bottom. Camera and flashes installation are dependant.
- Lighting of flashes must be homogeneous and lateral. Be aware about shadows of submarine equipment such as manipulator.
- The INS is a surface unit. So we have to set it in the sub cabin. We have chosen a position keeping safety rules and relative comfort in the cabin.

- GPS is used in two configurations: For INS / DVL calibration with submarine towed backward at surface and for INS initialisation before dive. For the towing configuration we make a small mast keeping the GPS antennae always out of water and clear from elevation mask. This mast is not convenient for submarine launch, so it is removed in normal operation.
- PLSM acoustic pointer must be set in a position in direct view with the base.
- The installation of the two computers in the cabin must respect safety rules and facility of use.

Taking in account those request the following bracket have been made:

- Bracket supporting DVL and master flash. This bracket deports the DVL in front and in the axe of the sub.
- Bracket supporting multibeam
- Bracket supporting remote flash on the manipulator arm and avoiding shadows.
- Supports for INS on top of the central console in the cabin.
- Support for one computer on the starboard console in the cabin.
- Support for GPS with mast and without mast.

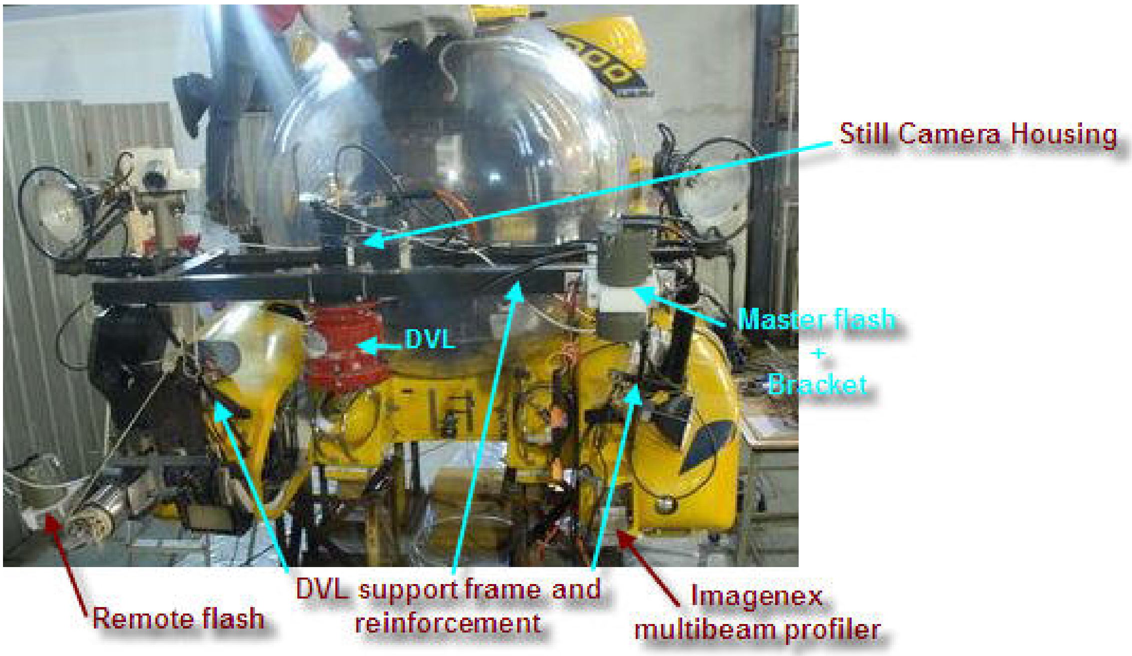


Figure 43. Remora 2000. Mechanical interfaces.

2.3.3.2 Electrical wiring

The electrical wiring is designed according to available passing through and power line.

All equipments are powered in 24 V DC. As the manipulator arm is not used for this job we use the manipulator line to power external and internal equipment.

We have not enough spare passing through to manage link from cabin to all external equipments. We will use one bulkhead connector to link cabin to junction box. Power will be applied to equipment through the same junction box. Each device is then connected to the junction box. This junction box is a pressure balanced oil filled (PBOF) type. This configuration is very useful and permits easy change for future configuration.

In the cabin, a repartition box gives access to the data link of each sensor.

A second bulkhead connector is used to manage a direct USB link from Cabin to camera. Long USB line is more difficult to realise and was not feasible through the junction Box.

Junction box has been designed and machined specially for the project. It is made with Acetale and device cables are connected trough cable gland and connecting blocks.

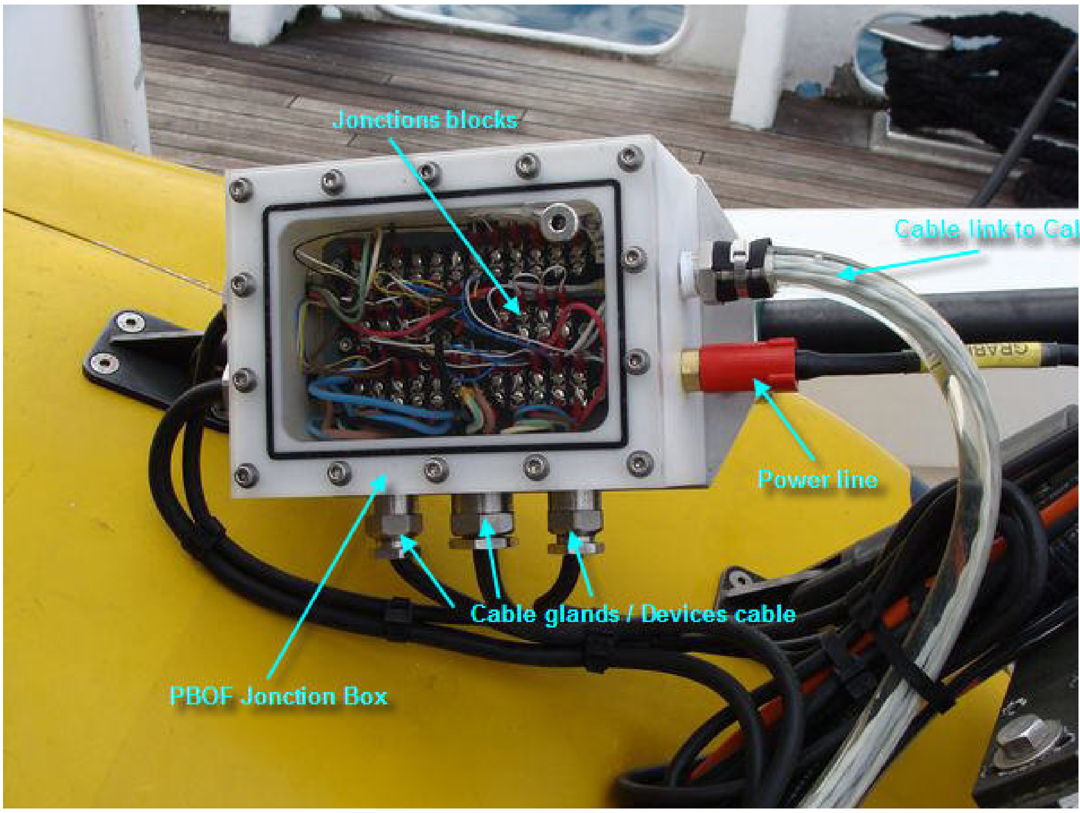


Figure 44. Cabin to sensors junction box.

Inside cabin, the laptops are self powered. Spare batteries insure working time capability. Devices are interfaced trough multiport serial PCMCIA adaptor.

The INS Phins is powered by cabin 24 DC Volt.

The laptops used were too big and changing batteries during survey was not convenient. This point must be upgrade.

Wiring table are shown in the next chapter.

2.4 Instruments synoptic

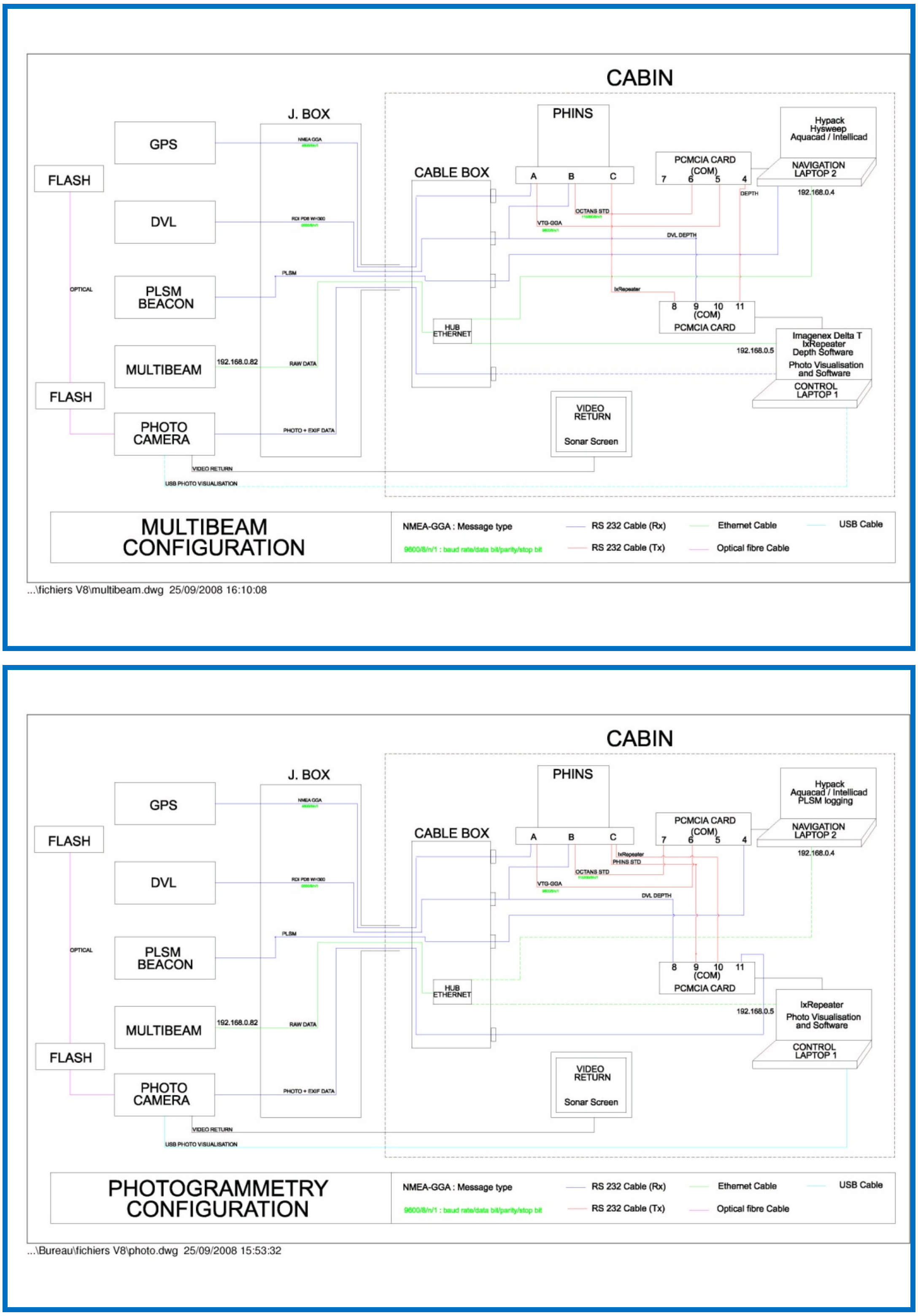


Figure 45. Instruments synoptic.

2.5 Instruments configuration

2.5.1 Phins configuration

The PHINS is the central instrument for the positioning. We need:

- to interface additional navigation sensors (DVL, DGPS)
- to configure settings (communication protocol, levels arms, etc…)
- to configure data output (data will come out from the Phins to the navigation software HYPACK)

PHINS can provide several communication protocols, this chapter explain what protocol have it in and out and the complete configuration of the PHINS to provide to the complete system coherence.

LEVER ARM

The communication / configuration of the PHINS is possible through the repeater cable (RS 232) and the firmware iXRepeater.

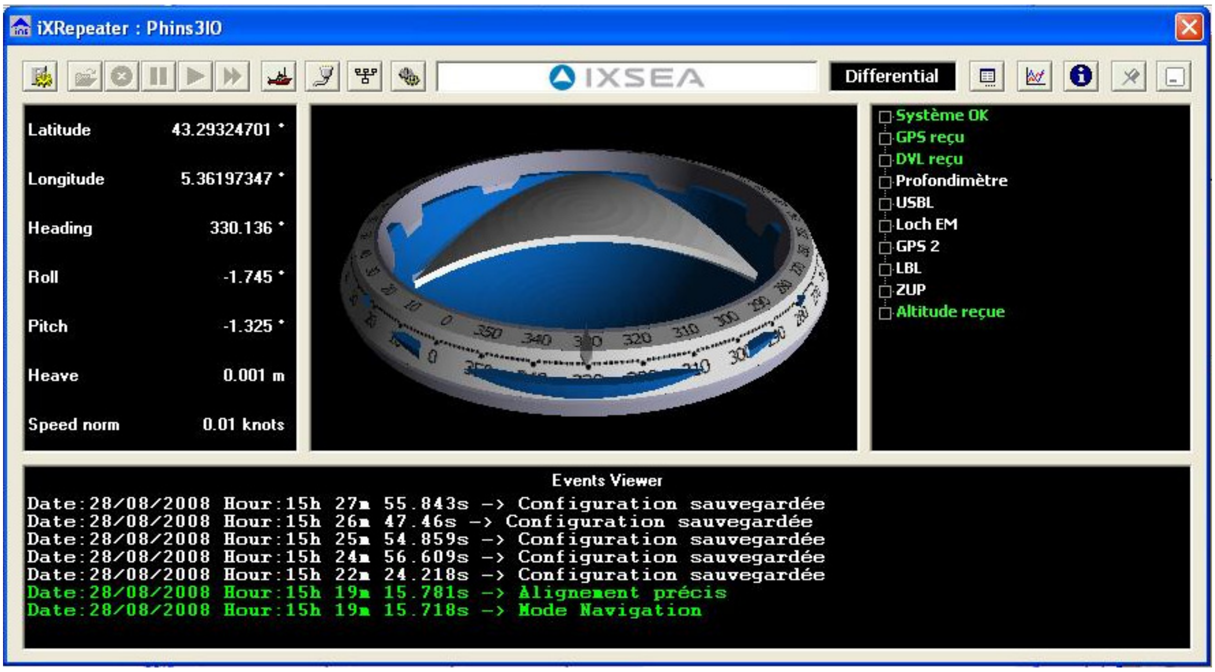


Figure 46.iXRepater Software firmware interface

From this software we can configure the lever arm of the external sensors DGPS and DVL

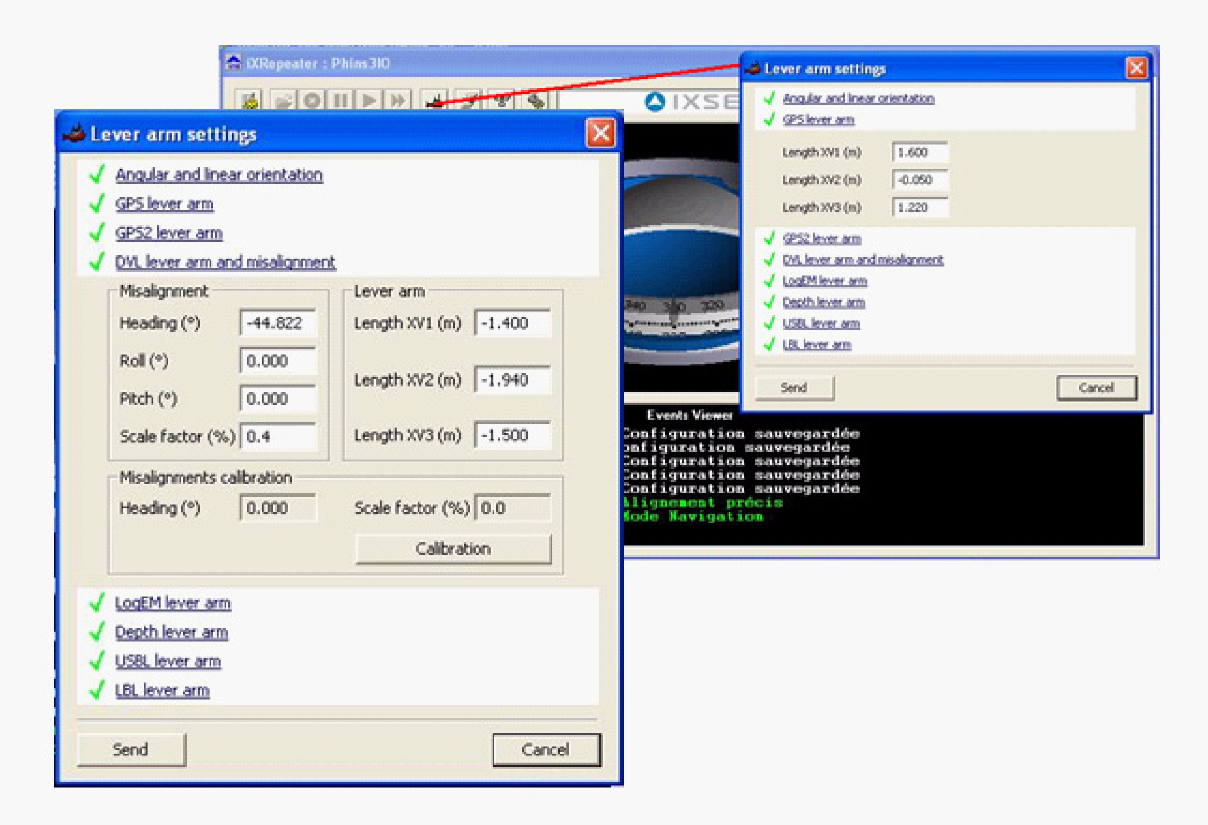


Figure 47.

The primary lever arm indicates the offset between the PHINS and the COG of the submarine.

The secondary lever arm indicates the Multibeam offset, the place where we want to apply compensation.

The values we must enter here are determinates in the "**Section Offsets Remora 2000**"

GPS LEVER ARM

X1: -1.148

X2: 0

X3: + 1.791

DVL LEVER ARM

X1: +2.157

X2: 0

X3: -0.401

Please note that misalignment value must be determinates by the PHINS-DVL Calibration "Section PHINS DVL CALIBRATION"

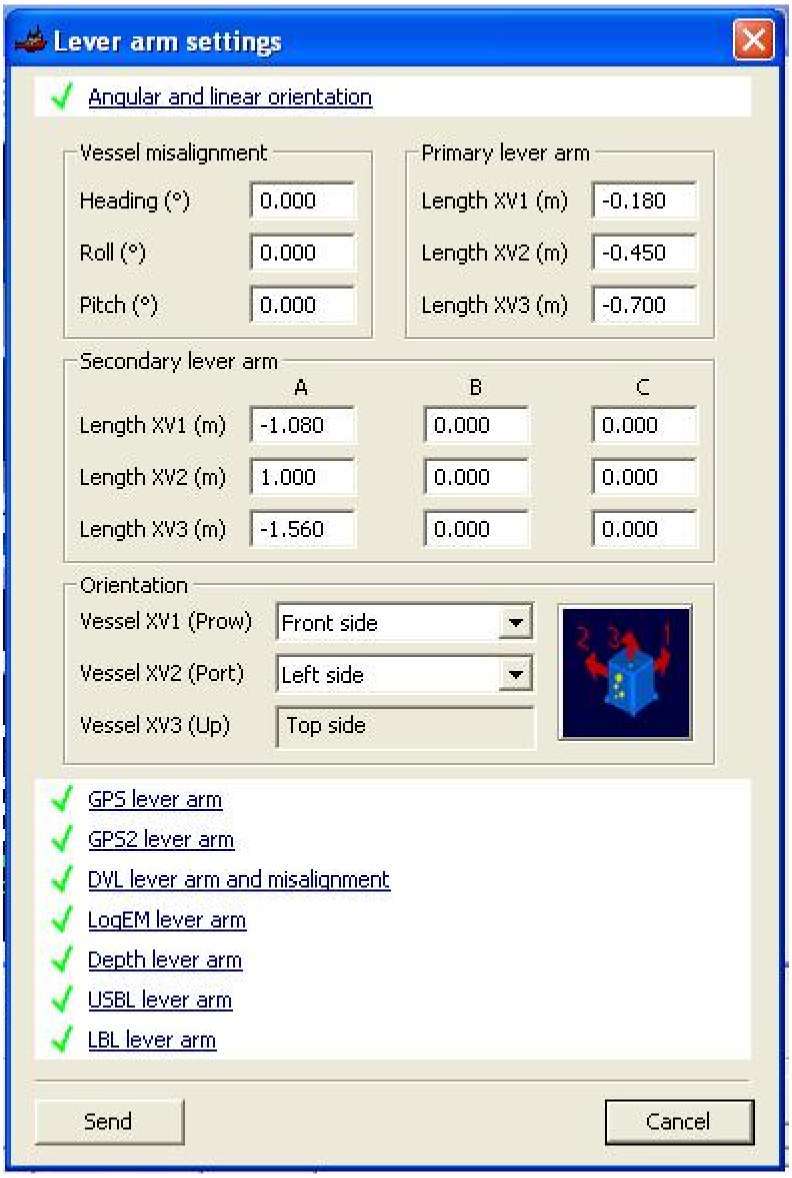


Figure 48.

The PRIMARY LEVER ARM is the offset between the PHINS and the still camera housing.

The SECONDARY LEVER ARM is the offset between the PHINS and the Profiler head.

Communication port com

PHINS communication input and output are in R232:

- RS232 for monitoring (repeater and configuration)
- RS232 for sensor input
- RS232 for sensor output

From external sensors:

RxA: Protocol from DGPS: NMEA GGA

RxB: Protocol from DVL: PD6

RxC: N/A

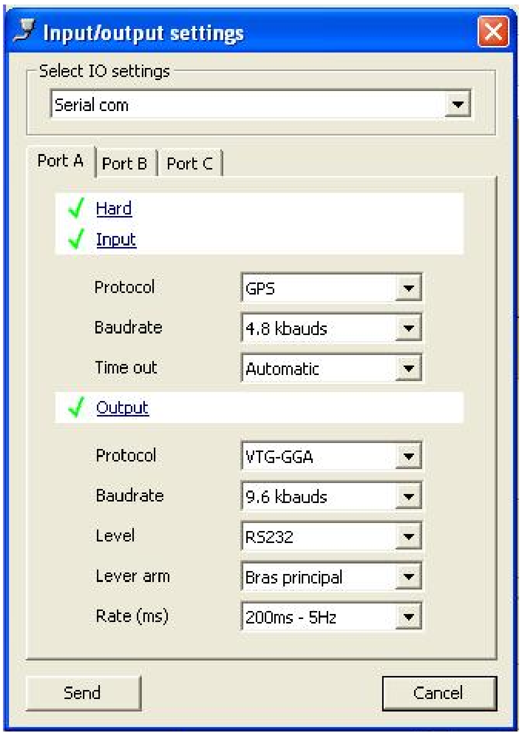
To Navigation software:

TxA: Protocol VTG GGA in Hypack navigation @ 9600 8 N 1

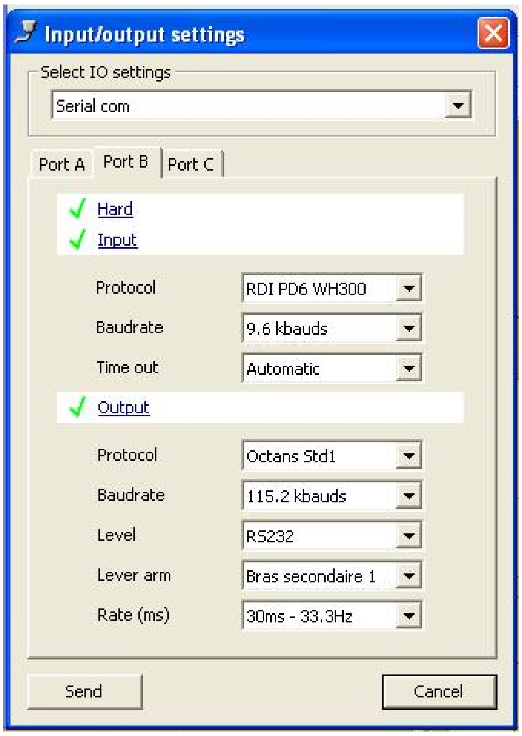
TxB: Protocol DMS TSS for Heave Pitch and Roll in Hysweep @ 115300 8 N 1

TxC: Protocol NMEA HEDT in Hysweep @ 9600 8 N 1

PORT A



PORT B



PORT C

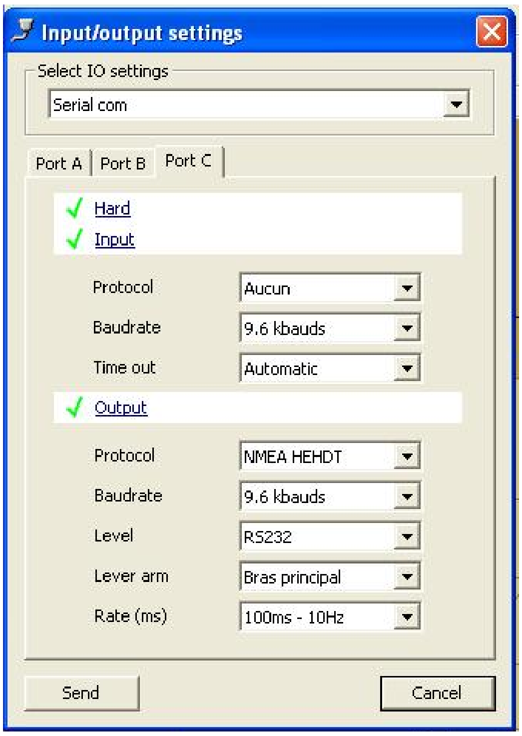


Figure 49.

2.5.2 hypack / hysweep configuration

In the HYPACK Software, the navigation data from the PHINS has been configured.

In the HYSWEEP extension for Multibeam, the Profiler Imagenex, the motion data from the PHINS, the heading from the PHINS are configured in.

The Z value is extract from the PLSM data and incorporated in HYSWEEP.

2.6 REMORA 2000 OFFSETS

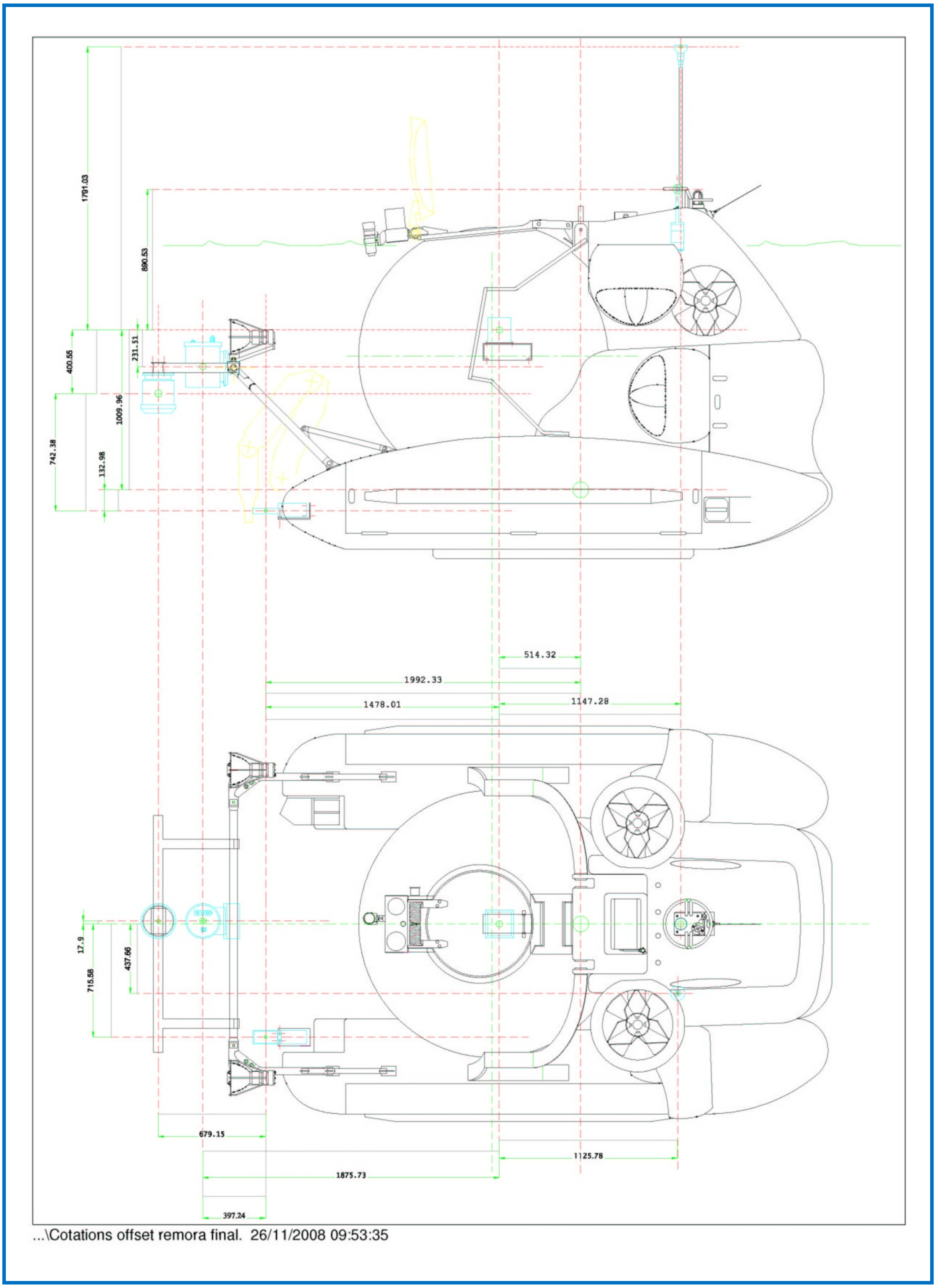
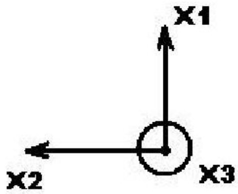


Figure 50. Remora 2000. Offsets.

All offsets have been measured on plan.

Offsets between equipments on the Remora 2000

Considering the direction of the PHINS as :



PHINS-GPS :

X1 = - 1,14775
X2 = 0
X3 = + 1,79103

__NB :__ Those mesures need to be used for the calibration stage only!
(GPS is in high position)

PHINS-DVL :

X1 = + 2,15716
X2 = - 0,00179
X3 = - 0,40055

PHINS-MB :

X1 = + 1,14293
X2 = + 0,71558
X3 = - 1,15300

PHINS-COG :

X1 = - 0,51432
X2 = 0
X3 = - 1,00997

PHINS-PHOTO **:**

X1 = +1,87573
X2 = - 0,00179
X3 = - 0,23152

PHINS-PLSM POINTER :

X1 = - 1,12578
X2 = + 0,43766
X3 = +0,89053

2.7 Calibration phases

2.7.1 Calibration phins-photo box

2.7.1.1 Procedure

The purpose of this calibration is to determine the installation bias between INS (Inertial Navigation System) PHINS and Camera.

The INS is giving attitude value (roll pitch and heading) relative to his own reference. We need attitude value of the photography.

The determination of the bias is done in two ways.

The first one consists to use the INS to measure the roll and pitch of the camera housing. This job is done in the workshop, the camera and INS are installed on the sub. The sub is in a stable position.

First we log data of INS in its working position.

Then the INS is installed on top of the camera housing using a mechanical interface specially designed. This mechanical interface replaces the cover of the housing.

The INS is oriented at the same value than when installed inside the sub.

Acquisition of pitch and roll is made. Differences of data between the two installations (inside sub / top of housing) are the biases of roll and pitch.

The bias of orientation is obtained by taking a picture of the MRU leveled under the camera and oriented in the same heading than when installed in the sub.

Figure 51. Manufacturing of Camera support for the Housing

Note:

Taking bias of the camera housing and apply them to the camera itself suppose that installation of the camera in the housing is perfect.

Mechanical control have been performed when camera bracket as been machined.

Control alignment of camera and housing bracket.

The second way to determine the bias consists to use a set of chained photogrammetric calibrations.

The first set of photo is used to make a calibration, in air of a digital D200 Nikon camera with the calibration grid in the right position: i.e. putting it horizontally and just under the D300 digital camera fixed on the submarine.

The calibration grid is installed under the camera and perfectly leveled with a spirit level. The phins is installed on the grid and oriented in the same position than in the cabin frame.

Once the calibration is in the right position we insert in the field the Phins sensor with some identified points to be able to measure its orientation. See figure belox.

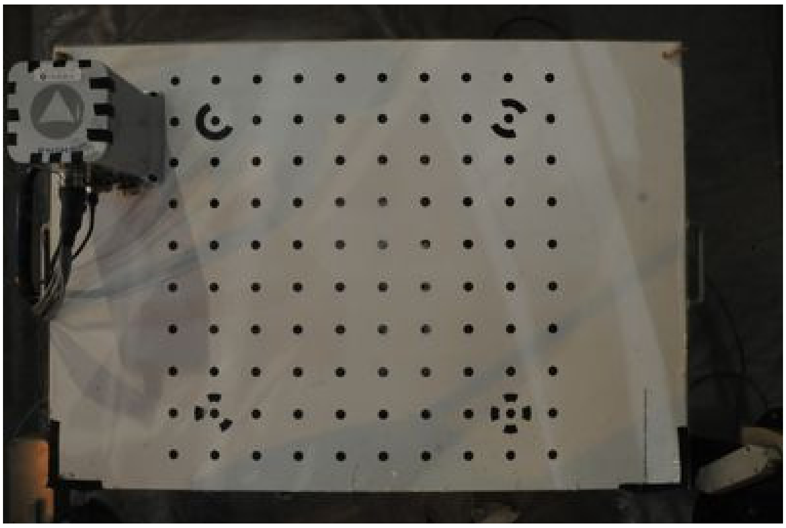


Figure 52. Reference picture for camera heading bias measurement.

The second one is used to obtain the calibration of the D300 in its housing and in Air. As the housing is fixed on the submarine we move the calibration grid under the camera.

This set of photo is used to determine the attitude of the camera using photogrammetry algorithm.

In this set of view the Phins is not present but the first view of this set is done with the calibration grid in the same position than for the first calibration.

This will give a common reference between the two calibrations and will allow processing all the photographs in the same bundle adjustment.

That's means we will have at the end of the process, in the same reference system, the Phins, the calibration grid, all the photograph orientations.

According to the procedure the calibration grid will appear always stable and the position camera always different (even if the D300 was stable and fixed to the submarine)

That's means that the photo orientation corresponding to the first photograph for the D300 calibration will give the camera orientation in the same reference system than the Phins, visible on the photographs used for the D200 calibration.

This will give the heading offset between the D300 camera inside the housing and the Phins.

These final results will be available in January 2009.

Figure 53. Calibration grid leveled under the Camera.

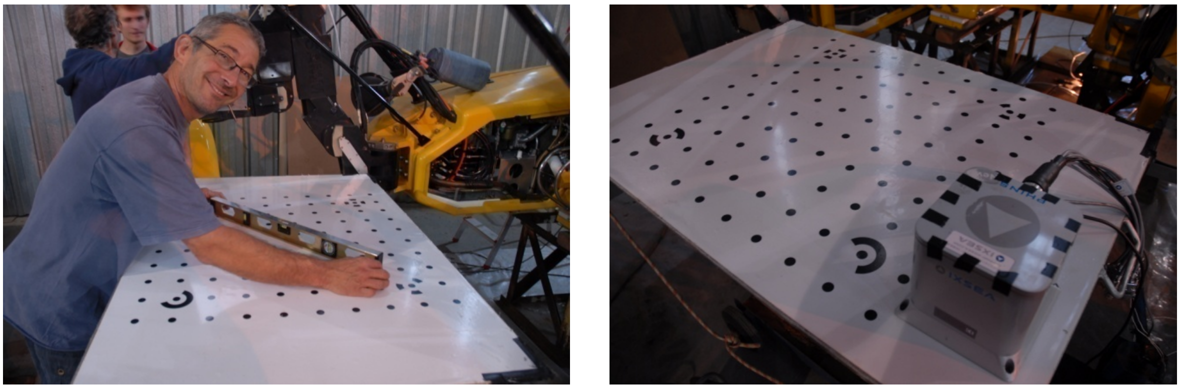


Figure 54. Setting the calibration grig horizontally. On the left: adding the PHINS sensor..

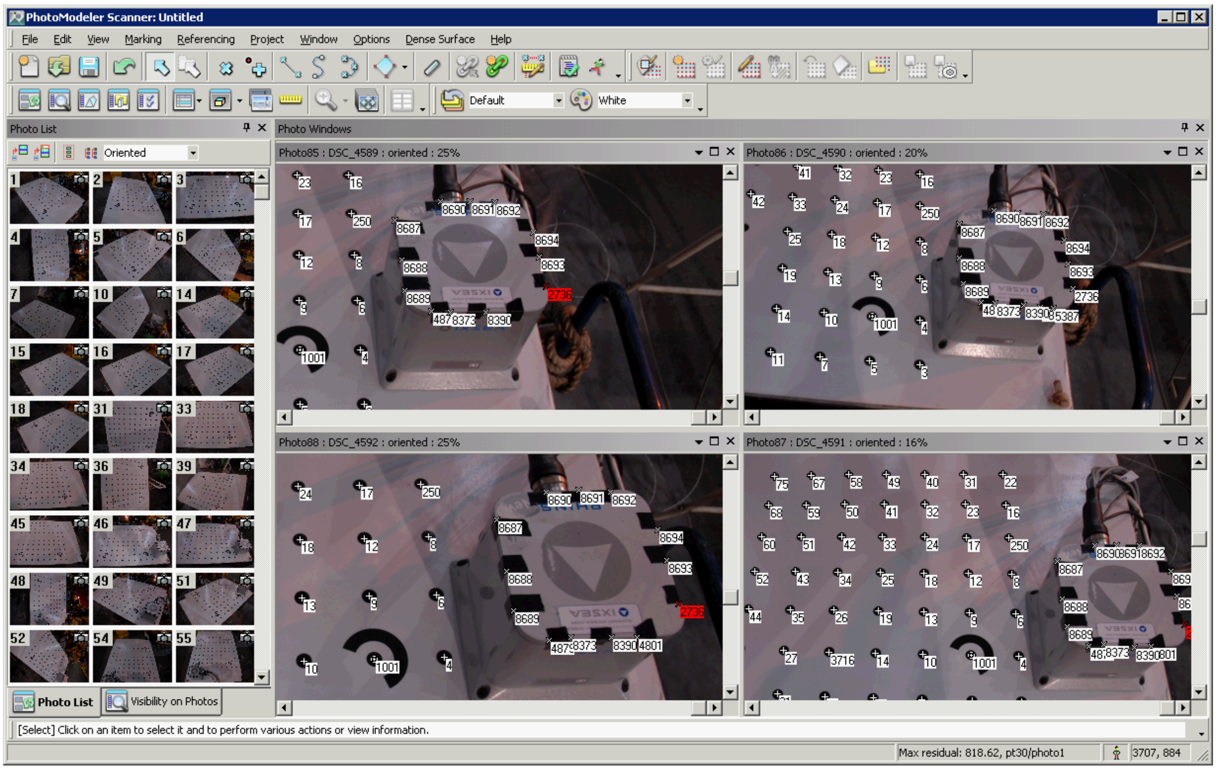


Figure 55Calibration D300 in Housing vs PHINS. Processed with Photomodeler™

2.7.1.2 Results

Biais calculation between the PHINS on the SubMarine Cabin and the Photo Box

2.7.1.2.1 Run 1

PHINS in Submarine R2K

Heading Phins in R2K: 218.14°

Pitch Phins in R2K: 0.77°

Roll Phins in R2K: 0.51°

PHINS on Photo Box

Heading: 218.28°

Pitch: 1.00°

Roll: 0.41°

2.7.1.2.2 Run2

PHINS in Submarine R2K

Heading Phins in R2K: 218.18°

Pitch Phins in R2K: 0.76°

Roll Phins in R2K: 0.49°

PHINS on Photo Box

Heading: 218.22

Pitch: 1.00°

Roll: 0.40°

PHINS in Submarine R2K Return

Heading Phins in R2K: 218.17°

Pitch Phins in R2K: 0.77°

Roll Phins in R2K: 0.51°

2.7.2 Calibration phins –dvl

All procedure are detailed in the chapter

Results:

To perform the PHINS/ DVL calibration, the REMORA 2000 has been towed by the MINIBEX 1km backward, with the DGPS installed on a mast.

The misalignment values found are:

- Heading: -44,070°
- Scale factor: 1.3%

With these parameters, 3 checks tests have been done:

- First check after the first dive 13:54
- Second, before the second dive, few minutes after the first dive 13:57
- Third check after the second dive 16:12

	PHINS data		DGPS data		
	Easting	Northing	Easting	Northing	"Error"
13:54	687 998.2	4 789 290.3	687996.8	4 789 292.0	2.2
13:57	688 016.6	4 789 267.3	688 019.7	4 789 269.1	3.6
16:12	688 014.0	4 789 281.1	688 013.2	4 789 285.2	4.2

All error is below the DGPS accuracy.

2.7.3 Multibeam calibration

2.7.3.1 Procedure

For the Multibeam calibration we use exactly the HYPACK / HYSWEEP calibration procedure.

Extract of hysweep documentation:

"While it is difficult to accurately measure the angular mounting components (roll, pitch, and yaw) of multibeam systems, errors in these measurements can lead to inaccurate surveys. The patch test is a data collection and processing procedure to calibrate these angles, along with positioning system latency.

In the PATCH TEST, the roll test is, by far, the most important because it is misalignment in the roll direction that leads to the greatest survey errors. The roll test always works and gives repeatable results.

The other tests that depend on accurate positioning (latency, pitch and yaw) do not always work. Sometimes they do, but don't be surprised if you run one of these tests twice and get somewhat different results. (Use the average in this case.) We think that drift in GPS positions is responsible.

Extract from HYSWEEP Procedure

"Patch Test Procedure

- ***Collect survey data in the prescribed pattern**.*
- ***Process the data in the MULTIBEAM EDITOR** through all three phases of the editing process. At this point, the Patch Test option will be enabled in the MULITIBEAM EDITOR Tools menu*
- ***Run the Patch Test** which will calculate offset adjustment values for latency, pitch, yaw and roll.*

***Note**: The recommended order of Patch Test Processing has been (1) Roll, (2) Latency, (3) Pitch then (4) Yaw. The Patch Test will use each progressive adjustment value to calculate subsequent adjustments. It is therefore wise to run the calculations in order from the one unaffected by the others to the one affected by all of them. Due to improvements in our methods, the influence of order has become insignificant except for the yaw calculation. It is still wise to perform this calculation last.*

- ***Enter the adjustment values in the Offsets Dialogs in the HARDWARE program**.*
- ***Correct the offsets in data collected** with incorrect offsets in post-processing. Enter the correct offsets in the Offsets Tab of the Read Parameters dialog of the SINGLE BEAM or MULITBEAM EDITOR. This process corrects only the edited data. The Raw data will remain unchanged..*

Patch Test Data Collection

Lines are run over specific bottom terrain in a specific way for each offset. patch test only works on overlapping data so take care to stay on line. And always collect two sets of data to double-check the results.

Verify the multibeam power and gain settings before data collection to minimize spikes.

Single Head Data Collection Pattern

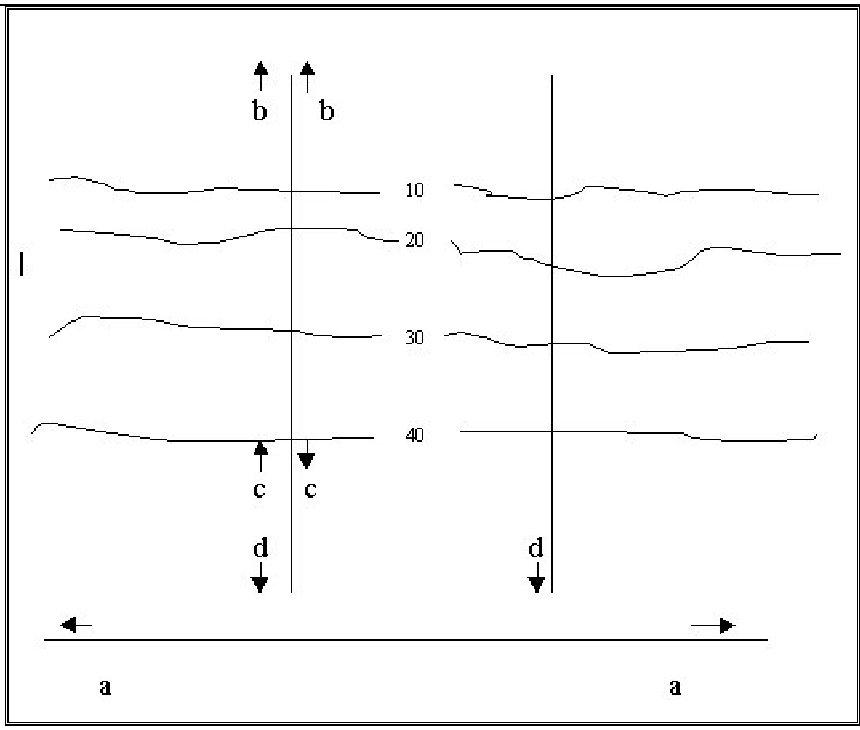
Map View of Patch Test Survey Lines with Bottom Contours. *(a) Tests Roll Angle* *(b) Tests Positioning System Latency* *(c) Tests Pitch Angle* *(d) Tests Yaw Angle*	

Figure 56. Map View of Patch Test Survey Lines with Bottom Contours.

- ***To test the roll angle**, locate an area where the bottom is smooth and flat. Create a 200- to 300-foot planned line over this area, and then run the line in both directions at normal survey speed. Over these bottom conditions, latency, pitch and yaw angles do not matter.*
- ***To test latency**, create a 200- to 300-foot planned line perpendicular to a bank. Then run the line twice in the same direction, once at maximum survey speed and again as slowly as possible. It doesn't matter whether the line is run up-slope or down-slope. Choose an area where the current is slow, to minimize crabbing and make it easier to stay on line. Errors in pitch and yaw angles cancel out.*
- ***To test pitch**, run reciprocal survey lines across the bank at normal survey speed.*
- ***To test yaw**, create a second planned line parallel to the latency and pitch line and offset by channel depth. Run each of the parallel lines in the same direction at normal survey speed."*

For our case, all this procedure will be done with the submarine REMORA 2000, we need to find a adequate place to perform this calibration.

2.7.3.2 Calibration results

The Multibeam calibration has been done the Monday 6th October.

The Multibeam calibration is necessary to realize an overlapping of several set. The calibration permit to cancel the mounting bias between the Motion Sensor (which is the INS) and the Profiler Head.

At this stage we met a problem; in fact during the calibration we use the pressure sensor of the DVL. It appears this sensor is not enough accurate, then the data overlapping became impossible, so the calibration calculation has been impossible too.

Indeed, we don't really need these values. Because the Multibeam data logging procedure we established for the Multibeam bathymetry doesn't need overlapping data.

The only problem we can meet is less accuracy, this lack of accuracy can't cause a inexistent slope in Bathymetric data.

2.8 Multibeam representation data

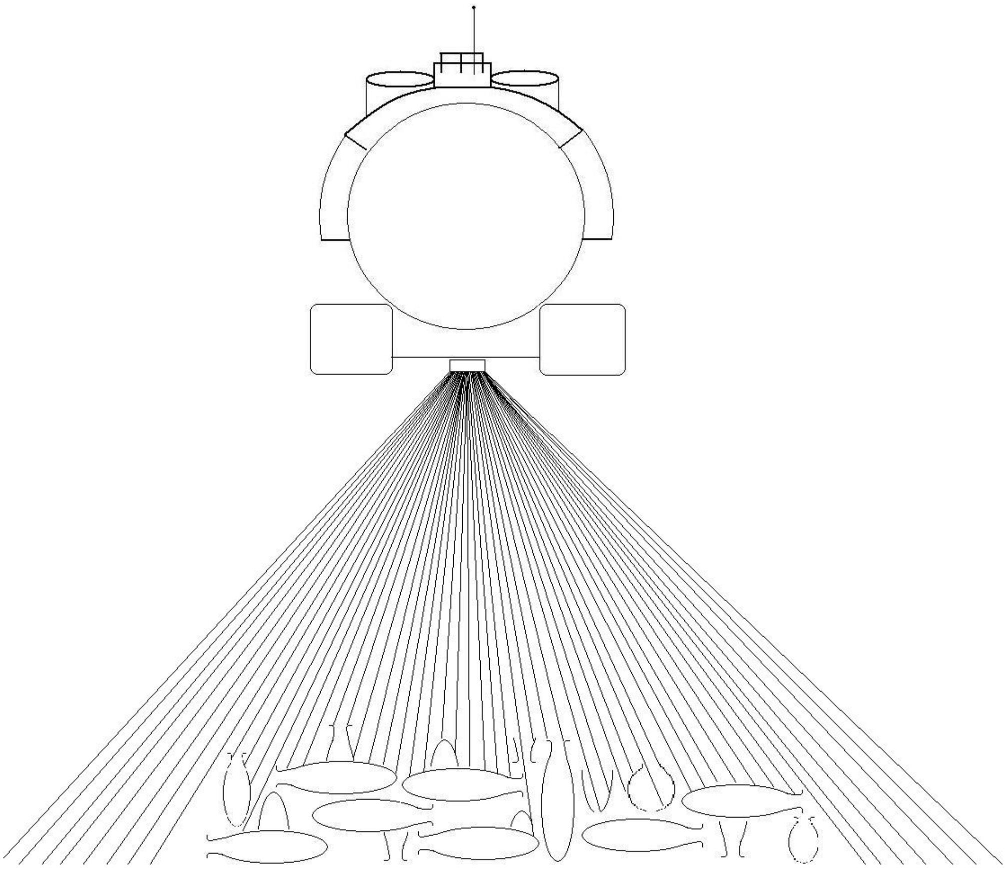
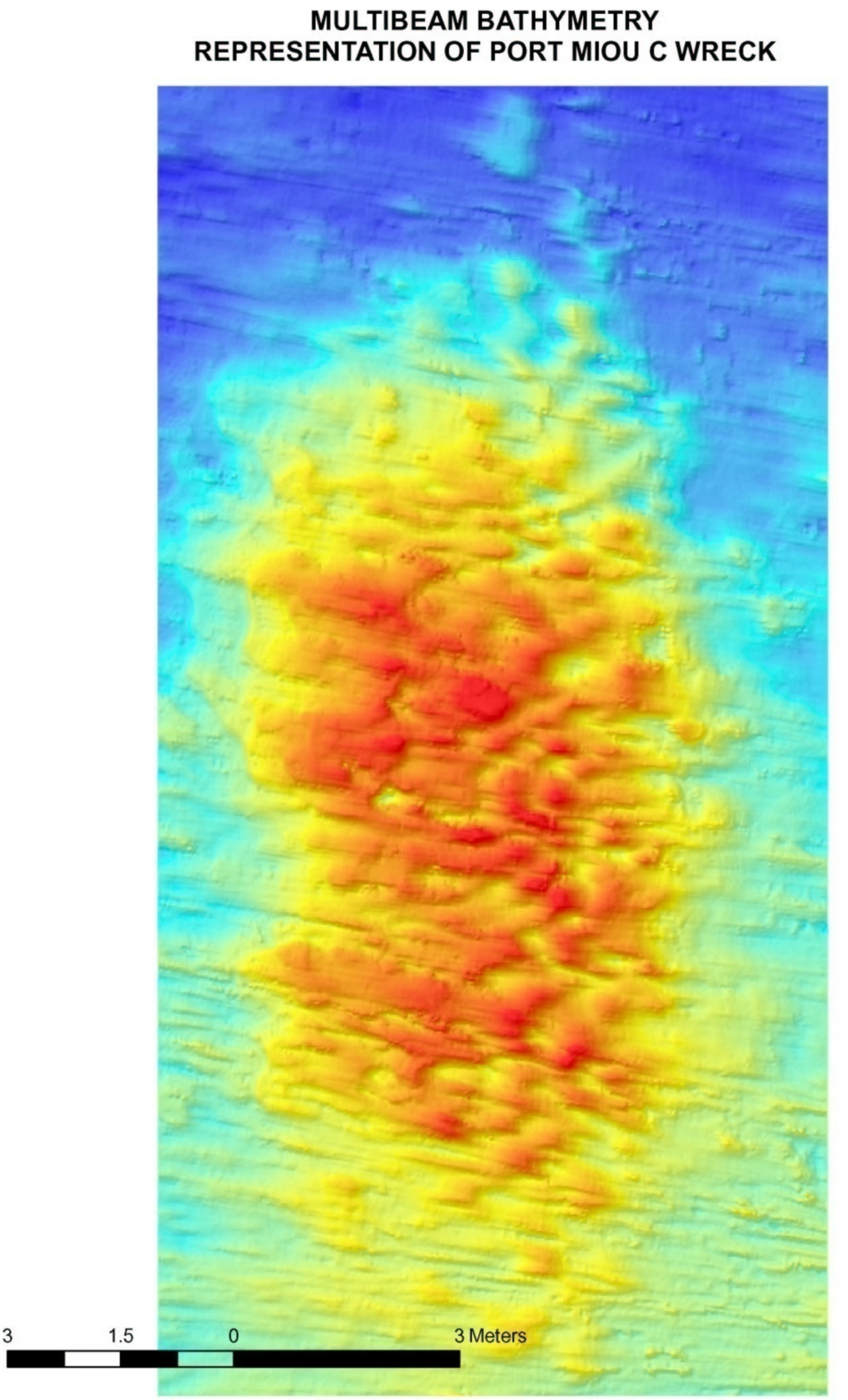


Figure 57. Representation of the sounding wreck with REMORA 2000.


MULTIBEAM BATHYMETRY
REPRESENTATION OF PORT MIOU C WRECK
3
1.5
0
3 Meters

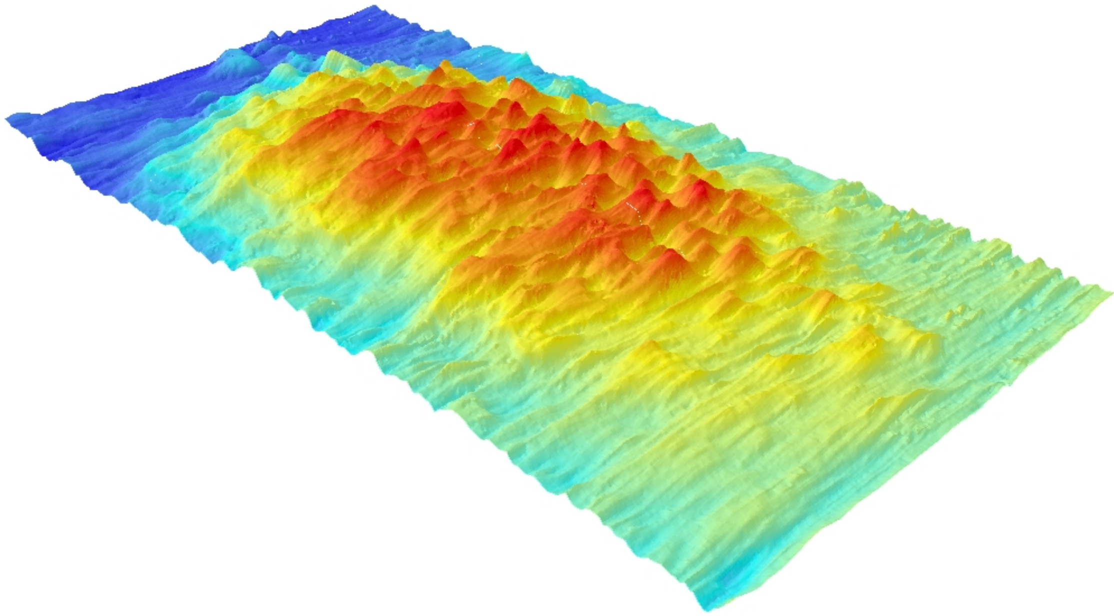


Figure 58.2D & 3D View of multibeam bathymetry

2.9 Conclusion

For the Marseille Mission, COMEX was in charge of the acquisition data Multibeam and photogrammetric data with ISME and CNRS.

All Multibeam integration has been done during trials and workshop.

And the Photogrammetric integration has been done in collaboration with ISME, COMEX and CNRS.

3 Capturing Navigation Data

In all the times the REMORA 2000 dives for take photos, the ISME logging software (NikonControlSw) worked well and recorded data of all internal sensors. The software is generic and acts in the RS232 lines of the submarine. It can be configured with a lot of sensors and the users can choose which signals are to be recorded or not depending on the PC resources available. The developed software will be available for future use out of the VENUS Project. The NikonControlSw tool records data on ASCHII file and take care of command the Nikon in autorun or in manual photo shot way. This tool, that coming from gained experience of the past missions, worked well in all day and was useful in test and calibration of the onboard sensors during the navigation.

4 Photogrammetry survey

The full photogrammetric data were recorded on October 11th in one diving session of the Remora 2000. All the navigation data where stored in the EXIF field of each photographs.

492 photographs were correctly taken with the appropriate navigation data.

Some of the following illustrations are also present in the Deliverable 2.4: the new version of this deliverable shows the first results and the uses of the Rapid Mosaciking software during the mission in Marseille.

Rapid Mosaicing producing automatically orthophoto georeferenced from photographs taken by Remora 2000 using the navigation data.

The software allows directly extracting the navigation data embedded in the photographs, rectifying each of them and finally produce a mosaic in Geotiff. (Georeferenced TIFF).

A simple GIS (Geographic Information System) allow the user to display the seabed mosaic and read/store absolute coordinate.

We decided to use the on board navigation data without any 3D points or homologous 2D points on photographs. The proposed approach produces a geotiff file of the site, using all the photographs and without any computed points.

The main idea is to use the approximate orientation of the photographs 6 parameters,

Translation and three angles, (X, Y, Z, Omega, Phi, and Kappa) and the altitude given by the Remora navigation data. First the photographs are projected onto a plane representing the seabed, second a treatment is done to compute polygonal intersection of the projected photographs, third photographs are merged and the complete and absolute perimeter is used to compute the Geotiff parameters.

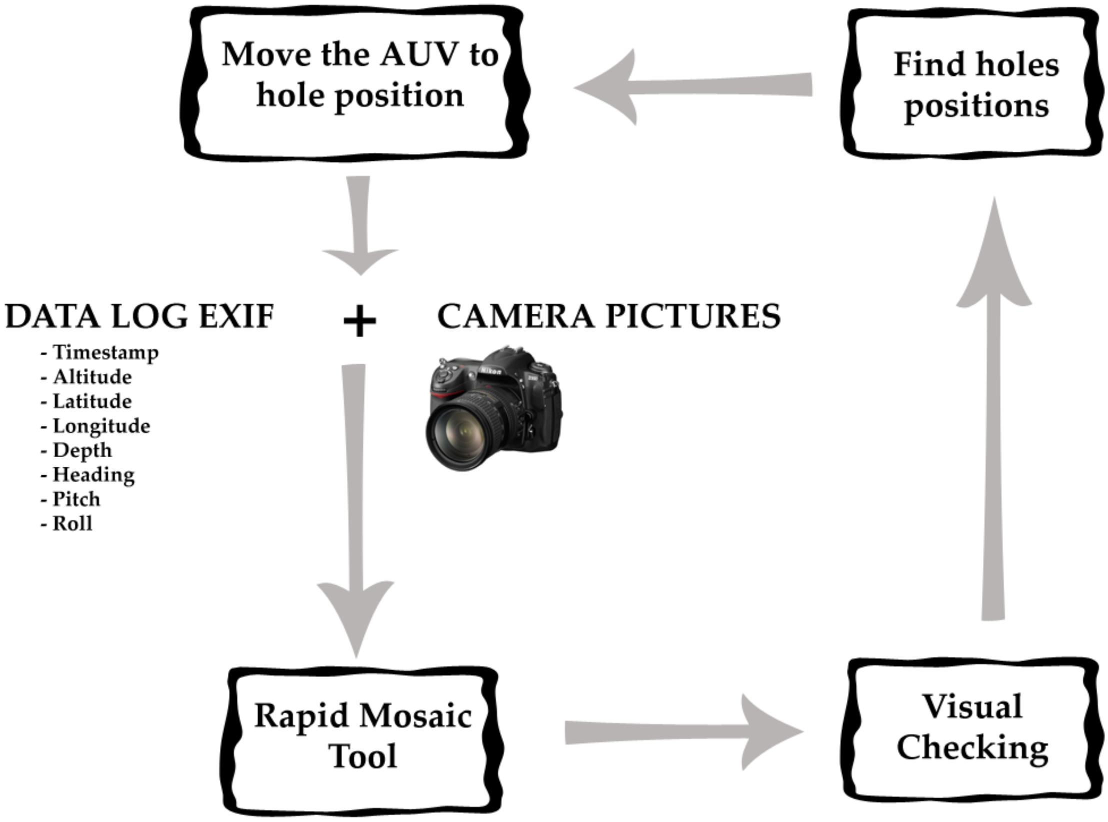


Figure 59. Rapid Mosaic software: synoptic.

4.1 First results with navigation data

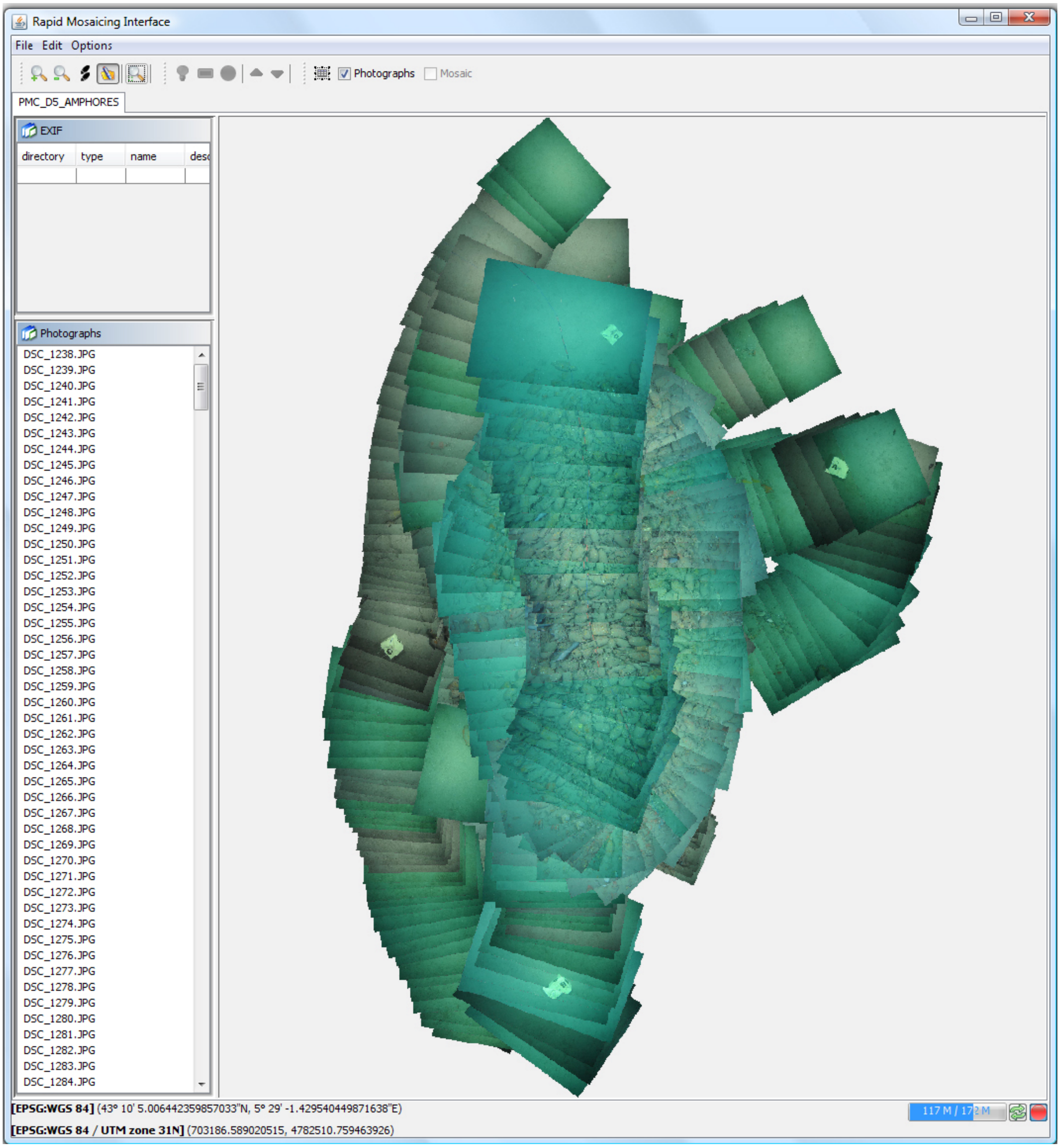


Figure 60. View of all the photographs georeferenced by navigation data, one hour after the diving.

All the photographs taken this day were correct, focus and well illuminated. The submarine makes two surveys one at 2 meters from the seabed and the second at 3 meters.

All the photographs are exploitable.

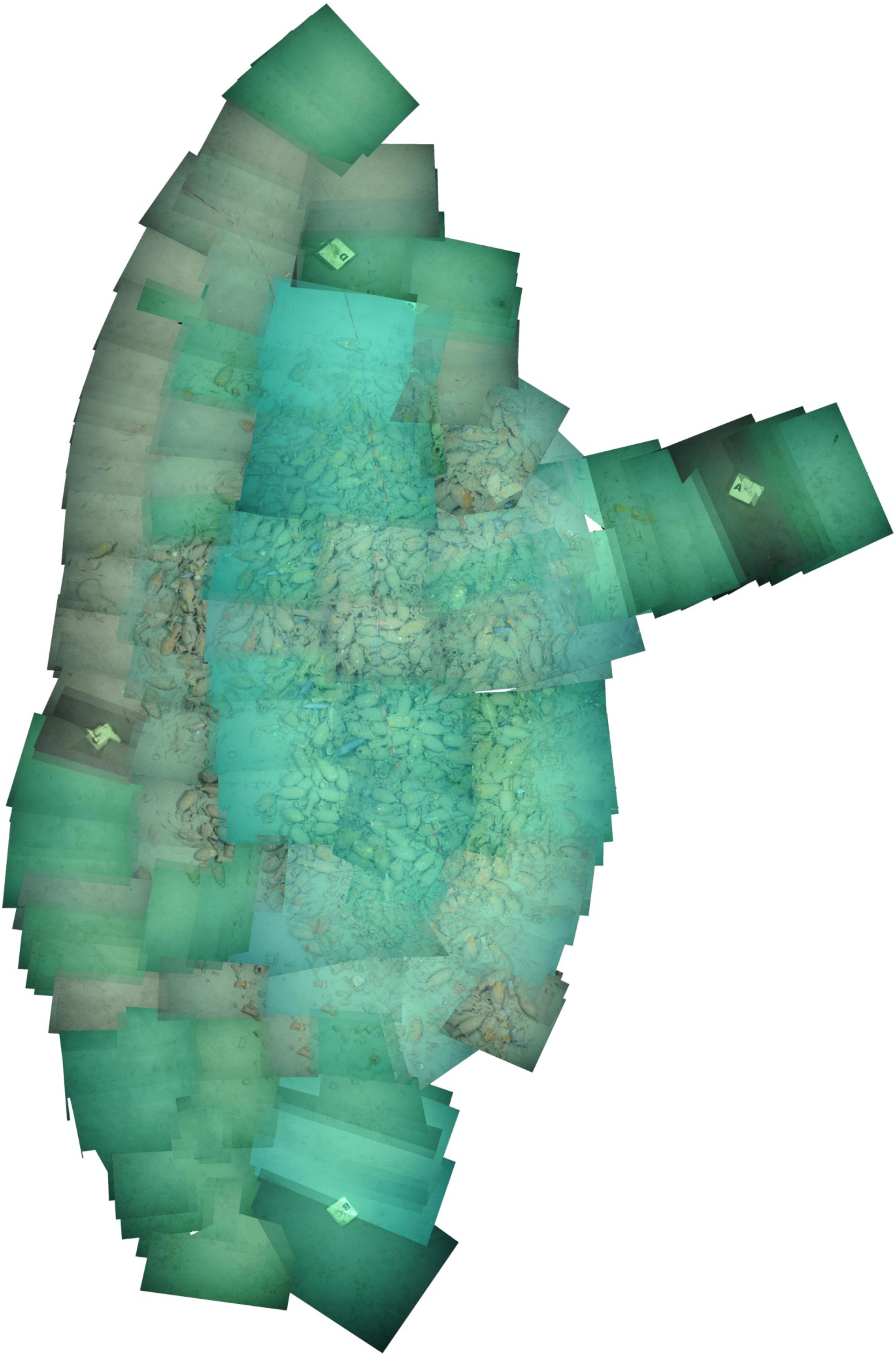


Figure 61. Geotiff generated with a subset of the photograph.

4.2 "On the fly" control

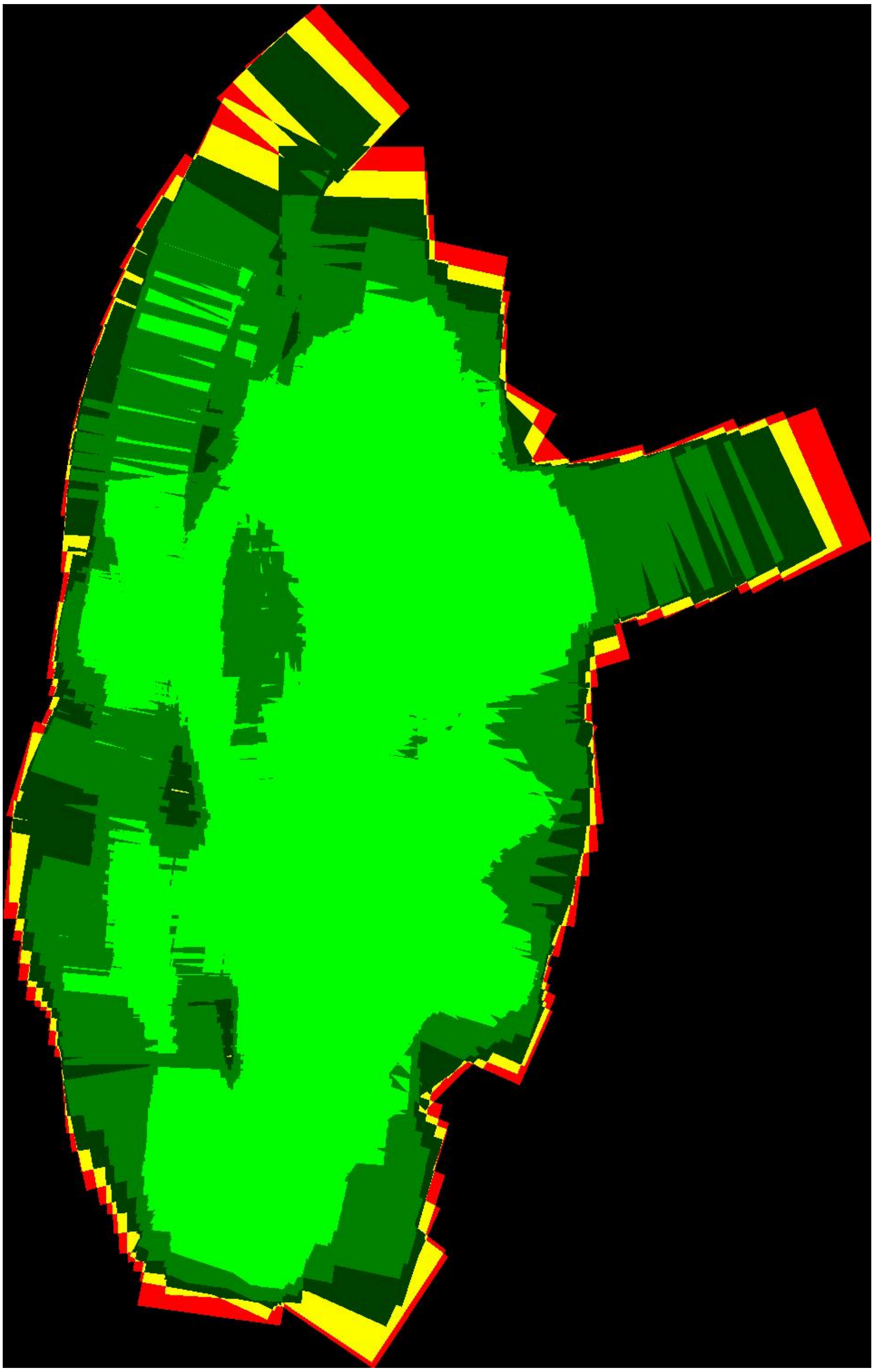


Figure 62. Geotiff Connection Map: 1 pixel = 2cm.

- No coverage
- Covered by 1 photograph
- Covered by 2 photographs
- Covered by 3 to 4 photographs
- Covered by 5 to 9 photographs
- Covered by at least 10 photographs

Rapid Mosaicking software allows the user to check the correct overlap of the photographs and to decide if we need another dive and where or to decide the end of the survey.

RapidMosaicking software produce also VRML file to study the submarine trajectory.

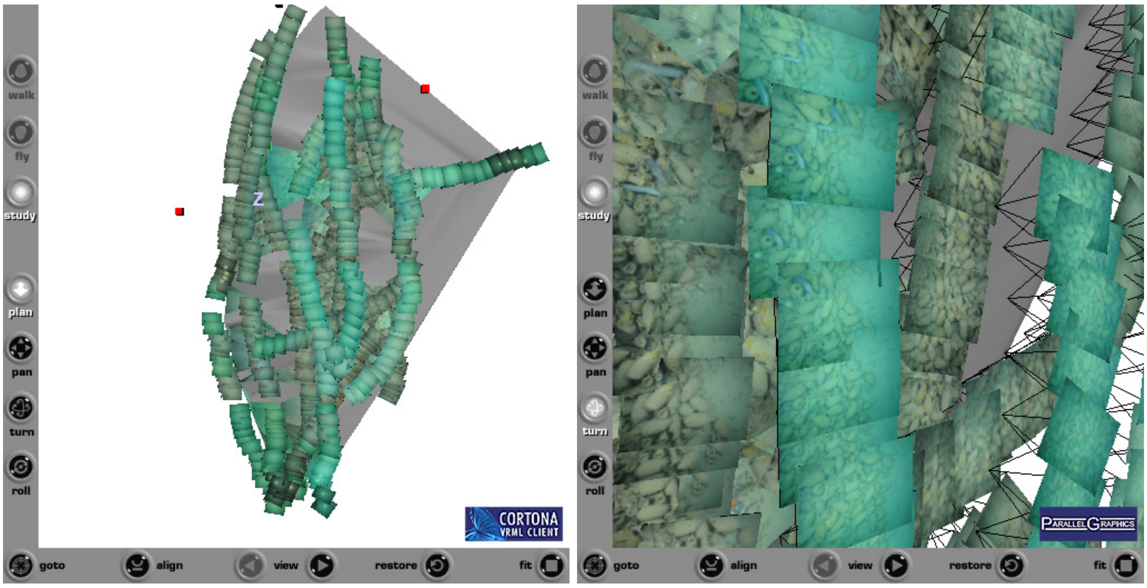


Figure 63. 3D VRML visualization using the full accuracy EXIF field.

In the present case the photographs taken on October 11th in the morning are correct and we can decide to stop the photographic survey.

4.3 Manual photograph orientation

One month after the mission the manual orientation is done. 285 photographs have been oriented with Photomodeler ™ and with a good accuracy (RMS on image residual is less than 5 pixels).

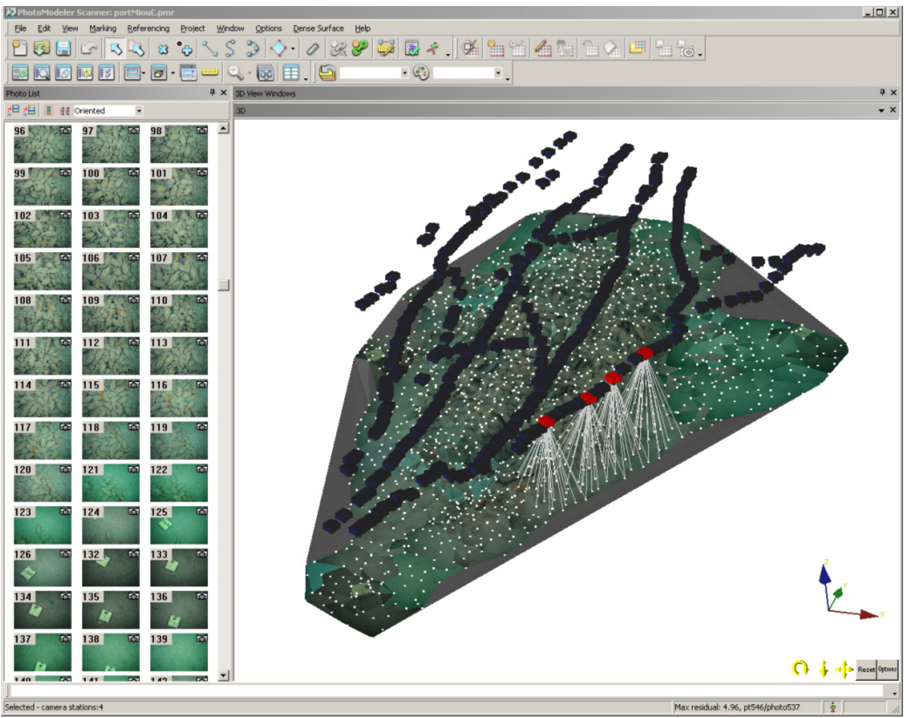


Figure 64. Oriented photographs with Photomodeler.

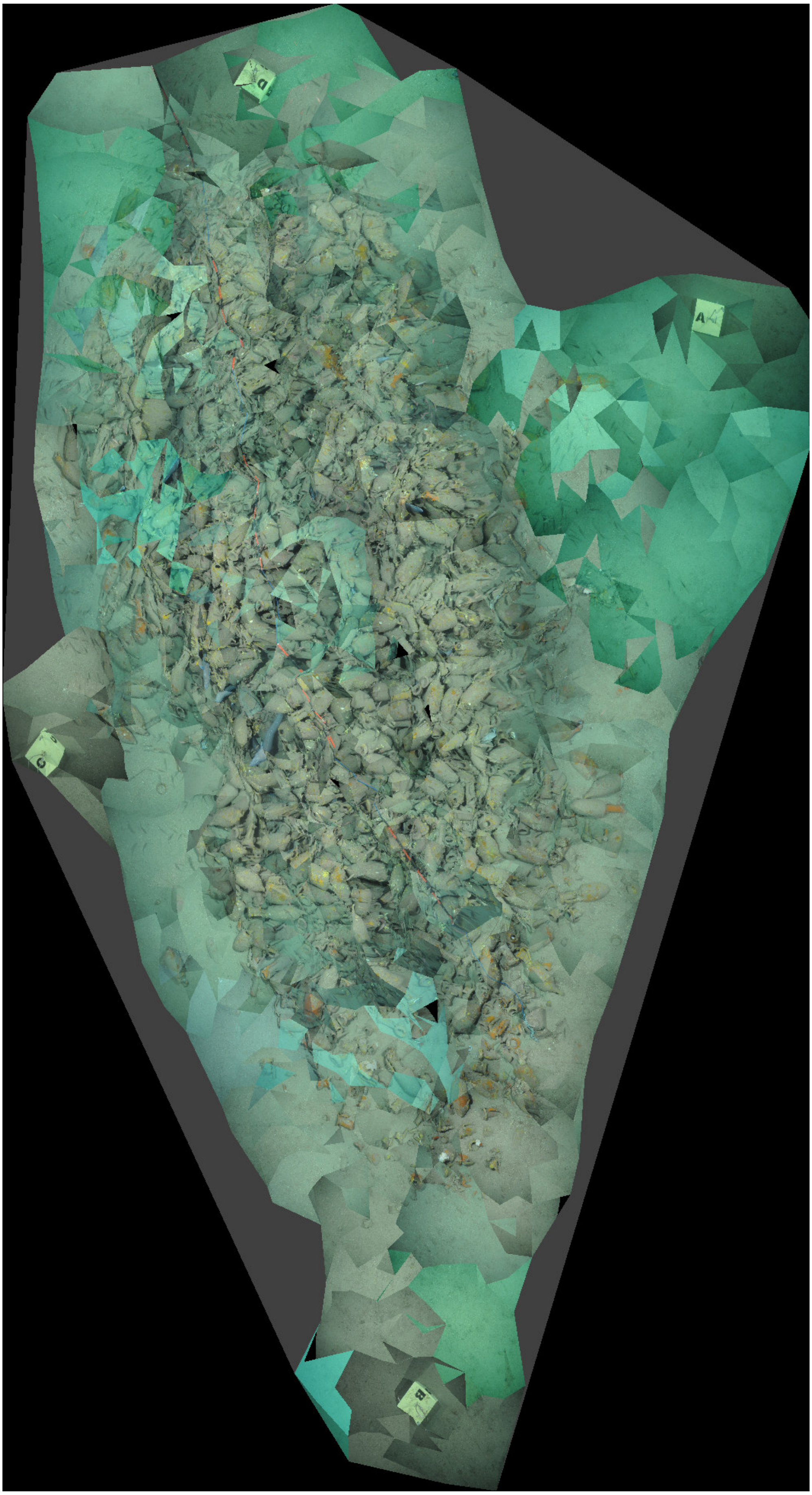


Figure 65. OrthoPhoto generated with manual orientation data.

This photo orientation will be used in the next month by confrontation with navigation data.

By the way an orthophoto was generated using the orientation data (point on seabed and oriented photographs).

5 First archaeological considerations

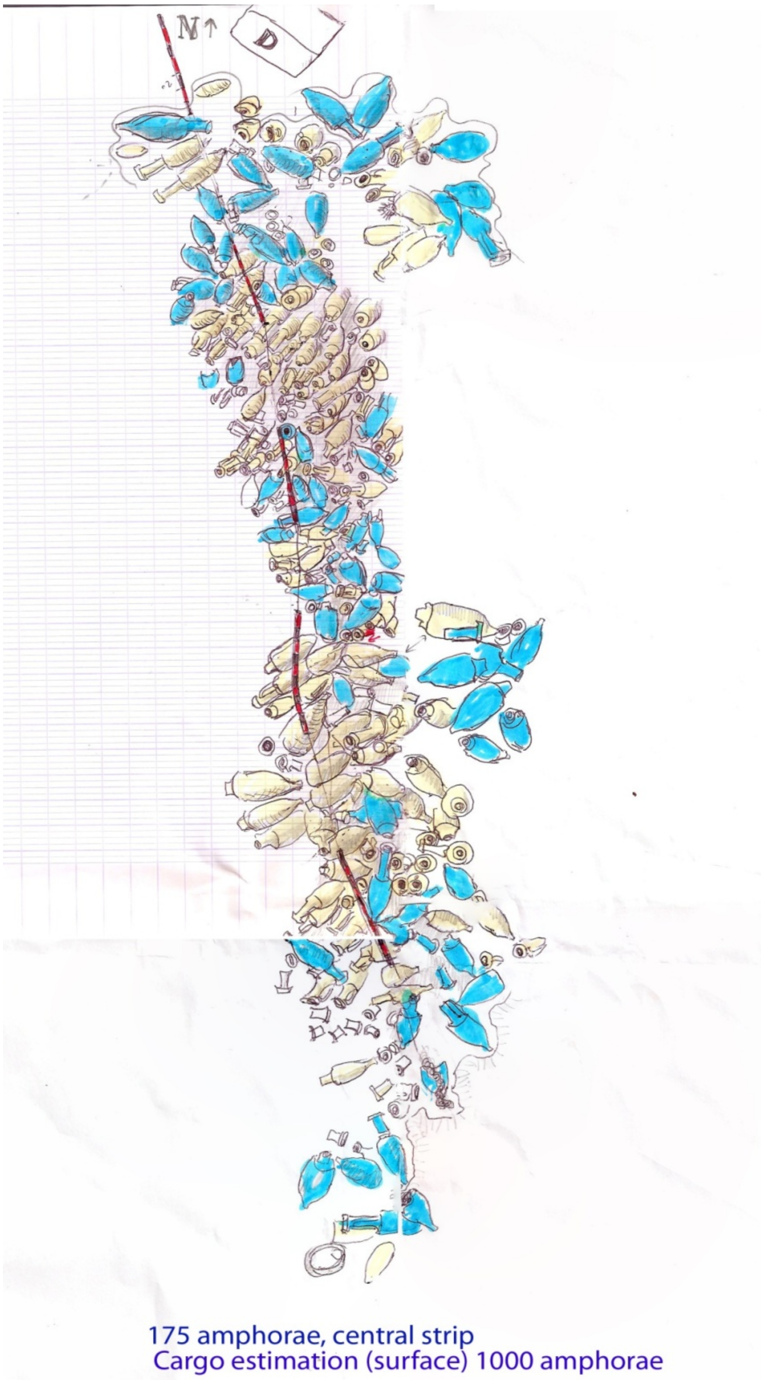


Figure 66. manual sketch of the site, made by Luc Long, using the photographs and then the rapid mosaic obtained on October 11th.

The link between navigation data and photographs allows archaeologist to have a good visualization of the entire site during the mission and also some archaeological considerations. (on the sketch above, in white the amphorae still on their right place, in blue the one moved probably by trawler.).

Before the operative mission at sea a lot of preparation was made, by COMEX, ISME and CNRS, in lab, in ground and also on site.

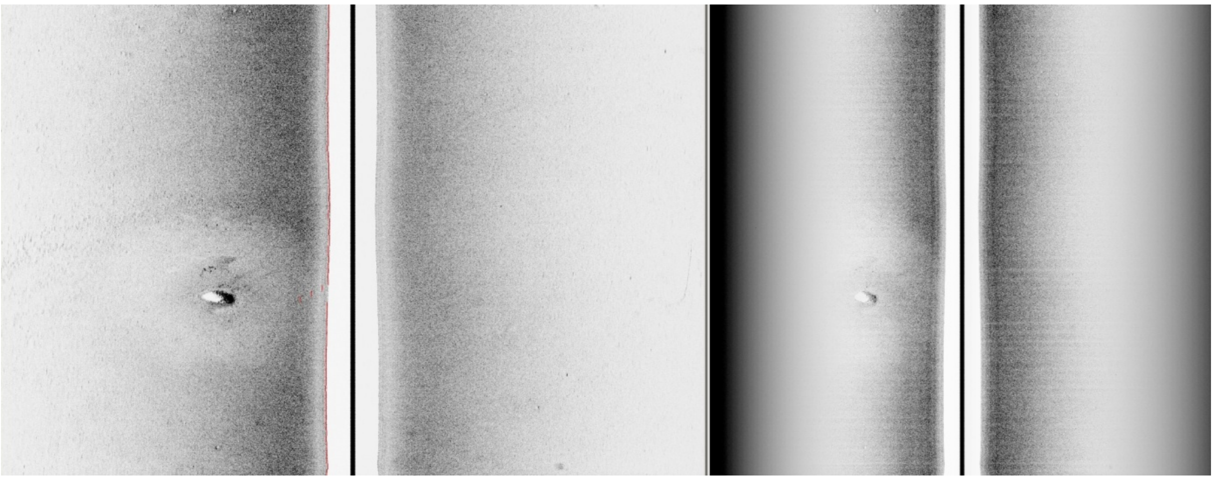


Figure 67. Port Miou C wreck by side scan sonar. March 2007.

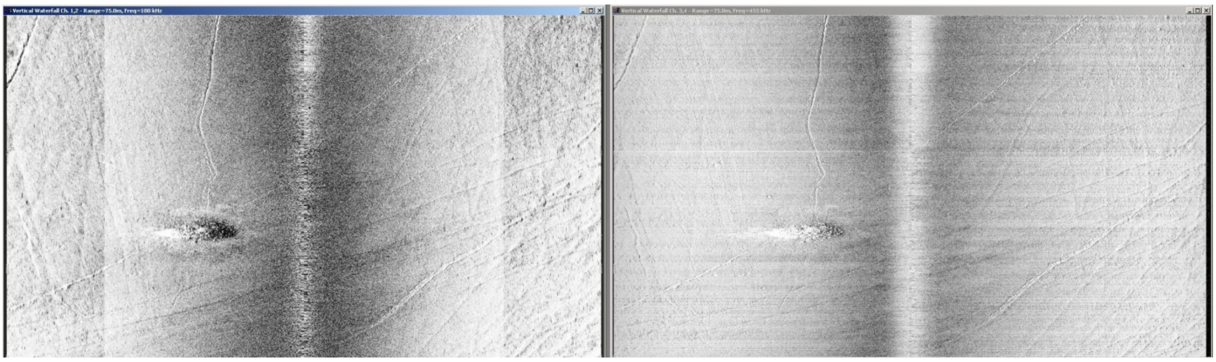


Figure 68. Port Miou C Side scan sonar, September 2008.

We can see on these two images (side scan sonar image made by COMEX in 2007 and 2008) the emergency to record these wrecks, at least the surface layer. On the second image, made one month before the mission a clear trace of trawler, pulled by a ship pass over the wreck.

The fine observation of the broken part of the amphora, possible with the quality of the photographs, show that there were more than one trawler passage, and some of them probably older than 10 years ago.

6 Mission in Marseille: Daily report

6.1 Sunday 5th October 2008

6.1.1 On board personnal

The following persons are aboard for the day:

- COMEX: Malcolm Puggioni, Jerôme Costa, Emmanuelle Seguin, Florent Rochais, Fred Gauch, Fred Alcala, Yvan Tchernomordik, Gilbert Pachoud, Jonathan Morvan.
- CNRS Pierre Drap, Julien Seinturier

- ISME: David Scaradozzi.

6.1.2 Sketch

First dive for VENUS project in Remora 2000 with all interfaced equipments:

The dive has been performed on TILES WRECK close to the Pointe Rouge Harbour

Adjustment of REMORA 2000 buoyancy

Adjustment all equipment configurations

Calibration PHINS DVL:

Go and return following the PHINS DVL calibration procedure have been done. Values are incorporated in PHINS configurations.

Figure 69.Calibration PHINS DVL.

Calibration PHINS DVL: REMORA towed in surface by the MINIBEX to provide the instruments calibration (The DGPS mast has been deployed to get the calibration easy)

6.1.3 Chronology

11h00 am

The Minibex casts off from Pointe Rouge.

Direction the ‘Tile wreck’, close to Marseille to make tests with Remora.

Remora weight calibration.

11h30 am

ROV on site.

11h45 am

TUS at sea

12h04 pm

Remora gate closed, E. Seguin and Y. Tchernomordik onboard

12h10 pm

Remora dives to the site

12h16 pm

Remora reaches on the seabed.

12h30 pm

Remora goes up (40m depth) for a camera to monitor connectivity test. It seems to be a problem on the connection.

12h36 pm

Remora is on surface and move for a PHINS calibration.

12h44 pm

Remora is towed.

12h50 pm

DVL provides bad values. The cause can be that the DVL is hitting the hull.

13h00 pm

Remora is freed.

13h08 pm

Remora dives to the site.

13h09 pm

First TUS (Telephone Ultra Son) contact (10m depth)

13h14 pm

Remora on the seabed (48m depth)

13h19 pm

DVL is clearly logged in the PHINS (set up on protocol PD4 instead of PD6)

13h28 pm

Remora left the seabed.

13h31 pm

Remora drop bubbles at 30m depth.

13h33 pm

Remora is on surface.

13h38 pm

Remora is towed by the minibex.

13h40 pm

Start Of Line (SOL)

A: 43°13’39.31’’N 5°18’19.18’’E

B: 43°14’02.43’’N 5°19’02.81’’E

Heading 234°, length 1200m

13h55 pm

DVL do not provide good values anymore. Maneuver is engaged to take the Remora from the sea and restart the calibration on a less depth seabed.

14h10 pm

Remora is on the bridge.

14h15 pm

Remora door opened. Minibex makes route to Pointe Rouge

15h38 pm

Lomac and TUS (Telephone Ultra Son) deployed. A calibration of the DVL/PHINS is started.

15h39 pm

Remora’s door closed.

15h49 pm

Remora is put at sea.

15h52 pm

Start Of Line (SOL)

15h59 pm

Remora is towed by Minibex.

16h08 pm

End Of Line (EOL). New lines are planned

16h27 pm

SOL

16h50 pm

EOL

17h10 pm

Noise test on the multibeam are goods (no interferences from Remora). Maneuver to take Remora onboard.

17h16 pm

Remora is on the bridge.

17h38 pm

Minibex at Pointe Rouge.

6.2 Monday, October 6th

6.2.1 Sketch

Second dive on the TILES WRECK to test Multibeam acquisition:

This day is dedicated to the calibration of the Remora 2000 submarine navigation systems. The calibration focuses on the DVL / PHINS system and multibeam calibration. According to the time spent for the navigation system calibration, it is envisaged to proceed to a calibration of the photogrammetric systems. This calibration relies on the determination of the distance to ground for the photographs shots and the settings of the flashes. A compromise has to be found between photographs shots frequency and flashes reload time.

A Multibeam acquisition has been done on TILES WRECK and the acquisition of Multibeam Calibration Data.

Figure 70. Tiles wreck for Multibeam Calibration.

During the data processing, it appears that the Pressure sensor on the DVL had been not enough accurate to realize the good data to correct the depth value between the Sub marine and the surface.

We found a corrective action to this problem, the use of PLSM for the elevation value.

6.2.2 On board personnal

The following persons are aboard for the day:

- COMEX: Malcolm Puggioni, Jerôme Costa, Emmanuelle Seguin, Florent Rochais, Fred Gauch, Fred Alcala, Yvan Tchernomordic, Gilbert Pachoud, Jonathan Morvan.
- CNRS: Pierre Drap, Massimiliano Casenove, Julien Seinturier
- ISME: David Scaradozzi.
- IST: Luis Sebastiao
- MCC: Luc Long
- MIBAC-SBAT: Pamela Gambogi

6.2.3 Chronology

8h30 am

Teams are on the minibex. The persons onboard are:

- Comex: Fred Alcala, Fred Gauch, Gilbert Pachoud, Emmanuelle Seguin, Malcolm Puggioni, Jerôme Costa, Florent Rochais, Yvan Tchernomordic, Jonathan Morvan.
- CNRS: Pierre Drap, Maximiliano Casenove and Julien Seinturier

- ISME: David Scaradozzi
- Guest : Alban Bouchard.

9h15 am

Last verifications on systems and procedures before going at sea. Working on the connection between sonar and control system. Two problems appears:

- The Multibeam computers used to process multibeam data are not working together. After inspection, the processing computer is not able to listen to navigation data. This problem is solved by replacing the processing computer. Time has been spent to reinstall needed software on the new processing computer.
- The Minibex navigation computer cannot be started. Technical intervention (change of a defunct alimentation) has enabled to restart the navigation computer.
- Changement de configuration du mat GPS sur le remora .

11h30 am

Validation of the Nikon D300 camera and of the Processing + Navigation computer to be used in Remora 2000. The camera is put on the underwater housing and placed on the Remora 2000.

The checklists of the remora 2000 system are dones.

11h40 am

The minibex take the sea. The testing site is the TILES WRECK

12h30 pm

Launch on board

13h00 pm

Preparation of the Remora 2000 dive. This dive is dedicated to the calibration of the multibeam sensor but photography test and altitude validation of the photograph systems are planned. A set of photograph should be shot.

13h15 pm

Remora 2000 is deployed. The submarine will dive to the tiles wreck and proceed to a multibeam calibration and test. During the first step of the dive, a calibration of depth will be realized using a plumb line. After this test, the submarine will resurface and the plombline will be removed in order to continue the dive and proceed to multibeam calibration.

During this diving session, the Remora 2000 should take photographs of the site with the phogrammetry system.

13h40 pm

The Remora 2000 is resurfacing and the plumb line is removed by a minibex diver. The Remora 2000 go for a second dive as the comex team prepare a ROV dive to survey Remora 2000 multibeam calibration.

13h42 pm

Remora going to surface for plomb line removal

13h48 pm

Remora at surcace, plumb line removed

13h51 pm

Ouverture de ballast, prise de plongée

13h58 pm

Remora submarine arrives on tiles wreck

14h00 pm

Minibex move to be positioned upon the wreck and Remora starts multibeam bathymetric survey following North-South direction.

14h08 pm

ROV is deployed

14h11 pm

ROV exit from the cage, Testing ROV pump on the tiles. Ventouse is lost and recovered.

14h37 pm

ROV enter the cage

14h40 pm

ROV on the bridge

14h49 pm

Remora multibeam calibration is over. Starting photograph survey of the wreck

15h06 pm

Vertical photography testing over

15h20 pm

Security contact

15h30 pm

Security contact

15h50 pm

Remora work finished, leaving seabed and begin to go up

16h06 pm

Remora in surface

16h10pm

Remora on the bridge, opening of the door. Minibex living wreck site and move towards Pointe Rouge.

16h45

Minibex arrives in the port of Pointe Rouge

17h10 pm

Reconditioning Remora

6.3 Tuesday, October 7, 2008

6.3.1 Sketch

This day is dedicated to the preparation of the site for the mission. Some scale bars and cement block will be placed on site to serve as future control points. During this day a new depth acquisition system will be tested. The remora 2000 submarine will use PLSM system to get a suitable depths, as yesterday tests revealed that the pressure based deep sensor wasn't accurate enough for the mission needs.

The Minibex go on site to prepare the site wreck for photogrammetry: Installation of Blocks and scaled bars.

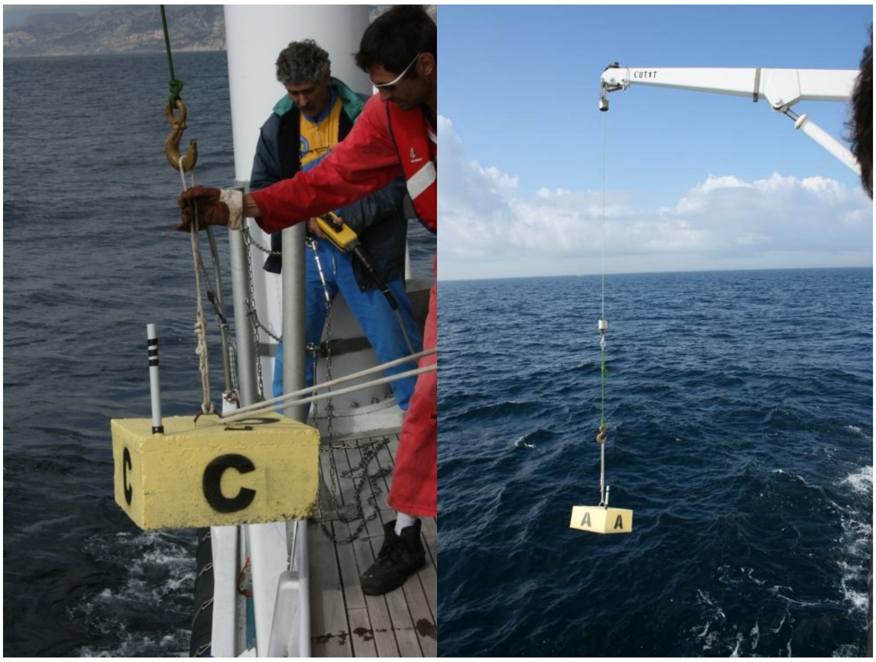


Figure 71. Laying of Dead Blocks

Figure 72. The first block on the site. Photograph from the ROV.

6.3.2 On board personnal

The following persons are aboard for the day:

- COMEX: Malcolm Puggioni, Jerôme Costa, Emmanuelle Seguin, Florent Rochais, Fred Gauch, Fred Alcala, Yvan Tchernomordic, Gilbert Pachoud, Jonathan Morvan.
- CNRS: Pierre Drap, Massimiliano Casenove, Julien Seinturier
- ISME: David Scaradozzi.
- IST: Luis Sebastiao
- MCC: Luc Long
- MIBAC-SBAT: Pamela Gambogi

6.3.3 Chronology

9h00 am

All personal are onboard. Minibex captain make a briefing about security during operation.

9h50 am

Minibex cast off from Pointe Rouge and go to Frioul (Baie de Grand Souffre).

10h20 am

Minibex in dynamic positioning at the north of Raonneau island.

10h53 am

The ROV dives to deploy the acoustic beacon for PLSM. Testing of PLSM positioning with Remora 2000 submarine are planned. The Minibex search for suitable zone (a relief is needed) to make a multibeam bathymetric survey and some photograph testings.

11h25 am

Minibex is in Dynamic Positioning near an area rocks. The PLSM base is installed at 30 meters depth to the Southern East of the site.

11h40 am

All PLSM system deployed.

11h48 am

Encounter of the ROV and the PLSM base.

11h56 am

PLSM base and plane correctly positioned on the seabed.

11h58 am

Testing communication with radio buoy (HF) onboard

12h23 pm

ROV at sea with PLSM transpondeur on the cage. Testing communication with PLSM. The buoy is then taken off.

13h40 pm

ROV in the cage and cage on the deck.

14h00 pm

Set up of the Remora 2000 submarine with PLSM pointer. Reconfiguration of the internal cabling to enable to get PLSM data.

15h49 pm

Closing remora door with Popof and Emmanuelle onboard

15h54 pm

Remora 2000 takes the sea. The submarine moves in surface for a PHINS alignement.

16h02 pm

The Remora 2000 submarine dives

16h06 pm

The Remora 2000 is on the seabed (53m depth). The submarine moves towards PLSM base. The PLSM works properly. The Remora 2000 then moves to the rocks area for bathymetry and photograph testing. Bad visibility.

17h43 pm

Remora 2000 finishes the testing on seabed.

17h45 pm

Bubbles throws from Remora 2000 at a depth of 30 meters.

17h49 pm

Remora 2000 on sea surface.

18h02 pm

Remora 2000 on the bridge.

18h06 pm

Remora 2000 door opens. Start of maneuvers to take back the PLSM system (Base, geuse, cable and buoy).

18h35 pm

ROV at sea. The ISME and CNRS team gets photographs from the camera. Rapid mosaicing and photogrammetric model generation are validated. Data matches with Remora 2000 navigation data log.

19h10 pm

ROV find the hook of the crane.

19h30 pm

Minibex is moving to Pointe Rouge

20h03 pm

Minibex arrives in Pointe Rouge. Day 1 end.

6.4 Wednesday, October 8th

6.4.1 Sketch

It's a raining and winding day.

The tests to use the PLSM system to integrate the Z value instead of DVL pressure sensor has been done close to the Frioul.

The aim is to use the Z value extracted from PLSM AQUACAD and sent to Hypack / Hysweep and the ISME logging photo software.

Figure 73. Laying of PLSM Base.

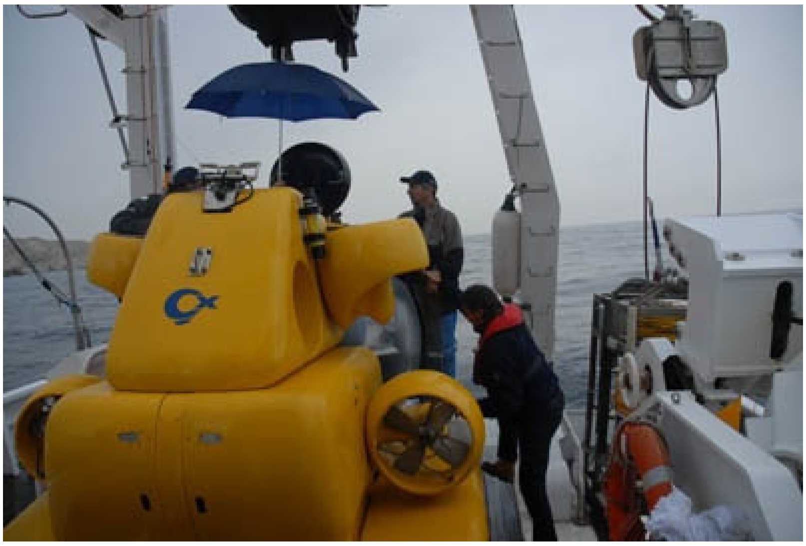


Figure 74. Underwater tests.

6.4.2 Onboard personal:

The following persons are aboard for the day:

- COMEX: Malcolm Puggioni, Jerôme Costa, Emmanuelle Seguin, Florent Rochais, Fred Gauch, Fred Alcala, Yvan Tchernomordic, Gilbert Pachoud, Jonathan Morvan.
- CNRS: Pierre Drap, Massimiliano Casenove, Julien Seinturier
- ISME: David Scaradozzi.
- IST: Luis Sebastiao
- MCC: Luc Long
- MIBAC-SBAT: Pamela Gambogi

6.4.3 Chronology

11h15 am

ROV on the seabed, visual contact with the wreck. Amphorae seems to be in good condition. Lots of fish living on the site, that could be annoying for photogrammetric survey. The ROV dive aims to determinate the contour of the wreck.

1h33 am

The first cement block (marked 'A') starts to descent.

11h50 am

The first cement block is placed on the east of the site. The minibex move to take place at the vertical of the south of wreck.

11h50

The second cement block (marked 'B') start to descent

12h13 pm

The second cement bloc is placed on the south of the site.

12h20 pm

The third cement block (marked 'C') start to descent.

12h33 pm

The third cement block is positioned on the west of the wreck

12h42 pm

The fourth cement block start to descent. The lunch is taken.

13h02 pm

The fourth is positioned on the North of the site.

13h14 pm

ROV return to its cage.

14h06 pm

Preparation for the positioning of scale bars on the wreck.

14h12 pm

The scale bars are put on water. The minibex rear is placed on the north of the wreck.

14h45 pm

Scale bars line is positioned. Difficulties occurred when the line has been taken in the cable of the ROV. A disengagement maneuver has been conducted.

15h00 pm

Preparing the PLSM for a positioning of the system base / cable / buoy

17h12 pm

ROV is in its cage

As PLSM tests failed, the minibex preparing to route to Pointe rouge for the night. New tests of PLSM system are planned for the next day.

17h22 pm

ROV on the bridge of the minibex

17h29 pm

Minibex leaving to Pointe Rouge.

19h00

Minibex amarred in Pointe Rouge.

6.5 Thursday, October 9th

6.5.1 Sketch

The Minibex went on Port Miou C site.

The PLSM has been laid on the seafloor with waterproof batteries to keep the same absolute reference during all operations.

Multibeam Bathymetry had been performed.

There is a problem of flashes batteries. The Photogrammetry aborted.

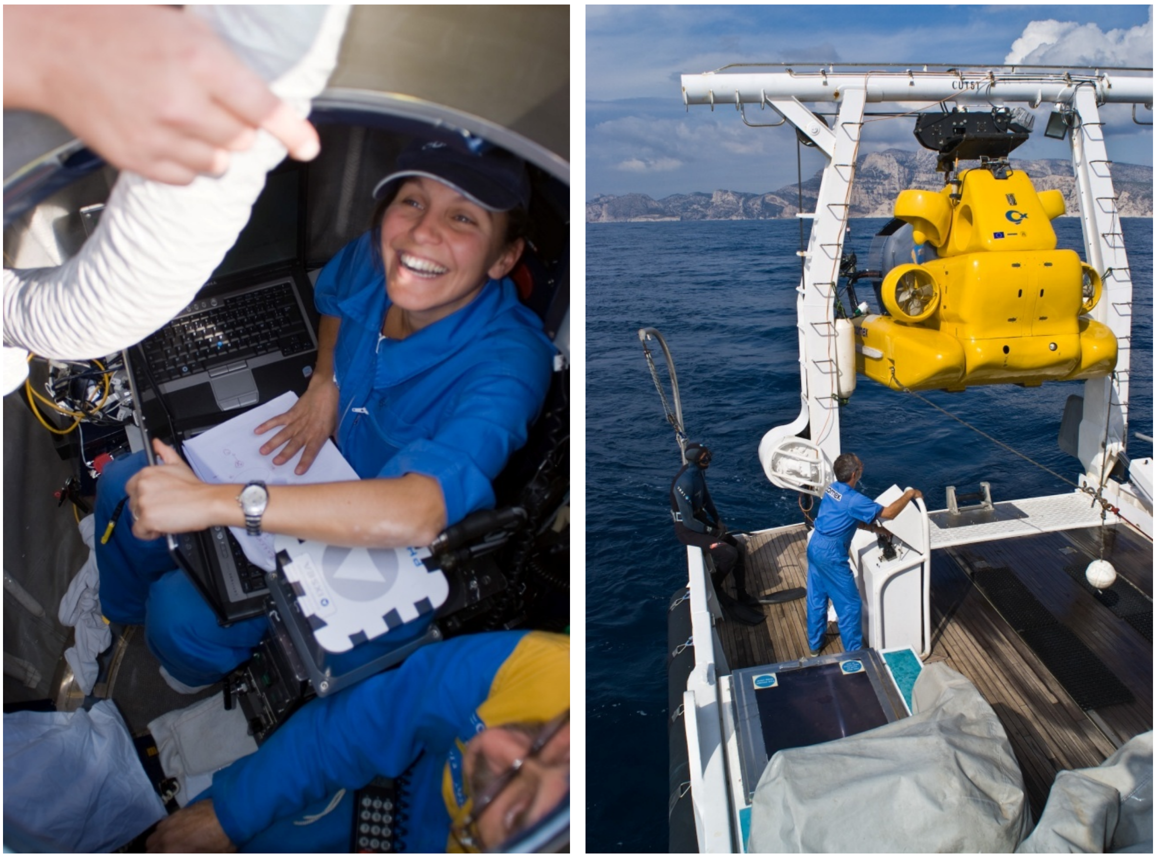


Figure 75. On the Right: checklist inside the Remora 2000 before diving. On the left: just before diving.

6.5.2 Onboard personal

The following persons are aboard for the day:

- COMEX: Malcolm Puggioni, Jerôme Costa, Emmanuelle Seguin, Florent Rochais, Fred Gauch, Fred Alcala, Yvan Tchernomordik, Gilbert Pachoud, Jonathan Morvan.
- CNRS: Pierre Drap, Massimiliano Casenove, Julien Seinturier
- ISME: David Scaradozzi.
- IST: Luis Sebastiao
- MCC: Luc Long
- MIBAC-SBAT: Pamela Gambogi

6.5.3 Chronology

8h00 am

Minibex cast off from Pointe Rouge and move towards the Port Miou C site.

10h00 am

Minibex arrives on site. Stand in Dynamic Positioning. ROV take the sea.

11h20 am

ROV in the cage

11h30 am

Cage on the bridge

11h59 am

TUS put on the water

13h08 pm

Remora 2000 submarine Ready to dive. Door closed. Emmanuelle and Popov onboard.

13h14 pm

Remora ballast opened

13h16 pm

Submarine on the seabed (97 m)

13h27 pm

Minibex moves for 10 meters in the 270.

13h33 pm

ROV encounter the submarine.

14h00 pm

ROV cable hanged on the submarine

14h02 pm

ROV cable degaged.

14h16 pm

Bathymetry completed, Remora moves on the wreck. Photograph shooting starts. ROV observation reveals that right flashes does not work. Confirmation by Remora 2000 team.

14h46 pm

ROV in the cage

14h31 pm

Cage on the bridge. Remora 2000 begin a new bathymetric survey.

15h08 pm

Remora 2000 got the clearance for leaving the seabed.

15h12 pm

Bubbles lachées at 35 meters.

15h16 pm

Bubble visual contact from Minibex.

15h19 pm

Visual contact with Remora 2000 from Minibex.

15h23 pm

TDS put in charge

15h28 pm

Remora 2000 submarine on the bridge.

15h39 pm

16h00 pm

Minibex moves to Pointe Rouge.

17h29 pm

Minibex is in Pointe Rouge. Day 2 end.

6.6 Friday, October 10th

6.6.1 Sketch:

Technical Break of DVL at the last time.

The decision to not cancelled Remora 2000 dive to proceed to camera adjustment.

The dive is realized without precise navigation

The DVL is repaired at Night.

Figure 76. On the left: Fred Gauch is opening the DVL housing, on the right, download the photographs.

6.6.2 Onboard personnal:

The following persons are aboard for the day:

- COMEX: Malcolm Puggioni, Jerôme Costa, Emmanuelle Seguin, Florent Rochais, Fred Gauch, Fred Alcala, Yvan Tchernomordic, Gilbert Pachoud, Jonathan Morvan.
- CNRS: Pierre Drap, Massimiliano Casenove, Julien Seinturier
- ISME: David Scaradozzi, Silvia Zanoli.
- IST: Luis Sebastiao
- MCC: Luc Long
- MIBAC-SBAT: Pamela Gambogi

6.6.3 Chronology

8h06 am

Minibex casts off from Pointe Rouge and move to Port Miou C wreck site.

9h26 am

Minibex is on the site. The crew prepares the SVP (Sound Velocity Probe) sensor to perform a celerity test.

9h40 am

Celerity test is done. And PLSM functionality is checked.

9h45 am

TUS (Telephone Ultra Son) is put on water.

10h20 am

ROV checklist is done.

10h24 am

Remora 2000 submarine is ready. The door is locked.

10h28 am

Remora 2000 takes the sea.

10h29 am

The submarine dives to the wreck.

10h38 am

Remora 2000 is on the seabed, depth 98 meters. The submarine starts the survey of the site. The ROV inspects a point given by archaeologists. The investigated point reveals an buried amphora and not a plate.

11h10 am

Remora 2000 has ends the first step of its survey (bathymetry of the wreck),

11h12 am

ROV is put on water. The ROV controls the Remora 2000 which is completing the photograph shooting.

11h22 am

ROV in the cage.

11h26 am

ROV on the bridge.

12h29 pm

Remora 2000 leaves the seabed.

12h38 pm

The submarine reaches the surface.

12h50 pm

Remora 2000 is on the bridge.

12h55 pm

Remora 2000 door opened. The flashes have not worked properly. COMEX, CNRS and ISME team looking for a way to guarantee the flashes stability during the whole photograph shoot session. The Remora submarine is in standby.

15h15 pm

The Remora 2000 prepares for a new test dive dedicated to flashes setting. The submarine will do different session of photographs shooting at different altitudes and with HMI turned off then on. The Navigation systems of the submarine are not working properly. The photographs will not be used to make a mosaic of the site.

16h35 pm

The Remora 2000 is ready for the dive, door closed.

16h37 pm

The submarine takes the sea.

16h41 pm

The Remora 2000 is on the seabed at a depth of 110 meters.

16h48 pm

The ROV is put on water. The Remora 2000 is on the wreck.

16h50 pm

ROV leave the cage. Remora 2000 plan a survey in 3 step:

1. With HMI off
2. With HMI on
3. With HMI at low power.

17h12 pm

ROV in the cage.

17h15 pm

ROV on the bridge.

17h22 pm

Remora 2000 submarine leaves the seabed at a depth of 98 meters.

17h27 pm

Bubbles from remora.

17h30 pm

Remora 2000 arrives at sea surface.

17h36 pm

Remora 2000 is on the bridge.

17h39 pm

The door of the submarine is opened.

17h50 pm

The TUS and USBL are onboard.

18h20 pm

Minibex is on the Sormiou calanque for the night.

19h30 pm

Comex team attempts to repair the Remora 2000 navigation systems. A lock on the Doppler system is detected. A Cold restart of the system solves the problem.

6.7 Saturday, October 11th

6.7.1 Sktech

Camera and Navigation are adjusted.

Global measurement photogrammetry and Multibeam Run can be done, and have been done.

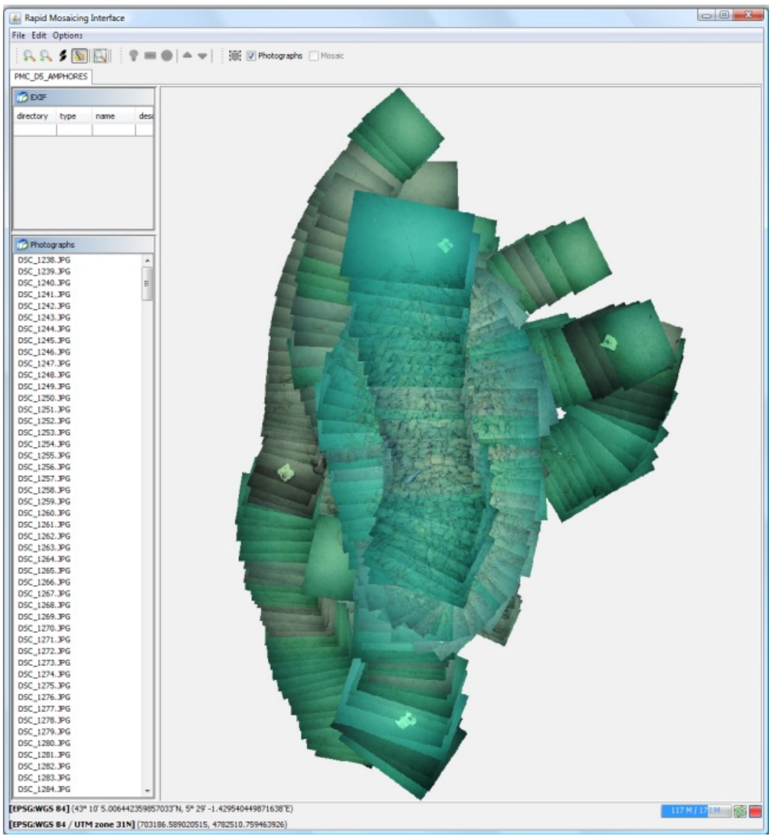


Figure 77. RapidMosaicking software used for overlaps checking.

6.7.2 Onboard personal

- COMEX: Malcolm Puggioni, Jerôme Costa, Emmanuelle Seguin, Florent Rochais, Fred Gauch, Fred Alcala, Yvan Tchernomordic, Gilbert Pachoud, Jonathan Morvan.
- CNRS: Pierre Drap, Massimiliano Casenove, Julien Seinturier
- ISME: David Scaradozzi, Silvia Zanali.
- MCC: Luc Long
- MIBAC-SBAT: Pamela Gambogi

6.7.3 Chronology

08h50 am

Minibex casts off from Sormiou and go to the Port Miou C site.

09h40 am

Minibex on the site,

10h00 am

ROV checklist is done.

10h10 am

Remora 2000 submarine is ready. The door is locked.

10h15 am

Remora 2000 takes the sea.

10h18 am

The submarine dives to the wreck.

10h38 am

Remora 2000 is on the seabed, depth 98 meters. The submarine starts a photogrammetric survey of the site. The ROV is used to control flashes behavior.

11h22 am

ROV in the cage.

11h26 am

ROV on the bridge.

12h03 pm

Remora 2000 leaves the seabed.

12h12 pm

The submarine reaches the surface.

12h30 pm

Remora 2000 is on the bridge.

12h35 pm

Remora 2000 door opened. Camera is opened and photographs began to be transferred on ISME and CNRS laptops.

12h55 pm

Photographs first control seems good. Flashes have worked properly and the photographs are clear. A first mosaic creation process is launched to estimate the coverage of the wreck and the photographs overlap.

13h30 pm

The photographic coverage of the wreck is validated. As the set of 680 photograph is exploitable for the photogrammetric survey and the bathymetry acquisition is done, the data acquisition is declared ended.

14h45 pm

Minibex make route to Pointe Rouge.

15h25 pm

Minibex arrives in Pointe Rouge. Onboard personal left the board.

7 COMEX super achile ROV checklist

7.1 Cage

1. Bâche d'equipression
2. Lumière cage
3. Jupiters correctement serrées
4. Ombilical correct
5. Chaussette ombilical
6. Manille ombilical
7. Noix de la cage

7.2 ROV

1. Projecteur ROV
2. Fouilleur ROV
3. Bras
4. Moteur
5. Chaussette ombilical
6. Manille ombilical

7.3 Visuel ROV

1. Pas de bout dans l'hélice
2. Pas de fuite d'huile
3. Jupiters correctement serrées
4. Dôme camera propre
5. Transpondeur en place

7.4 Pilotage

1. Pas d'alarme vigilohm
2. Videos correctes
3. Sonar en function
4. Tension VDC ROV à l'arret

7.5 Checklist of the Nikon D300 camera and housing:

1. Battery is inserted.
2. Compact flash inserted and empty.
3. USB, Serial and Flash inserted.
4. Camera power on.
5. "GPS" string blinking.
6. Configuration parameter check.
7. Parameter MODACITY is set to "Single Shot".
8. Parameter MODE is set to "Aperture Priority".

9. Parameter FOCUS is set to “Manual”.
10. Camera lens is blocked with a scotch to 14mm. (*secured manual fix of the focal*)
11. Parameter QUALITY is set to “Fine”.
12. Parameter APERTURE is set to “8”.
13. Parameter ISO is set to “800”.
14. Parameter OVER EXPOSURE is set to “”
15. The lens is cleared.
16. The O-Ring is ok.
17. The case well is closed.
18. All the external connectors plugged.

Figure 78. End of mission.

Domani è un mistero …

Ma oggi è un dono, è per questo che si chiama presente.