INSTRUMENTATION VIEWPOINT

number 8

Autumn 2009

MARTECH 2009

Third International workshop on marine technology
November 19th - 20th , Vilanova i la Geltrú

Head Office
SARTI Technological Development Centre of Remote Acquisition and Data processing Systems
Technical University of Catalonia (UPC)
Rambla Exposició 24 08800 Vilanova i la Geltrú (Barcelona, Spain)

Member of: Xarxa de centres de suport a la innovació tecnològica (Innovation Network). TECNIO.

ISO 9001:2000 Acredited by: Det Norske Veritas

Publisher/Editor: Antoni Mànuel Lázaro

Production/Design: MELMAK STUDIO (Xavier Cortés, Alberto Martínez, Iris Santamaria)

Language adviser: Shahram Shariat Panahi

Collaborations: Proceedings Instrumentation Viewpoint 8 extended abstracts.

Paper Version:
ISSN 1697-2562
DL B-51.702-03

Electronic version:
ISSN 1886-4864
DL B-32814-2006

This publication has been designed using Adobe Pagemaker, serial number 1039-1413-9288-5774-8172-4630

Cover: Underwater pictures, thanks to Ramon Margalef
Picture collaborations: Eva Guasch

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The acceptance of the articles presented depends on their scientific quality and their adaptation to magazine's editorial line.

EDITOR'S NOTE

The eight issue of Instrumentation Viewpoint is in your hands. This issue is a summary of the Third Marine Technology Workshop communications. The Marine Technology Workshop, Martech 2009 is an initiative from Tecnoterra Associated Unit (Technical University of Catalonia and Scientific Research Council). The main objective of the Martech Workshop is to exchange information and points of view on the current and future research in marine instrumentation technology.

Martech 2009 will be held in Vilanova i la Geltrú, one of the most important fishing ports in Spain with an old marine tradition and 50 minutes away from Barcelona by train.

The Martech 2009 planned sessions are:

M1: Instrumentation and Metrology.
M2: Ocean Bottom Sensors and Observatories.
M3: Control Systems; Marine Robotics: ROVs, AUVs, ASVs, Gliders.
M4: Underwater Imaging and Communication.
M5: Seafloor Characterization and Seismic Imaging.
M6: Advanced Remote Sensing of the Ocean Surface.
M7: Signal Processing.
M8: Mechanical Structures Design.
M9: Marine Biology Technology.
M10: High Resolution Measurement Systems; Acquisition and Analysis Methods.
M11: Interoperability in Sensors Networks; Data Management.
M12: New trends in Marine Sensors Design.
M13: Bioacoustics and Passive Acoustic Monitoring Techniques.

The effort involved in continuing to publish a magazine is much greater than publishing the first issue, and for this reason I have to thank all the SARTI members and other collaborator groups for their innovative research and technology transfer contributions Our goal is not only to make Instrumentation Viewpoint a window for our activities but also a platform to share experiences with instrumentation colleagues. I invite you participate in the future Instrumentation Viewpoint issues, and we hope that these interchanges of information and experiences that we have initiated allows all of us to establish new collaboration links.

Best regards from your partner

PhD. Antoni Mànuel

Director of TDC SARTI (UPC)

CONFORMITY OF THE QUALITY IN THE MEASURES

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Abstract- We'll want to implant the awareness of the importance at measurement's quality that must have with systems acquisition of own design. The choice of system acquisition will be very important because this system will must fulfill our expectations.

Keywords- acquisition's system, traceability, uncertainly, accuracy

I. INTRODUCTION

In any method or acquisition's system we must think the next question: "the data that we'll want to acquire have the sufficient accuracy that we wish?". Normally this concept is very clear for the designer however we must have answer another question: "the uncertainly of my system of measure will be sufficiently small in order that from the data acquisition could extract conclusions?".

II. BASIC CONCEPTS

Uncertainly according to the definition of CEM [1] "The uncertainly is a quantitative measure of the quality measurement result, which allows that the measurement results should be compared with other results, with references, specifications or standards". The uncertainly is calculated by probability

Some the probability distribution more used are the normal distribution and the uniform distribution. At Fig. 1. We can see graphically theses probability distributions calculated with a histogram:

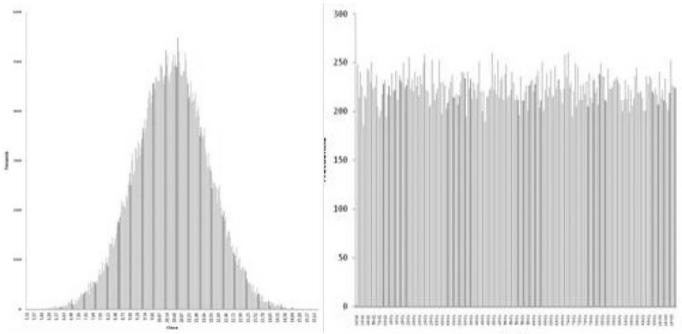

Fig. 1. Histograms representing the normal distribution and the uniform distribution respectively

The usual notation of uncertainly is shown in equation 1.

$Y = X \pm U$

Equation 1. Typical notation of the uncertainly in a result

Traceability

According to the definition of CEM [1]." A traceability chain, see Fig.2., is a unbroken chain of comparisons, had established all uncertainties. This ensures that a measurement result or value of pattern is associated with references to higher levels, up to primary standard."

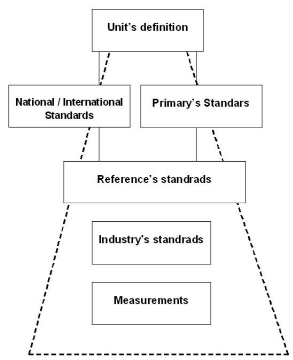

Fig.2. La cadena de trazabilidad

III. SYSTEM ANALYSIS

Before beginning the design of the system we must evaluate the uncertainly that must have the system. For example if we choose a system for acquiring for pressure variations and I´ll need evaluate variations around to 1 atm, and the resolution of the equipment used is 0,5 atm, i can think that system is good for make the work. Such an analysis is not valid, because we must calculate the uncertainly system. In fact is possible that the uncertainty's system can be over 1 atm and my acquisition system isn´t good for the work.

Equation 2, according to UNE-EN 30012 [2] we can relate the expanded uncertainly (U) of the equipment with the value of Tolerance (T) of the measurement

$$3 < \frac{T}{2 \cdot U} < 10$$

Equation 2. Relation between Tolerance (T) and expanded Uncertainly (U)

we want to do. In our case the tolerance is the minimum value that we want to see, in the previous example is 1 atm.

The values 3 and 10 have the next explication:

The value 3 indicate that the system has the top value of uncertainly compared to tolerance. In this case our system has the minimum requirements to have an value acceptable.

The value 10 indicate that our system has a lowest value of uncertainly compared to tolerance. This is an ideal case, but if we want to get 10 usually the equipments that we need are very expensive.

For this is reason, all equipments or systems must pass a calibration by the manufacturer, which will give the accuracy, by ourselves through some internal method. The most important is maintenance the traceability chain.

IV. TOLERANCE´S MODIFICATION

One time that we calculated the uncertainly of our measure's system, we must know that the minimum value that we want to see no longer corresponds to the initial value, because has been altered by uncertainly. Now our tolerance (T) will have been modified and will become (T'). This variation is showed in the Fig. 3.:

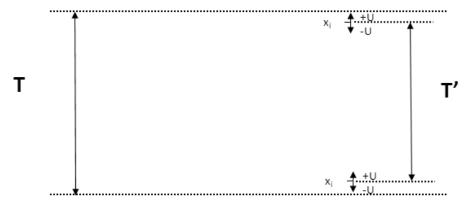

Fig.3. Tolerance's modification of the process

V. SYSTEMATIC

To determine the best equipment for the purpose that we wish, we must choose that equipment or measurement system. In the next diagram, Fig. 4.,we can see the steps to follow for a good choice:

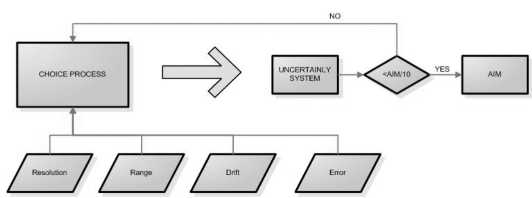

Fig. 4. Diagrama de sistemática del proceso

VI. CONCLUSIONS

We carried out a systematic study to make a choice according to our needs. In this way we can reduce the purchase price of equipment and give a validation for the value that we want to analyze.

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OVERVIEW OF EXISTING INSTRUMENTATION RELEVANT FOR OCEAN OBSERVATORIES

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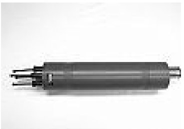
More than two decades of technical development in electronics, telecommunication, optics and acoustics measuring techniques have opened new possibilities for on-line monitoring of the marine environment. Increasing computing and filtering capacity of instruments and sensors have increased the measurement accuracy at the same time as the equipment has been made smaller, longterm stable and consume less energy. Advances in telephone and satellite communications have increased the capacity to transfer data in real time, or close to, from any part of the world to the home office.

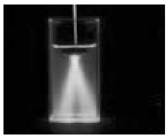
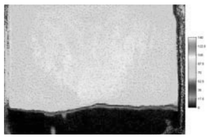
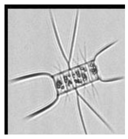
The term ocean observatory is interpreted differently depending on which investigator is asked. The users of profiling Argo floats (http://www.argo.ucsd.edu/) will often refer to their instruments as the world's biggest array of ocean observatories including more than 3000 units. Environmental buoy based monitoring systems with real time transfer of data have been established in various parts see e.g. http://www.poseidon.ncmr.gr/; http://www.gomoos.org/; http://www.pmel.noaa.gov/tao/; http://www.puertos.es/index.jsp and http://tabs.gerg.tamu.edu/Tglo/. Also many ports and harbors operate on-line installations, mainly used for navigational safety, which could be regarded as combined Oceanographic/Meteorological observatories e.g. http://online. msi.ttu.ee/tallinn/?eng and http://www.azti.es/ingles/estation.asp.

More recently large and expensive cabled observatories with high measurement and experimental capabilities have been installed. The first was set-up in Sagami bay off Japan (http://www.jamstec.go.jp/jamstec/station.html). Others have been installed off the Canadian west coast (http://www.venus.uvic.ca/), off the French Mediterranean coast (http://antares.in2p3.fr/), off Oman (http://www.lighthousehouston.com/technology/lori/video) and off the US west coast (http://www.mbari.org/mars/).

Regardless off which platform serve as support for the measurements they all carry sensors which are more or less mature for long term deployments on observatories. In this presentation the performance (accuracy and longterm stability) of a selection of chemical, physical and biological sensors will be addressed and exemplified with data from a wide variety of environments. Immerging sensor technologies will also be discussed. Also the successful combined use of sensors and mechanical actuators (on long term observatories) will be addressed.



THE EFFECT OF HYSTERESIS ON THE FLUXGATE SENSOR BEHAVIOR

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Abstract - This paper describes the principle of operation of the fluxgate sensors. The effect of the magnetic hysteresis was specially taken into account. It was found that the hysteresis does not distort the linear characteristic of these devices.

I. INTRODUCTION

Different methods and techniques have been used for the measurement of magnetic fields. They are based on different phenomena, such as induction, Hall effect, magneto-resistance, magneto-optic effects or super-conducting quantum effect.

In this paper our aim is to describe the fluxgate technique [1,2] and to investigate the influence of the ferromagnetic hysteresis on the device behavior.

The fluxgate technology, to measure weak magnetic fields, was used in large scale during the Second World War for the detection of submarines. Due to the good sensitivity of these magnetometers, they were largely utilized in geophysics to measure the earth's magnetic field, because they were accurate enough to sense small fluctuations, being capable of measuring the perturbations derived from the presence of large amounts of underground materials such as oil or other minerals of economic value [3]. This method is useful for the measurement of fields with intensities below 1 mT with resolutions in the range 0.1-10 nT.

The fabrication of integrated devices [4] including very small ferromagnetic cores, using materials with high permeability, low coercive force, low magnetostriction and a wide range of possible frequency operation was the technological ground for the construction of new devices. Nowadays, fluxgate magnetometers are used in different fields, being of special mention their utilization aboard spacecrafts to monitor the outer earth magnetic shield or in more remote zones of the solar system [5], in electronic compasses, and to replace SQUIDs in biomedical applications [6].

II. OPERATION PRINCIPLE

Different designs of fluxgate devices can be found in the specialized literature. Our setup uses the configuration represented in Fig.1, whose behavior is easy to understand. Two equal ferromagnetic longitudinal cores of permalloy form this structure. Each core has one winding with N1 coils. A second winding with N2 coils embraces the two cores. A sine wave alternate excitation current i_{ex}, of frequency f_0 and rms-value I_{ef}, is injected in the lower windings with opposite magnetization effect. An external dc magnetic field H_0 affects equally the two cores. The magnetizing effect of the field H_0 acts differently in the two cores.

In the case of a non-vanishing field H_0, a voltage u_0 will be detected, which contains even harmonics of the excitation frequency f_0.

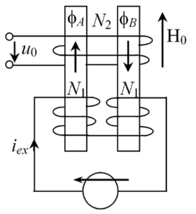

Fig.1. Fluxgate configuration used to measure an external dc-field.

III. THIRD ORDER POLYNOMIAL MAGNETIC CHARACTERISTIC

To show this effect let us assume that a polynomial expansion represents well the ferromagnetic characteristic of each core. Thus, the flux φ is written in terms of the odd powers of the total equivalent magnetizing current $i_s=N_1 i_{ex}\pm L_0 H_0$, the '+' signal being taken on the left core and the '–' signal on the right core. The L_0 parameter translates the field H_0 in terms of an equivalent current.

$$\varphi=A_1 i_s - A_3 i^3_s \quad (1)$$

The output voltage u_0 will be given by (2).

$$u_0=N_2 d/dt\,(\varphi_A-\varphi_B) = 12 N_2 A_3 N_1^{\,2} I^2_{ef} L_0 H_0 w_0 \sin(2w_0 t) \quad (2)$$

This output voltage is, in this case, purely sinusoidal of frequency $2f_0$, because the assumed magnetic characteristic was truncated to the third power of the magneto-motive force. It is also important to note that u_0 presents an amplitude proportional to the dc-field H_0, indicating that this method can be used to measure this current. If more odd powers of the magneto-motive force were present in the magnetic characteristic the output voltage would include more even harmonics of the excitation current.

In Fig.2 we show the time evolution of the magnetic fluxes φ_A and φ_B, and their difference φ_A - φ_B. The dc component is naturally eliminated in , remaining the second harmonic. 0u

The polynomial characteristic in (1) includes the nonlinear effect due to magnetic saturation. However, the effect of the magnetic hysteresis must be taken into account, because those materials always present some degree of hysteresis.

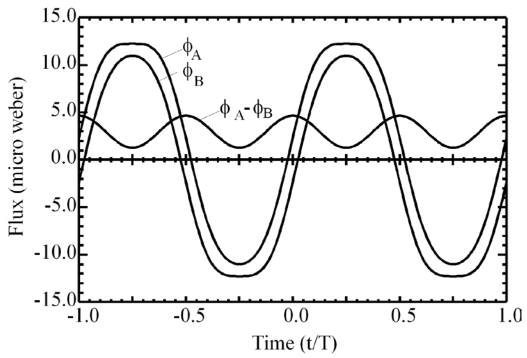

Fig.2. Time evolution of the fluxes and of their difference.

IV. THE EFFECT OF THE MAGNETIC HYSTERESIS

The magnetic characteristic represented in Fig. 3 was chosen, being assumed that the excitation field is always strong enough to drive the material into the saturation, in order to guarantee that the maximum hysteresis cycle is always described. Fig.3. Hysteretic magnetic characteristic.

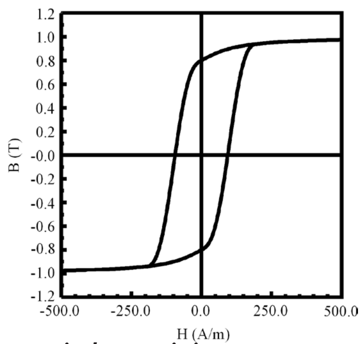

Fig.3. Hysteretic magnetic characteristic.

The configuration described in Fig.1 was also used in this case, and the resulting fluxes are shown in Fig.4. The output fluxes and the voltage u_0 are quite different from the previous example.

The observation of the output signal spectrum shows that all the even harmonics of the excitation current are now present. However this fact is not due to the hysteretic character of the core material, but only to the non-linearity, as was proved by using different magnetic characteristics, with different coercive fields. Even in the case of zero coercive field, a large number of even harmonics were always present. However, the presence of hysteresis increases the weight of the harmonics of higher order. The next step was to investigate the linearity of the fluxgate when the new hysteretic characteristic was considered.

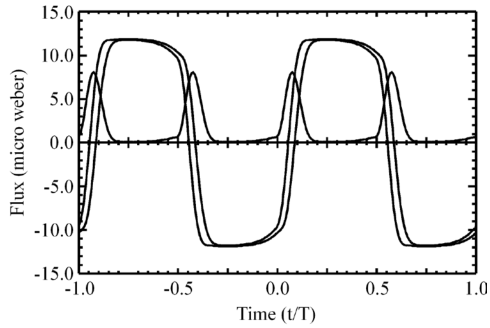

Fig.4. Time evolution of the fluxes and of their difference with magnetic hysteresis.

V. OUTPUT LINEARITY RESULTS

In the simple example when a third order polynomial magnetic characteristic was considered it was shown that the output voltage amplitude was proportional to the dc-field H_0. It was necessary to investigate the linearity of the fluxgate when a much more general characteristic was considered. Therefore, the magnetic hysteretic cycle was taken into account and the magnetic fluxes φ_A and φ_B, and their difference was determined. The output voltage waveform was determined by numerical differentiation and a discrete Fourier transform was used to investigate the relation between the second harmonic in u_0 and the intensity of H_0.

It was verified that this relation is very close to linearity. Our next step was to investigate the possible linearity between the other harmonics present in u_0 and H_0. It was verified that for the other harmonics the linearity was not so perfect, but was still very close. We then represented the root mean square value and the peak value of the output voltage and a close linearity was also verified. In Fig.5 we represent these last results graphically. The sequence of curves, from bottom to top, represents the second harmonic, the fourth harmonic, the root mean square value and the peak value.

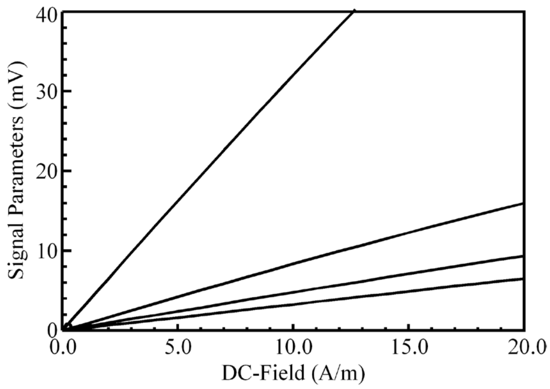

Fig.5. Output waveform parameters versus dc-field in the ferromagnetic cores.

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A SIMPLE APPROACH FOR MODELING IMPACT FORCE PARAMETERS FOR DIFFERENT MATERIALS

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Abstract – On this paper we consider the case of impacts between rigid objects. We are interested on estimating the impact pulse-width and peak force for different materials over a wide range of masses. Some experiments were conducted in order to calculate real values for specific masses, and then a fitting curve model was used to predict new parameters for objects with different masses.

Keywords – Parameters Modeling, Impacts

I. INTRODUCTION

On this paper we investigate the case of impacts between rigid objects and the estimation of two important parameters: the impact pulse-width, and the peak force. These parameters are required in order to perform a signal processing analysis based on neural networks [1], where the training signals are calculated using a model of the impacting force that is generated during the collision. The purpose is to characterize the response of different materials, like steel, aluminium, bronze, and brass.

A previous work [2] showed that these parameters are largely dependant on the mass of the colliding objects. For this reason, an experimental investigation has been conducted for estimating real values of pulse-widths and peak forces for some specific masses, then a study developed to analyze if it is possible to fit this values into a model, in order to estimate new parameters values for objects with other masses.

II. PROCEDURE AND EXPERIMENTAL SET-UP

For this study, we propose to use an impact generator device [2], and 12 cylindrical samples of different materials (steel, aluminium, bronze, and brass). Samples dimensions are as follow: all are cylinders with a diameter of dc = 30 mm, and there are three lengths: L1 = 10 mm, L2 = 30 mm, and L3 = 50 mm, designated as the small, medium and large samples, respectively. Correspondent masses are shown in Table 1. The impacting device is a sensorized impactor on a pendulum, like the one shown in Fig. 1. Samples are located over hard foam and it is possible to adjust the impacting speed by changing the impactor's swing angle. The sensor mounted on the impactor is an accelerometer and its signal is acquired through a 12-bit analog-to-digital converter with a sampling frequency of 2.5 MHz.

Table 1.

Material	Samples weight in [gr]		
	Small	Medium	Large
Aluminium	21.3	61.6	102.3
Steel	56.3	166.9	277.1
Bronze	70.4	209.5	348.1
Brass	60.8	180.1	299.6

Impactor effective seismic mass: 100 gr

In order to have a representative measurement of the impacts, for each sample, ten individual impacts are used to calculate a mean average response in the time domain. From these, the parameters pulse-widths and peak forces are measured, for each material.

With these values, a rational model is used to calculate the best fit curve approximation. Two linear polynomials are used for the numerator and the denominator, as shown in equation (1) [3], with coefficients p_1 and p_2 for the first one, and q_1 for the last one.

$$f(x) = \frac{(p_1 \cdot x + p_2)}{(x + q_1)} \quad (1)$$

III. RESULTS AND CONCLUSIONS

From the experimental measurements using the impacting device, and after applying ten impacts to each sample and averaging the results, the pulse-width and the force peak parameters were calculated. Using these values and the MATLAB curve fitting tool, the coefficients p1, p2 and q1 were calculated.

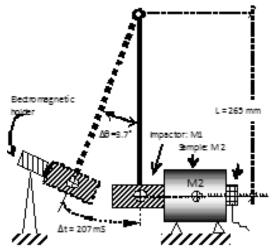

Fig.1 - Impacting device

On Fig. 2, a plot of the "pulse-width Vs mass" shows the relationship between these two parameters. Hard markers indicate the actual values obtained form the experiments, and dotted lines indicate the model fit approximation. As it can be observed, each material has its own tendency. It is interesting to notice that brass and bronze follow parallel trajectories and never cross, probably because both are mainly made with copper and a different alloy mixture that causes this shift. Aluminium and steel also follow their own trajectory, but cross each other in the beginning of the graph.

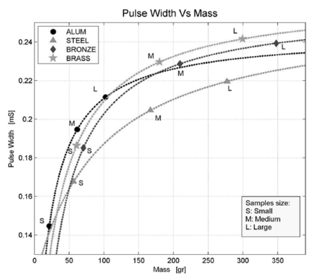

Fig. 2. Pulse-width Vs mass. Hard markers are known experimental results. Dotted lines are curve fitting results.

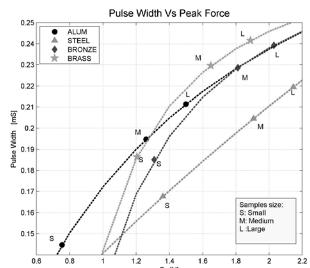

Fig. 3. Pulse-width Vs Peak Force. Hard markers are known experimental results. Dotted lines are curve fitting results

The relationship between the "pulse-width Vs peak force" is shown in Fig. 3. Here as well a model has been calculated and hard markers indicate experimental values for each material. As it can be observed, the peak force increases as the mass and the pulse-width became larger. Brass and bronze show also similar behavior, with a pronounced curve, and for the case of aluminium and steel, the curve is smoother.

From these results, it is possible to conclude that the data fitting can help to estimate the value of the pulse duration and the value of the maximum force amplitude for objects with different masses and materials, with the advantage that it is not necessary to make specific experiments for every sample. Further work will be conducted to test the procedure for training the neural networks that require these parameters.

IV. ACKNOWLEDGEMENTS

We acknowledge the financial support of the Spanish "Ministerio de Educación y Ciencia", under grant DIP-2007-66615-C02-02; the Mexican "Consejo Nacional de Ciencia y Tecnología"; and the support the "Comissionat per a Universitats i Recerca del Departament d'Innovació, Universitats i Empresa de la Generalitat de Catalunya i del Fons Social Europeu."

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DESIGN AND DEPLOYMENT OF LOW-COST DRIFTING BUOYS FOR COASTAL MONITORING APPLICATIONS.

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Abstract – Several Low-Cost Drifting Buoys (LCDB) have been designed and constructed at ICMAN-CSIC to determine flow characteristics of The Guadalquivir Estuary. Position and velocity of the drifters can be sent to a local server every ten minutes. The battery module has been dimensioned to provide experiment duration longer than two weeks. Flow patterns registered by the LCDB successfully match Acoustic Doppler Current (ADC) data from some others moored ADC profilers.

Keywords – Low-cost drifting buoys, GPS/GPRS tracker, hydrodynamic pattern, real-time coastal monitoring

I. INTRODUCTION

Guadalquivir estuary is located at the South West of The Iberian Peninsula. Its last 80-kilometre stretch (the estuary hereafter) flows from Sevilla, the main fluvial harbour in Spain, to its mouth at Sanlúcar de Barrameda, in the Gulf of Cádiz, and it is characterised by its significant fluvial traffic (4.6 million tones during 2008). Water currents in the estuary are greatly influenced by a quite complex tidal regime and by periodical discharges from Alcalá del Río dam.

To help understanding these hydrodynamic features, we have designed, constructed and deployed several low-cost drifting buoys (LCDB) along the estuary. By tracking their position, it is possible to determine superficial flow patterns and turbulent dispersion taking place in the estuary.

The deployment of these LCBDs has been performed along various stretches of the estuary and the registered velocity patterns have been validated against current data obtained from several Acoustic Doppler Current Profilers (ADCP) moored along the estuary [1].

II. DESING AND CONSTRUCTION

The drifter covers have been constructed using 63-mm-tick Polyvinyl Chloride (PVC) PN-10 pipes. These covers are 50-centimetres-length, watertight, hollow cylinders containing two external battery packs and a low-cost GPS/GPRS personal tracker, as shown in figure 1. Surrounding the cover, there is a floating foam-ring that keeps one third of the drifter above the water surface. The bottom side of the cover has an anchor attached in order to minimize the influence of the wind in the movement of the drifter.

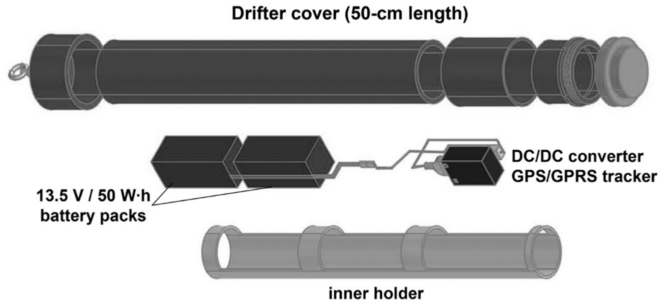

Fig. 1. LCDB components and diamensions.

The battery packs consist of 18 AA-alkaline cells, supplying a nominal voltage of 13.5 volts and a capacity of 50 watts•hour. The two battery packs are connected in parallel and grant power autonomy longer than two weeks when position reports are sent every ten minutes. A DC/DC converter conditions this power supply avoid damages in the GPS/GPRS tracker.

The GPS/GPRS tracker is a low-cost commercial model with the following characteristics: GPS frequency 1.1575.42MHz, Datum is WGS-84, Reacquisition < 0.1sec, TTFF Position Accuracy is 10 meters RMS without SA and Velocity Accuracy 0.1m/s without SA. This tracker can be configured to send automatic position-velocity reports periodically. In our deployments, this period has been set to 10 minutes, although it can be changed on the fly via SMS at any time.

The automatic reports sent by the tracker are GPRMC NMEA sentences, also know as "Recommend Minimum NMEA sentences, and they are transmitted via GPRS to a local server. When there is not GPRS service, these reports are recorded in internal memory in order to be sent when the GPRS service is re-set. The GPRMC sentence consists of twelve comma-delimited words, including satellite derived time, date, latitude, longitude, speed and bearing.

III. LCDB DEPLOYMENTS

Buoy deployments began on April 19, 2009, in the Guadalquivir estuary. The average duration of buoy drifts was more than six hours (tidal period). Buoys were deployed from a boat in a transect. Transect deployments were made by crossing the reach normal to flow at a constant speed and releasing the buoys along a line at approximately equal intervals. Transect deployments were used to map surface velocities and determine flow patterns. In addition, several deployments were carried out in the vicinity of the new lock of the Seville harbour.

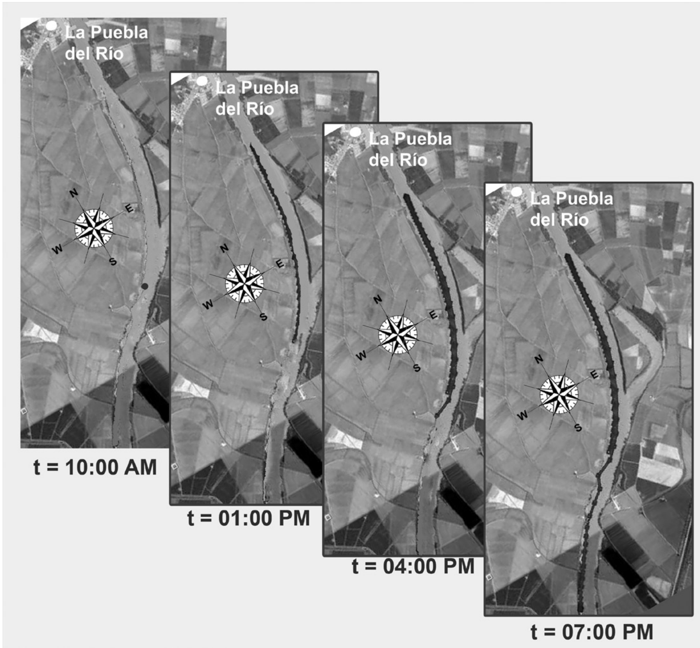

Fig. 2. Trajectory followed by one of the drifters nearby La Puebla del Río (Sevilla).

IV. I.T. INFRASTRUCTURE

In order to register the LCDB position in real-time, the GPRMC NMEA sentences sent by the drifter are periodically stored by the server. A Java application has been developed in the server to communicate with the trackers and build up a database with all that information. This application also allows the user to export the data in some standard formats (ASCII, xls, mat, kmz) easing the graphical representation of the information.

V. ACKNOWLEDGEMENTS

This Project is supported by Autoridad Portuaria de Sevilla (A.P.S., Sevilla, Spain) and by Consejería de Innovación, Ciencia y Empresa (Junta de Andalucía, Sevilla, Spain). The authors would like to offer particular recognition to Antonio Moreno (I.C.M.A.N.-C.S.I.C. technician) at deployments of LCDB.

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CONDUCTIVITY CELL FOR WATER QUALITY MONITORING

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Abstract – The measurement of electrolytic conductivity is widely applied as a control parameter and its relevance is continuously increasing, not only in industrial applications but also in the environmental monitoring domain. In this work the attention is focused on the electrical behaviour of a low cost in-situ four electrode conductivity sensor for water quality monitoring in estuaries and oceans.

The design of the sensor, the method used to determine the conductivity value, the circuit developed for signal conditioning and the data acquisition board that links the sensor to the computer for further signal processing are described in detail. The output values of the conditioning circuit are stored in the computer and compared with more accurate conductivity values obtained from commercial equipment. In order to obtain mare accurate results algorithms for digital signal processing have been presented and implemented.

Keywords - conductivity cell, electrolytic conductance, salinity.

I. INTRODUCTION

The measurement of electrolytic conductivity is widely applied in several application domains and the increase of its relevance has boosted research in the area. In order to obtain absolute methods, this measurement has recently undergone a critical revision [1], systems for traceable measurements are being developed [2] and the research for the best conductivity cell is always a goal for scientists and experimentalists [3-6]. In this paper the attention is focused on the electrical behaviour of a low-cost in-situ four electrode conductivity sensor for water quality monitoring in estuaries and oceans.

Although water itself is a poor conductor of electricity, the presence of ionic species in solution increases the conductance considerably. The conductance of such electrolytic solutions depends on the concentration and nature of the ions present. Conductivity is calculated from conductance, defined as the reciprocal of the resistance, measured by a sensor.

Electrode Conductivity Sensor

This paper presents a conductivity sensor that includes the implemented cell

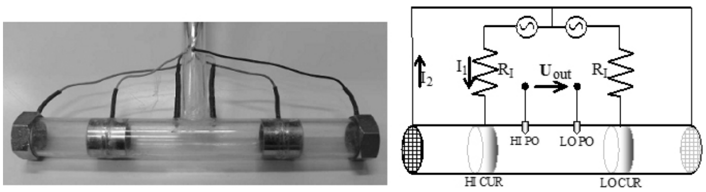

Fig. 1. Photo of the implemented four electrode cell.

presented in Fig. 1 with four electrodes and a plastic tube [7-9].

Two electrodes are ring shaped and stand inside the tube and the other two are metallic tips to measure the output voltage. The tube is closed on the two ends with metallic grids to achieve field confinement in the cell. The cell is connected to a printed circuit board with all signal conditioning circuitry whose output is connected to a data acquisition board to digitize data to be processed by the computer.

The geometry of the cell assures that the current inside the cell (in the region between the electrodes) equals the current that flows from the current sensors to the metallic grids on the top ends of the cell. That leads to a constant cell, Kc = 50 m-1.

II. EXPERIMENTAL CHARACTERIZATION

Tests take place in an automated temperature controlled bath using tap water as the solution whose conductivity is to be determined [10]. Sodium chlorite is used to increase water's conductivity in order to study sensor's output changes. The calibration of the conductivity value of the solution is performed with a commercial sensor from Hanna Instruments, HI 255-01.

At a first stage measurements are taken to adjust multiturn trimmers included in the conditioning system to their optimal value which is the one that leads to a minimal error for the desired range of conductivities to be measured. Fig. 2. presents the results obtained for $P_1 = 0.25\Omega$ and $P_2 = 4.65\Omega$ being 20% the worst relative error.

An algorithm to determine the value of the liquid conductivity from the output sensor voltage is implemented. Fig. 3 presents the liquid conductivity estimated.

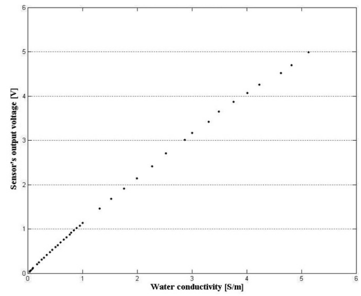

Fig2. Sensor output voltage for different conductivity values.

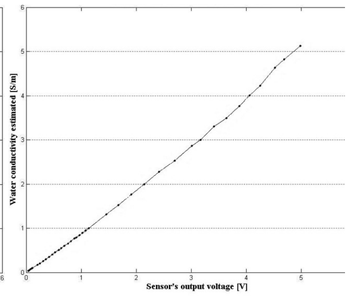

Fig3. Liquid conductivity estimated as a function of the sensor's output voltage

III. CONCLUSIONS

One advantage of the implemented cell derives from its full internal field. Because the field is internal, small amounts of antifouling material placed at the ends of the cell are effective in preventing internal fouling. Even if there are some limitations associated with the present solution, as the KC variation and a relatively poor flushing, the main advantages of this solution are its low cost, small proximity effects dependence, small amounts of antifouling material required and low volume of baths for calibration purposes.

Digital signal processing techniques and auto-calibration techniques can be used to improve measurements accuracy.

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MODELING FOR THE IMPLEMENTATION OF FEIGNED PROTOTYPE FOR THE CHARACTERIZATION OF COMMUNICATIONS AMONG NETS OF WIDE BAND PLC AND WI-MAX

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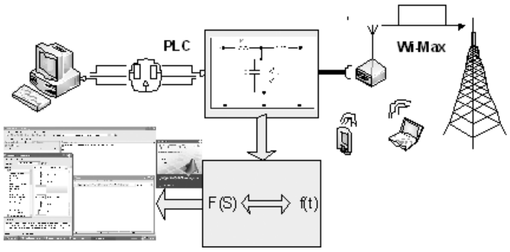
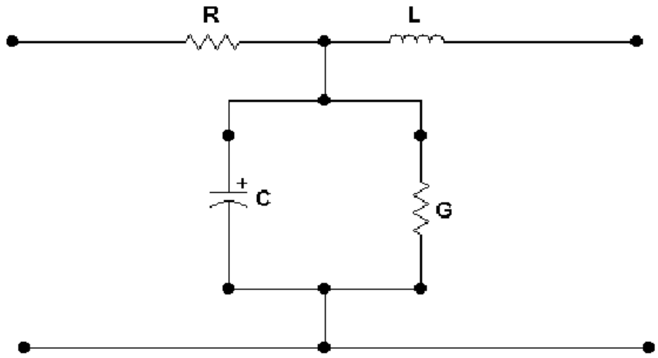
This paper presents the development of a model to be simulated in MatLab tool, which allows the characterization of a hybrid model of communication between the PLC and WiMax technologies. This model facilitates the development, implementation and deployment of technologies that contribute to a total connectivity and the mobility of users in the communication of information, as given the existence of various types and formats of information coupled with the major problems is the very nature of the information has overwhelmed the capacity of conventional media generally based on coaxial cables, optical fiber and copper twisted wire, so that new technologies with extensive capabilities for data transmission are essential to avoid saturation of services. Example of this is the communications cord, also known as Power Line Communications (PLC) and WiMax. This article explains the design of a prototype simulator that facilitates the convergence of these two technologies are very important in recent years PLC and Wi-Max, the design is programmed into the simulation tool Simulink of Matlab. The first step was the development of part of the modeling blocks for the overall design, which corresponds to the electrical and mathematical modeling of the prototype (Figure 1).



The proposed design shows the possibility of convergence between PLC and Wi-Max in at least two different but complementary ways: convergence and service convergence technologies. The convergence of services refers to the confluence, within the infrastructure provided by the CFE (Commission Federal de Electricidad), mainly based on fiber optics that cover much of the Mexican territory, and power lines high, medium and low tension and that according to national legislation to allow the parastatal to be carrier of carriers, without the possibility of distributing to end users, so that lease their services to various telecommunications service providers, who will become triple play service providers and even quadruple-play, and who, until recently, was seen as independent and equipped, each as different telecoms operators, ie, telephone service, the pay-TV and supply of Internet services that were provided by different suppliers, may now be available to customers on a single telecom provider. technological convergence of the integration, within a telecommunications device, the two technologies initially identified with specific services, first PLC as a technology that uses the power of low and medium voltage up to and on the other WiMax , which uses radio spectrum to transmit signals. The idea is that technologies of computers, television, telephone and data networks are combined to provide multimedia devices capable of identifying and processing signals associated with different telecommunications services. PLC module lets you use power grids to provide advanced telecommunications services. There PLC applications using narrow-band frequencies on the order of kHz for use in monitoring and control, but also can reach transmission rates of several Mbps with frequencies in the range of 1.6 to 30 MHz (Cañete, 2002). In this part of the article is a review of the configurations of power distribution networks used in different parts of the world. Then analyzing the transfer function for different sections in low-voltage isolated radiation is considered due to the PLC technology and the effect of electromagnetic interference with radio-frequency communications, especially in some specific bandwidths. It also proposes a model of PLC channel that collects some of its main features, and finally, the article closes with conclusions. According to a number of previous studies is that although there are various schemes for the generation and transmission of energy in European countries, as well as Asians, and even the Americans, was based on a generalized model, ideal the behavior of a power line while following the general electrical model. electrical model A characterization of the channel electric transmission line has four parameters that affect its ability to fulfill its role as part of a power system



(Figure 2): resistance, inductance, capacitance and conductance.
These parameters are crucial for determining the properties of the PLC channel used to carry telecommunications signals. The EMC uses PLC frequencies between 9 kHz and 30 MHz at high frequency cables leakage arising in the form of electromagnetic radiation, antennas behave as low-efficiency (Zimmermann and Dostert, 2002). This form of radiation causes interference with radio communications frequencies mainly between 1 and 20 MHz bands and assigned to AM radio. There is thus a crucial problem for electromagnetic compatibility (EMC) with such communications. The degree of interference depends on the transmission power, distance and configuration of the cables. More precisely, the fraction of radiated power is determined by the symmetry of the network, and this symmetry is defined in terms of the impedance between conductors: if a pair of conductors impedance between conductor and earth is of equal magnitude, the network is symmetrical. In turn, that this symmetry between the two drivers are required to carry the same current (I). Connect the neutral and ground attack can be a good alternative to achieve a high symmetry in the line. In order to assess the true impact of PLC interference with radio communications are necessary to make measurements with systems that are operational. This is work that has already begun to do in some countries.

RESULTS

Important considerations:

1. The attenuation is variant with time and frequency.
2. There is dependence of the channel with respect to location, network topology and load type. 3. High interference by the noise produced by the type of loads connected. 4. Various forms of impulse noise. 5. EMC measurements that limit transmission power.

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DECORATIVE PVD COATINGS AS AN ENVIRONMENTALLY CLEAN ALTERNATIVE TO CHROME PLATING

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Abstract – The objective of this work is to conduct applied research and development to demonstrate that metal or ceramic coatings deposited by Physical Vapor Deposition (PVD) are equivalent or superior in performance and are a cost-effective alternative to chrome plating in decorative applications. Chromium plating is commercially used to produce wear-resistant and decorative coatings, but the plating bath contains hexavalent chromium, which has adverse health and environmental effects. The present study describes and compares the mechanical and tribological properties of TiN, AlTiN, ZrN and ZrCN coatings deposited by CAPVD (cathodic arc plasma physical vapor deposition), on nickel plated aluminium substrates. The properties of the above mentioned PVD coatings have been compared with the properties of conventional chromium plating.

Keywords – Physical vapour deposition, Decorative coating, Mechanical properties, Tribology, Adhesion.

I. INTRODUCTION

The increasing environmental and worker safety pressures on chrome plating are leading many industries to adopt alternatives. Chromium plating is commercially used to produce wear-resistant and decorative coatings, but the plating bath contains hexavalent chromium and produces large volumes of chrome-contaminated toxic waste, which have adverse health and environmental effects. For this reason, the use of hexavalent chromium is being limited. It has not been until the last decade that strong activity aimed towards systematically replacing this "dirty" technology with high performance dry coating "clean" methods. Engineers faced the difficult problem of finding an appropriate alternative coating technology, which would offer quality and cost-effective production coatings according to the available standard in each case. Among the many available technologies the processes that are most widely viewed as being capable of replacing chrome plating are the physical vapour deposition (PVD) and chemical vapour deposition (CVD) techniques, which are used to produce functional hard coatings or decorative thin films. Deposited PVD coatings can have a wide colour range, for example, titanium nitride (TiN) is gold coloured, and titanium carbonitride (TiCxNy) can vary in colour from gold to purple to black depending on the composition. Zirconium nitride (ZrN) has the colour of brass and is much more wear and scratch resistant than brass. Decorative/wear coatings are used on door hardware, plumbing fixtures, fashion items, marine hardware, and other such applications.

II. EXPERIMENTAL DETAILS

Coating deposition

The coatings studied in this research were TiN, TiAlN, ZrN and ZrCN deposited by PVD/CAPVD (cathodic arc plasma physical vapour deposition) on a nickel plated aluminium 6063 substrate with a thickness around 0.5 µm. A compact MIDAS 450 system (Millennium Coatings S.L.) equipped with three advanced controlled arc cathodes in a chamber volume of 1 m3 was used for coating deposition. PVD decorative coatings are by their nature very thin, and do not act as a corrosion barrier. Therefore, the decorative PVD coatings should be applied on top of the corrosion resistant nickel electroplated coating. The properties of the above mentioned PVD coatings have been compared with the properties of conventional chromium plating on a nickel plated aluminium substrate.

III. COATING CHARACTERISATION

The mechanical properties of the coatings were determined with an ultra-microhardness testing system, capable of measuring force versus displacement, using a Vickers diamond indentor (DIN 50359). Tribological evaluation was performed using a pin on disc tribometer, according to ASTM wear testing standard (G-99). Furthermore, the scratch tests technique was employed for adhesion evaluation of the coatings.

IV. RESULTS

Table 1 shows the average results of the plastic hardness and specific wear rate (Pin on disc tests under lubricated conditions) for the studied coatings. The hardness values obtained for the AlTiN coating were the highest among the PVD coatings under study. The hardness of the TiN, ZrN and ZrCN coatings were quite close to each other, and hence the differences between them could be considered to be within the standard deviation interval. Furthermore, all studied PVD coatings presented higher hardness and elastic properties than conventional chromium plating.

	chromium plating	TiN	AlTiN	ZrN	ZrCN
Plastic hardness (GPa)	8.4	16.1	29.2	15.7	16.1
Specific Wear Rate (m3/m.N x10-16)	4,24	1,1	5,27	1,27	0,44
Critical load failure (Lc) (Scratch test) (N)	9	15	11	25	23
Coating colour	Silver coloured	Golden yellow	Grey anthracite	Brass coloured	Golden coloured

Table 1: Mechanical and tribological properties and coating adhesion

Despite having the highest hardness, the AlTiN coating presents a high specific wear rate, probably as a consequence of residual stresses within the coating that lead to a higher adherence loss. On the other hand, it can be observed that studied PVD coatings, with exception of the AlTiN coating, have better tribological performance than the conventional chromium plating.

The Coating adhesion was evaluated by the critical load, i.e. the normal load at the first coating failure, was found to increase in the following order: conventional chromium plating, AlTiN, TiN, ZrCN and ZrN (see Table 1). In all coatings, the critical load corresponded to semicircular cohesive failures, which are typical for brittle materials. For loads higher than the critical load the coatings showed large cracks, on both sides of the scratch. For all PVD coatings the level of the critical normal load is probably sufficient for many applications.

V. CONCLUSIONS

The studied PVD ceramic coatings are better than the traditional chromium electroplated coating due to their superior hardness, adhesion and wear resistance. The PVD coatings can replace the decorative wear resistant coatings; in addition a wide colour range is available.

The introduction of PVD processes as a substitute for chromium plating in decorative applications represents a development towards an environmentally clean technology. Future successful applications of PVD coatings, as alternative to chromium plating, should considered collectively many factors like wear resistance, friction coefficient, costs and environmental issues.

CABLING, CONNECTORS AND SPLICES STRUCTURE FOR THE OBSEA. EXPANDABLE SUBSEA OBSERVATORY

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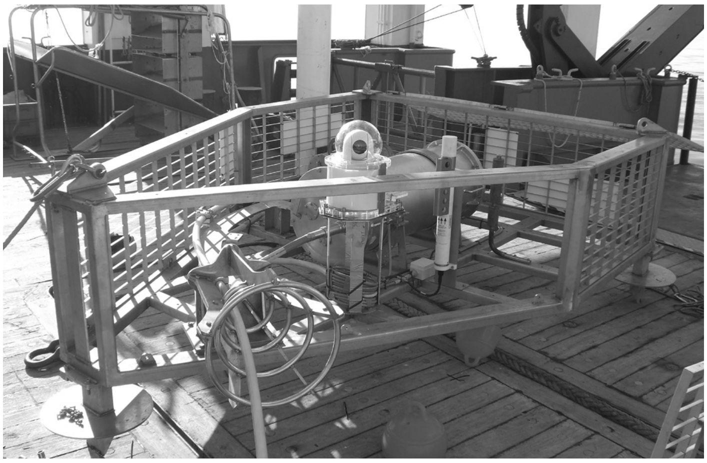
Abstract - The OBSEA observatory, for its construction, characteristics and location in the seafloor, needs a cabling and connections structure capable to satisfy its finality and to resist de adverse conditions of the sea environment.

Keywords - OBSEA, observatory, underwater cabling, wet-mateable connectors

I. INTRODUCTION

Along the OBSEA development many possibilities have been analyzed regarding the subsea and ground cables to be used, equipments and sensors as well as structure materials and containers for electronic equipment (instruments, sensors, power supplies, and control unit).
The submersed module has specific cables, hybrid connectors with power and



optics, electrical wet-mateable instrument connectors and watertight boxes that resist substantial pressures.
The future topology is based in a collection of cabled subsea modes that are forming a expandable communications network powered and communicated from land using a submarine cable. The network is supplying the electrical power to the connected oceanographic instruments and performs the monitoring, supervision and maintenance tasks to guarantee the maximum reliability and availability of the installation for what the cabling and connectors structure is a fundamental part of the project.

II. EVOLUTION AND RESULTS.

After the analysis of several options, were selected next elements:
Submarine cable:
STC hybrid; copper conductor and 6 single mode optical fibers, 31.8 mm diameter, 2 steel wires layers for protection and traction, polyethylene isolation, aluminum sheet and white polyethylene outer jacket.
Trunk cable connector:
Hybrid flexible cable assembled by an oil filled high pressure hose with standard electrical and optical wires and terminated with a connector for the junction box and a penetrator for the termination box. The connector and penetrator are a GISMA series 40 size 4 with 6 optical single mode fibers and 2 electrical conductors.
Instrument connection cables:
Combined power and signal cable MacArtney type 4622 with 2x1mm2 power conductors and 6 x 0,22m2 twisted pairs. Constructed with Polyurethane outer jacket colour blue.
Instrument connectors:
GISMA series 10 size 3 wet mateable connectors with 7 x Ø 1,5mm electrical pins
Underwater termination box:
Is a box used to adapt the rigid submarine cable with a flexible one that can be connected to the junction box. This box contains the splices of the optical fibers and the electrical connection of the copper conductors. The box has been provided by Telefonica and mounted by Tyco Telecom. The box given by Telefonica was previously used as a ground to sea connections box in Conil in the Columbus III cable (cable between the Americas and Southern Europe) and it is a Ø 200mm stainless steel cylinder designed to resist 5 Bar. It gives continuity for electrical connections (up to 100kv) and optical fibers (up to 30 fibers).

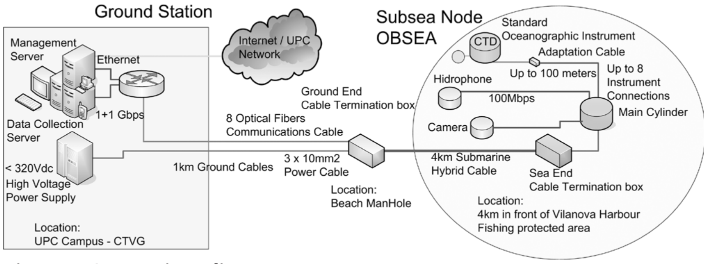


Figure 2. Connections diagram

Beach Manhole termination box:
Plastic splice box provided by Tyco Telecom holds the connection between the submarine cable coming from the observatory and the two terrestrial cables (optical and power) going to the ground station. It is the ground to sea interface.
Ground optical and electrical cables
1,5 km of standard outdoor cable with 8 Optical fibers given by telefonica and same length of electrical cable of 3x10mm2 given by Prysmian and installed by Abentel

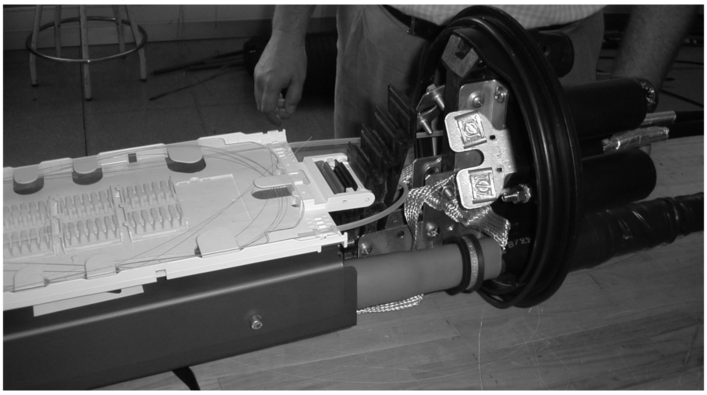


Figura 3. Beach ManHole termination box.

III. CONCLUSIONS

The analysis task required to choice the OBSEA components between the several existing alternatives has been vital to reach the objective of high reliability at low cost. The design of the connections and its implementation has been done following the initial specifications. A subsea observatory is an installation subjected to harsh environmental conditions such as high pressure, corrosive agents or biofouling, that are imposing continuous supervision and maintenance tasks, and the quality of the materials will establish its useful live.

IV. ACKNOLEDGEMENTS

The OBSEA project is being founded from the Spanish Ministry of Science and Innovation (MICINN). The authors acknowledge the support of the Telefonica, Prysmian Cables y Sistemas, and Tyco Marine for its cooperation in the project.

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WATERTIGHT TESTS FOR OBSEA EQUIPMENTS IN THE HYPERBARIC CHAMBER

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Abstract - Description of the procedures to assure the proper water protection of the equipments to be installed in the OBSEA subsea observatory.

Keywords - OBSEA, hyperbaric chamber, Watertight tests, pressure, sensors

I. INTRODUCTION

In order to be able to perform the required tests to assure the leakproof capacity of the watertight devices of the OBSEA project, in the SARTI installation there is a hyperbaric chamber. This chamber is an IBERCO model IB-80 with a capacity of 816 liters and with an approximate internal length of 1570 mm and diameter of 800mm. With this chamber is possible to perform test with a maximum pressure of 20 bar what it means a simulated depth of 200 meters. Using this equipment has been done a set of tests to guarantee the proper operation of the whole system (cylinders, cabling and connectors) of the OBSEA project.

Fig. 1. Hyperbaric chamber

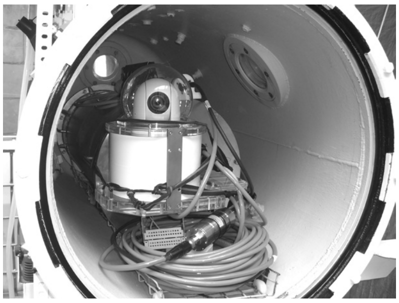

Fig. 2. Preparation of the test

In the fig. 1 is shown the hyperbaric chamber available in the SARTI development center.

II. DISCUSIONS AND RESULTS

One of the main difficulties when performing tests in the hyperbaric chamber is the connection of the devices under test (DUT) to outside of the chamber. The chamber has several penetrators in many sizes for the wall crossing using pressure watertight cable glands. The problem with these cable glands is that they allow the pass of the cable but not the connector of the cable end. It means that some tests using optical or submarine cables must be carefully planned in advance and using accessories to be able to perform the connection.
In order to test the totality of the components of the OBSEA subsea station first it has been done several tests with any isolated component and then has been done compatibility tests with several components in the same time but always with the limitation that the cables already terminated in both ends cannot be used to transmit data outside to the chamber and that the internal size is not big enough to test the whole station at once.

The components that have been tested are:
• The main junction box, (1000 x Ø 400 mm).
• The submarine cable termination box (600 x Ø 200 mm)
• Underwater IP Camera System OCEAN PRESENCE Technologies OPT-06
• Bjorge NAXYS Ethernet Hydrophone 02345
• CTD Sea-Bird Electronics SBE 37-SMP MicroCAT
• Underwater connectors from GISMA series 10 (electrical) and series 40 (electro-optical)
• Underwater electrical and optical cables
• Ethernet to serial special cable
• Some mechanical accessories

The cylinders and watertight boxes have been tested firstly without cables, connectors or electronics inside. These tests have been done at several pressures from few deciBars to the maximum allowed depth for the box checking for leakages in each test. With this procedure has been possible to detect structural defects and assembling faults without the inconvenience of destroying any component.
With these tests have been detected some leakages in the protecting caps of the junction box and in a welded seam of the termination box.
Once the leakproofness of the stainless steel boxes has been asserted the underwater connectors has been installed to allow the connection to the external devices. The connectors are designed to resist the adverse conditions of the marine environment and to allow wet connections of new instruments with the station in the seafloor. After that, new tests have been done to corroborate the correct assembly of the connectors.
Then we were able to install electronics inside the boxes and connect it to the exterior of the chamber using the cable glands. With these tests has been possible to monitor the heat generated for the power supplies and redesign the internal distribution to improve the dissipation and avoid hot areas. The other strategy that has been choice to increase the heat dissipation is the increment of the internal air pressure using dry air.
In order to test the hybrid cable (power and optic) we have done additional tests with the junction box and termination box connected together with this cable. Do to is not possible to take one end of the optical cable out of the chamber, to test that the pressure is not affecting the optical communication, it has been done a loop connection using four fibers of the hybrid cable between the two Ethernet switches of the junction box. Then the Ethernet connection has been got out the chamber electrically through and instrument port and cable gland.
The three oceanographic instruments currently installed in the OBSEA station have also been tested in the hyperbaric chamber in order to validate the manufacturer specifications. For the CTD, in addition, has been tested the special cable that is converting the serial data to Ethernet. This cable has a plastic box with electronic inside, to protect this electronic from the water pressure the box has been filled with epoxy resin. All this instruments has been tested, first, alone directly connected to an external computer, and then, all together connecter to the junction box (see fig. 2). These tests have been useful not only to test the waterproof of the components but also to verify that all the electronics are compatible working together and also to confirm that the humidity sensor is really useful to detect small leakages before than water will reach the internal electronic.

III. CONCLUSIONS

The tests have been useful to detect leakages in the assembly of some connectors and manufacturing faults that have been corrected before the installation in the seabed. These tests have been helpful also for the thermal characterization of the junction box when it is immersed in water to redistribute the internal components. Finally it can be certified that all the components resist more than twice the water pressure of the place where they will be installed.

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POWER SUPPLY CONTROL OF THE OBSEA SEAFLOOR OBSERVATORY

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Abstract - The aim of this paper is to present the design and construction process of the power supply needed for a remote data acquisition system. It is based on twelve AC to DC switching converters in a serial connection and a logic programmable controller (PLC). The energy is transmitted to the acquisition system, which is located several kilometers away, by means of a cable. The supply system has been designed with a higher capacity than the current requirements of the subsea station and the controller decides constantly the best configuration required at each moment.

Keywords - OBSEA, Power Supply, PLC, Omron CPL1.

I. INTRODUCTION

In such a big project as OBSEA (Expandable Submarine Observatory) a large variety of problems turns up during the designing process. One of them is the necessity of feeding equipment that works continuously and is installed some kilometers away from the control center. Therefore we have to design a system capable of detect the observatory consumption variations and respond automatically without the action of an operator. Furthermore, the chance of adding complementary sensors to the observatory forces to include a wide enough consumption margin to meet higher energy demands. Finally, to enable the monitoring of the process we need periodic reports and incident signaling.

To catch up with all this requirements, the whole system revolves around the programmable logic controller which analyzes the observatory consumptions using the data obtained by current and voltage sensors. Consequently, it activates the necessary number of converter switches. In usual conditions, the acquisition system works with only four converter switches but up to twelve units are installed to respond to possible consumption peaks or failures.

II. SYSTEM DESCRIPTION

The main elements of the system are the Omron CP1L M30DR-A programmable logic controller (18 digital inputs and 12 digital outputs), the twelve converter switches that supply 27VDC each and the analog module CPM1A-MAD01 that deal with the data acquired by the sensors. All of them are fed directly from the electrical grid. The converter switches are serially connected so the system can provide a maximum voltage of 27 x 12 = 324VDC. In the fig 1 can be seen the connection diagram of the power supplies. They are activated and deactivated by means of the twelve CP1L digital outputs working as switches.

The use of the whole capacity depends on the instantaneous consumption of the subsea station. To control it, two sensors are installed in the power circuit. Firstly, a LEM current sensor is serially connected to the switching converters output and provides to the PLC an output voltage proportional to the consumed current. Secondly, a voltage divisor connected in parallel provides a voltage proportional to the total generated voltage. These two signals are read by the analog module CPM1A and converted into 8 bit words that will be send to the CP1L module through its expansion bus. Moreover, to complete the analysis of the system status, the output of each switching converter is individually connected to one of the CP1L digital inputs using a bank of optocouplers that isolates the CP1L logic circuit from the power circuit.

All the data that reach the CP1L is processed to found the best output configuration in real time. The programming language used is a ladder program written in the CP1L by means of CX-Programmer, software provided by the manufacturer. The program has different targets to achieve. First of all, it has to work out how many switching converter are necessary depending on the current consumption and the number of converter switches currently running. When the current consumption grows up over a top threshold and not all the converter switches are on, a new one is started. On the contrary, if the current consumption falls under the low threshold and more than the minimum converter switches are on, then one of them is turned off. As well, the data from the voltage divider and the CP1L inputs is used to detect failures in the converter switches so they could be reported to the control center using the RS-232 embedded serial port. In the same manner, the program sends a status message each time a converter switch changes its state. Finally, the program has a maintenance function that ensures that all the converter switches work the same. It keeps count of every converter switch work hours and periodically checks if the running converter switches are the more restful ones.

To keep the best security and order, all the elements are placed in a steel box with the most possible simplified external connections. The objective is not to open it again after the initial starting if it is not absolutely necessary.

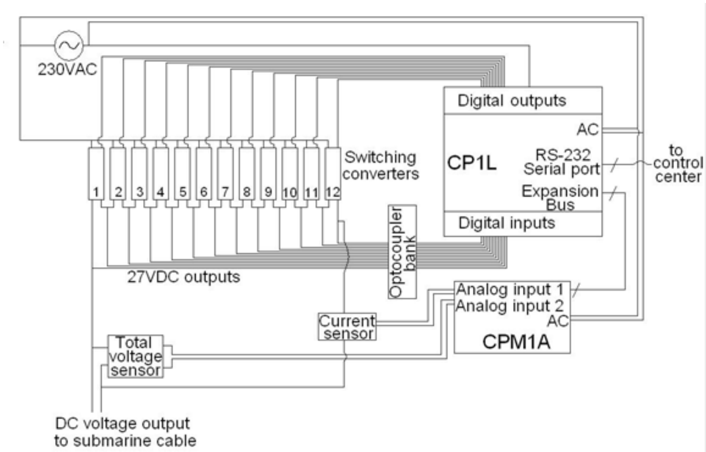

Fig.1 Schematic diagram of the power supply

III. CONCLUSION

The outline of this design responds to some particular requirements of a determinate remote acquisition system. Specifically it gives a solution to the need of automation. Nevertheless, these features don't differ too much from the characteristics that any other scientific equipment could require, either it is remote or not. Thus, the design could be adapted for innumerable applications.

Besides, the used components are the ones which best fit in with the acquisition system needs, but in the catalogues are thousands of different components so we can change any feature easily.

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SMART SENSORS MONITORING NODES AND GIS FOR DOLPHINS' ENVIRONMENT ASSESSMENT

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Abstract - The purpose of the paper is to report mainly the work developed in the areas of distributed instrumentation and geographic information systems for dolphins' environment assessment. A smart sensing node mounted in a buoy expressed by water quality transducers, a low cost hydrophone materialize and a GPS deliver the informations for an acquisition and wireless communication module that is connected through Wi-Fi to a laptop PC that is installed in a ship. Using the internet available connection (3G/UMTS modem is installed on the laptop PC) the data from different sensing nodes are transmitted to a host PC where specific software implemented materializing the geographic information system for dolphin life assessment (GIS). Thus, on-line environment assessment through dynamic web pages is carried out.

Keywords - waterquality, underwater acoustic monitoring, smart sensors, geographic information system

I. INTRODUCTION

A Geographical Information System (GIS) [1]. allows viewing, understanding, questioning, interpreting, and visualizing data in many ways, which reveal relationships, patterns, and trends, and can be used for environment quality assessment related to animal life conditions (e.g. dolphins of the Sado Estuary). In our application, water quality assessment includes different parameters such as pH, conductivity, temperature and turbidity [2][3]. These parameters are measured by the transducers characterized by analog output and additionally the digital information Basic TEDS (transducer data sheet) according to IEEE1451.4 [4] standard for smart transducers. Underwater acoustic signals are usually sensed using hydrophones that can be also used to acquire specific dolphin' sounds (whistles, clicks and bursts) [5].

The paper also reports a designed and implemented Geographic Information System developed with a Windows server 2003, SQL server, ASP.net, AXAJ and a GMAP technology, that supports the management of the information obtained

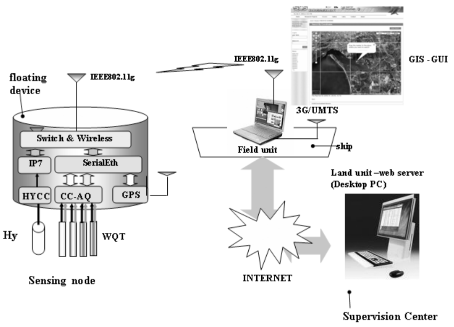

Figure 1. GIS hardware block diagram (HYCC- hydrophone conditioning circuit, WQS-water quality transducers, CC-AQ- conditioning circuits & acquistion, Hy-hydrophone, IP7-audio server, SerialEth – 2Xserial to Ethernet bridge, Switch & Wireless – IEEE802.3 switch and IEEE802.3 to IEEE802.11g bridge)

throw a distributed measurement nodes. The data from the sensing nodes are received by the Laptop PC through wireless communication and processed using a LabVIEW software. The processing results automatically uploaded on a GIS implemented in a land server (supervision center).

II. GIS HARDWARE

Taking into account that the dolphins' population under observation is spread over a large area (Sado Estuary), the Geographic Information System receive the data from a nodes wireless connected to a field advanced processing and communication unit expressed by a Laptop PC. The measurement nodes (Figure 1) includes: GPS unit for sensing node localization, water quality transducer unit, underwater acoustic signal measuring unit and wireless communication unit.

The measurement nodes prototypes include a GPS (GarminForetrex201) with RS232 communication capability that provides the information about the sensing node localization on the assessed area information is joined to the water quality parameters values measured using the WQT expressed by a set of Global Water Sensors (WQ101, WQ201, WQ301 and WQ770) that measure the temperature, conductivity, pH and turbidity. The 4-20mA signals from the WQ sensors are acquired using a 16-bit ADC of an acquisition unit uUP8930 from IPSIL that present an Ethernet port connected to the sensing node Switch&Wireless. Additionally the basic parameters (TEDS) of each WQ sensor are stored in a 1-wire memory (DS2433). The digital information from each measurement channel is managed through a 1-wire netweok that also include a 1-wire to RS232 bridge connected to the SerialEth unit.

In order to monitor the underwater acoustic sound in the Sado Estuary the sensing node includes underwater acoustic signal measuring unit including a hydrophone (Cetacean Research S003) with audio preamplifier that assure an amplified and filtered signal that is applied to the input of audio server based on VoIP technology (IP7).

GIS SOFTWARE - The developed GIS, called SonicQualSado, associated with Dolphin's Environment Assessment, includes dlltwo components: a LabVIEW instrumentation control and a knowledge management. Data logging capabilities were implemented by using Windows server 2003, SQL server, and ASP.net, AXAJ, and GMAP technologies.

From GIS, we may access data in a way that allows an easier interpretation, finding relationships, detect patterns and share data in a more understandable way. The method used to display data was supported by the GIS map. The map enables the visualization of queries to the database. Combining the data, we can get results such as the route of the ship in a given period. These features were implemented using the Google's GMAP API [6] to map the data.

In terms of software, the project was developed in ASP.NET 2.0 AJAX 1.0 (C# language), in the Microsoft ® Visual Studio 2005 Express Edition platform. The Microsoft ® SQL Server 2005 Express Edition was used for database management. The application data mapping is made using the Google's GMAP technology, accessible on the internet. The code to implement GMAP was done in JavaScript.

The application provides a real-time monitor of successive measuring locations by a ship that travels the Sado's river estuary. The preview is done in the GMAP by a set of markers (that identify the measurement points) connected by lines. This will give a rough idea of the route followed by the ship.

III. RESULTS AND DISCUSSION

Using the implemented system, several tasks, such as water quality parameter measurement, underwater acoustic signal acquisition and recording are carried out.

During the field measurement session, water quality parameters measured on different location were delivered from measurement nodes were received and processed on the Laptop of the field unit. Several results are presented on Table 1.

Table 1. WQ parameters for different measurement locations at different times

Date	Time	Lat.	Long.	T(ºC)	pH (units)	C(mS/cm)	TU(NTU)
25.06.08	12:01:44	38.29048	-8.91856	18.34	9.23	51.4	8.2
25.06.08	12.36.21	38.49795	-8.89395	21.19	8.82	50.9	33.4
25.06.08	13.31:10	38.51363	-8.90155	19.55	8.68	51.3	73.4

The underwater acoustic signals and the measured data are uploaded on the GIS that include web publishing capabilities through dynamic pages.

The GIS uses a digital map as the main element of the user interface. Not just data is visualized in the digital map, but also the map is also used to input data for searching tasks. Measured values of water quality parameters are associated with the map locations.

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EXPERIMENTAL ELECTRONIC INSTRUMENT FOR A HYDRAULIC TOWING WINCH

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Keywords - Tug winches, electronic instrumentation, data acquisition, electronic sensors, control system

The objective of this work is the design and implementation of an experimental electronic instrument that will be used for the automation control of an hydraulic towing winch. This electronic instrumentation system integrates the controller and the human machine interface (HMI). For this reason, an experimental programmable automation controller has been developed.

The heart of most machine control applications is an electronic controller such as a programmable automation controller (PAC) or programmable logic controller (PLC) [1]. The controller is used to receive sensor data and to control the machine using analog and digital I/O signals, and mathematical algorithms like PIDs [2]. Traditionally PLCs have been used in machine control and they are programmed using tools such as ladder diagrams or sequential function charts. One of the biggest benefits of using a PAC is the ability to add other tasks to the control application, which could not be handled by a traditional PLC [3]. For this reason, increasingly machine control is moving to PACs because they offer higher performance and more functionality, allowing operations such as high-speed data acquisition and processing, as well as motion control and vision which are not supported in traditional PLCs [1, 4, 5].

The designed electronic instrument must accomplish the control requirements for a naval deck machinery, composed by a tug winch with an hydraulic pump feeding four hydraulic motors, linked together to a towing drum [6]. The electronic instrument architecture, including the machine controller hardware and software, has been defined considering the following characteristics: (i) combination of HMI and real-time control in the machine control system; (ii) ruggedness, flexibility and modularity; and (iii) the availability of common intuitive development software for programming all the elements of the system [4, 7].

From the previous considerations, the adopted solution was based on a National Instruments (NI) CompactRIO PAC, a modular low-cost reconfigurable control and acquisition system designed for applications that require high performance and reliability. The system combines an open embedded architecture with small size, extreme ruggedness, and hot-swappable industrial I/O modules. NI CompactRIO is powered by reconfigurable I/O (RIO) field-programmable gate array (FPGA) technology. This solution comprises a CompactRIO chassis and real-time embeded controller (NI cRIO-9014) and several I/O modules (NI 9205, NI 9203, NI 9265, NI 9425, NI 9477). Figure 1 illustrates the architecture of the electronic instrument and software tasks running in HMI and Real-time Controller.

To take advantage of all the features and capabilities of a PAC, it is fundamental that the application code was well designed, coordinating various controller processes such as I/O, process control logic, communication to a HMI and other tasks [1, 5]. The LabVIEW Real-Time Module 8.6 introduced powerful new features for programming CompactRIO hardware that reduce development time and complexity as well as provide tools for monitoring and maintaining CompactRIO applications [8]. The basis of the CompactRIO PAC is the FPGA wich performs the interconnection of the I/O modules and offers performance maintaining the flexibility. CompactRIO is entirely programmable with LabVIEW, including the FPGA, real-time processor, and human machine interface.
The system was divided in several independent basic functional blocks or modules. These functional blocks improved the modularity and the flexibility of the system. This structure facilitates the addition of new elements to the system or the design of whole new system, simply by the design and addition of new software modules, or by the reuse of the existing ones.

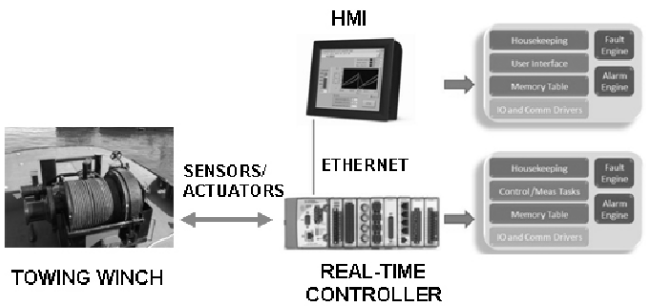

Figure 1: Architecture of the electronic instrument and running tasks.

Since the state diagram considers each possible state of the system, the use of LabVIEW Statecharts provides a system-level view that describes the complete function of a module, a system or an application [9]. Therefore, the use of Statecharts reduces the possibility of unexpected behaviour, because the state chart definition of a module forces to take into account the possible scenarios to which the software needs to respond.

The LabVIEW development tool also provides a powerful debugging and testing platform, so each module was previously verified and simulated using virtual panels and virtual machines (inputs/outputs). This virtual panels and machines allowed the functional verification of each module and the whole system.

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A PERMANENT SUBMARINE OBSERVATORY IN ALBORAN AND THE LONG TERM OBS FOMAR NETWORK: NEWS.

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The Eurasian-African plate boundary crosses the called "Ibero-Maghrebian" region from the San Vicente Cape (SW Portugal) to Tunisia including the south Iberia, Alboran Sea, and northern of Morocco and Algeria. The low convergence rate at this plate boundary produces a continuous moderate seismic activity of low magnitude and shallow depth, where the occurrence of large earthquakes is separated by long time intervals. In this region, there are also intermediate and very depth earthquakes. In this area there are several seismic networks deployed, as for example the WM BB network. But, due to the fact of that many events are located at marine areas and the pour geographic azimuthal coverage at some zones provided by land stations, earthquakes parameters (location, depth,…) are poorly determined. To solve these problems, two ROA initiatives have been funded by the Spanish "Ministerio de Educación y Ciencia": The ALBO project (RIOA05-23-002) and the FOMAR net project (CGL2005-24194-E).

The ALBO project consists to install a permanent ocean bottom observatory in the surrounding of the Alboran island. This submarine observatory will be installed about 1800m away from the island on the ocean bottom, with a 40 meters depth, and will be linked to the surface by a fiber optic submarine cable. The surface equipments will collect all data and transmit them to ROA by Navy intranet facilities and by satellite. In the submarine part several instruments will be deployed: a broad band seismic sensor (CMG-3T BB) and a pressure gauge are integrated in the Güralp system, but also a current meter will be installed. Also, several TCP-IP connections and power will be available for future additionally instruments. Complementary on the island, a permanent geodetic GPS, a mareograph and a meteorological station will be installed. The Alboran island is declared as a Natural Park and also as an underwater reserve, so authorizations for the installation was needed from several autonomic and national institutions. Now a day, all permissions are approved, a previous submarine survey (with divers) was done thanks to the collaboration of the Spanish navy and the permanent GPS is already installed and linked to ROA using the Navy intranet. Also, the whole submarine system is finishing and testing at Güralp Laboratories, so the ROA are going to install the main system on September 2009.

The FOMAR net project consists to deploy four long term (three years) temporal OBS's at the Gulf of Cádiz and Alborán sea. The OBS's are being manufactured in KUM Laboratories with a 3D BB seismic sensor (CMG-40T), an Hydrophone (HTI-04-PCA/ULF) and a KUM compass, and the recorder is a GEOLON-MCS (manufactured by SEND). All system is contained in titanium pressure tubes including batteries.

TEMPO-MINI: A CUSTOM-DESIGNED INSTRUMENT FOR REAL-TIME MONITORING OF HYDROTHERMAL VENT ECOSYSTEMS

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TEMPO-Mini is a new custom-designed instrument package created by IFREMER for real-time monitoring of hydrothermal faunal assemblages (J. Sarrazin et al. 2007).

TEMPO-Mini integrates a 2 megapixel streaming video camera with embedded event detection, 4 LED lights, an oxygen sensor, and a 10m-long 10-sensor temperature probe. An efficient and innovative biofouling protection system is set on the camera porthole, on the lights and on the optical oxygen sensor (L. Delauney et al.).

IFREMER collaborated with NEPTUNE Canada and VENUS Canada networks to acquire live data from the seafloor in Saanich Inlet near Sidney, BC, Canada. VENUS has provided the cabled network and node connections for an instrument platform including TEMPO-Mini, which was tested, deployed and connected in late September 2008. NEPTUNE has provided a junction box to allow the connection on VENUS network. After this test in shallow water TEMPO-Mini has been recovered in February 2009.

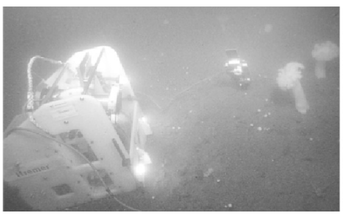

Fig. 1: TEMPO-Mini during the test deployment in Saanich Inlet, BC, Canada

Fig. 2: A view of the scene in Saanich Inlet, BC, Canada

In May 2010, TEMPO-Mini, up-dated with a CHEMINI Fe (Vuillemin et al. 2009), a new generation of in-situ chemical analyzer, will descend to 2300 m. Linked to the NEPTUNE network, the camera, lights, sensors and probes will help scientists to study the dynamics of deep-sea hydrothermal ecosystems of the Endeavour vent field in the North-East Pacific Ocean.

In this paper, we present the architecture and functionality of the system and zoom into the operational perspectives.

IFREMER extends our sincere thanks to NEPTUNE Canada, VENUS Canada, CCGS John P.Tully, ROV ROPOS team and all the other partners who made this successful deployment possible.

INTEGRATION OF A PERMANENT OBS OFFSHORE NE IBERIAN PENINSULA TO THE CATALAN SEISMIC NETWORK

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Abstract - We summarize the results of more than 3 years of operation of a permanent Ocean Bottom Seismometer (OBS) deployed 40 km offshore Catalonia (northeastern Spain) in terms of the site ambient noise conditions and quality of the data acquired. As observed on most of the ocean-floor observatories, the noise level at the OBS site is quite large on all components. However, the integration of the OBS station into the Catalan seismic network has allowed to improve hypocenter locations.

Keywords - Ocean bottom seismometer, ambient noise, seismic network

I. INTRODUCTION

The first initiative for long-term sea-floor seismic monitoring observation in Spain became a success on August 2005, when a permanent Ocean Bottom Seismometer (OBS) and a differential pressure gauge (DPG) were deployed 40 km offshore Catalonia (northeastern Spain) within the framework of a joint project between the Institut Cartogràfic de Catalunya (ICC) and the Observatori de l'Ebre, in collaboration with the Spanish oil company Repsol Investigaciones Petrolíferas. The OBS is located on sedimented sea-floor in shallow water (150 m in depth) at about 400 m from the Casablanca oil platform. The OBS is completely buried into the sediments (Fig. 1) and the DPG is deployed 10 m away from the seismic sensor. The system is linked by a 750-m length, 26-mm-diameter cable with the Casablanca oil platform, which hosts the power supply, the GPS, and the 1.8-m-diameter antenna for satellite data transmission via VSAT. The ocean-floor station was completely integrated into the Catalan seismic network (CSN) in October 2007, when satellite transmission allowed to have continuous and real time data available at the network data center in Barcelona (http://www.igc.cat). COBS data is integrated into the monitoring center data management system of the CSN through Earthworm. The station, with geographical coordinates 40.71ºN and 1.36ºE, has the code COBS at the International Registry of Seismograph Stations of the International Seismological Centre.

II. OBS CONTRIBUTION TO THE CATALAN SEISMIC NETWORK

The plan was initially designed with the main goal of improving the understanding of the seismicity of the region around, which is densely populated and is industrially very active. In this sense, singular infrastructures such as nuclear power plants, chemical and oil industries are present in the area, having these aspects great implications on the seismic risk assessment of the region. Moreover, the fact that some earthquakes occur offshore, leads to some difficulty in surveying seismic activity with the inland stations only. Thus, the installation of a broadband OBS for real-time data acquisition might improve the performance of the network. At present the implementation of the OBS to the seismic network has only been made partially. Despite the data provided by the sea floor sensor do not contribute to the automatic location system, they allow a whole waveform analysis and are used to perform the manual locations, which can be improved for local offshore epicentre events that would have a larger station gap without these data. Since COBS is operative, some local, regional and teleseismic events have been recorded

III. AMBIENT NOISE ANALYSIS

A seismic ambient noise study from the OBS and the DPG recordings has been performed, showing that, as observed on most of the ocean-floor observatories, the noise level is quite large on all components. It can be observed that the COBS noise shows large temporal changes, especially in the microseism band, that are linked to seasonal variations. On the other hand, both the wind speed and the significant wave height have a great influence in the calculated noise levels on all the 3 components. This indicates that wind driven gravity waves are important sources of seismic noise. Taking advantage of the high coherence between the OBS and DPG recordings, a low frequency noise correction has also been carried out, thus improving data fidelity.

IV. FINAL CONSIDERATIONS

Although the implementation of ocean-floor seismic stations is a difficult task and such deployments require solving important technological and logistical issues, long-term ocean-floor seismic observatories can contribute to the investigation of global-scale geophysical processes and to better constrain regional tectonics. In this way, COBS station contributes with broadband seismic data in real time to the Catalan seismic network and to the scientific community.

Fig. 1. Image of the buried OBS

PLOCAN, AN OFF-SHORE ENVIRONMENTALLY SUSTAINABLE INFRASTRUCTURE TO ACCELERATE OCEAN RESEARCH, DEVELOPMENT AND INNOVATION AT INCREASING DEPTHS.

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Abstract – The Canary Islands Oceanic Platform (PLOCAN) is a public infrastructure for research, development and innovation in the fields of ocean science and technology at increasing depths. Located East of Gran Canaria Island (Canary Islands, Spain), PLOCAN will provide rapid access to great depths at short distance from the shore, accelerating research and the generation of water column and deep-ocean knowledge. Specifically, PLOCAN will host a permanent deep-sea observatory, be a test-bed for innovative technologies, form specialists and provide training in the field and be a national base of manned and unmanned submersibles. PLOCAN's vision is focused on generation and exchange of science and innovations between the academic and the socio-economic spheres. PLOCAN will be a fully instrumented gate to the deep ocean, an efficient and cost-effective solution to test products and processes , and cluster private and public partnerships to face undersea challenges. Two years ahead of the planned official opening and start of operations, the academic world, entrepreneurs and corporations have already started to submit proposals to be included in the science and technology agenda. Activities will be essentially multidisciplinary, ranging from renewable energies, aquaculture, ocean observing fixed systems and submersibles, to biosciences and emerging technologies such as new materials and nanotechnologies. PLOCAN's vision is to be a true accelerator for marine and deep-sea research and development, with optimal conditions and full environmental guarantees.

Keywords – deep-sea, platform, environmental sustainability, science and technology, test-bed

OBJECTIVES

The main objective is to build and operate a fully autonomous oceanic platform dedicated to science and technology that contains a set of facilities and experimental laboratories. It will be placed at 50-100 m depth on the edge of the continental shelf, serving as a permanent access to the deep ocean using all kinds of vehicles, underwater machinery or instruments (autonomous, via cable or remotely operated) to observe, produce, take advantage of resources or install services at depth, with environmental guarantees. PLOCAN will open new opportunities for a great range of institutions in challenging areas that up to now only the oil industry could face.

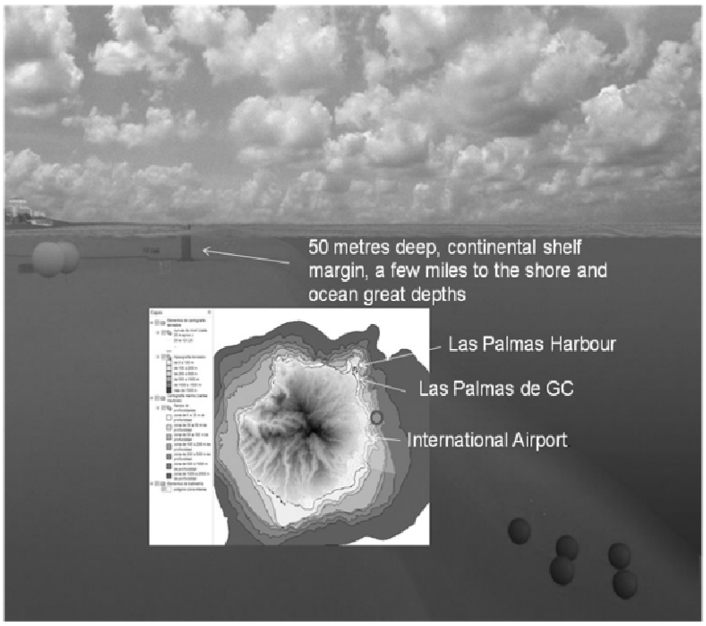

Fig. 2. Location of the platform

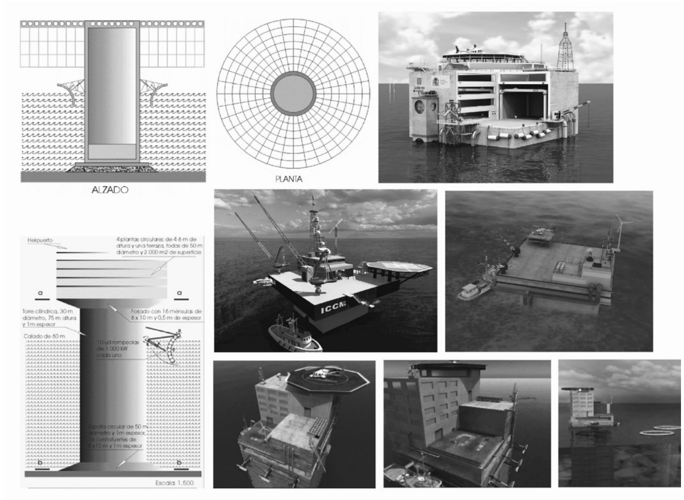

Fig. 1. Possible aspects of the future platform PLOCAN

Here is an overview of the objectives:

1. To provide a scientific and technological platform with the most effective means and conditions to perform and/or test observations and experiments at increasing depths.

2. To provide businesses with the best and in many cases the only test-bed for innovative activities in the deep ocean with adequate environmental guarantees.

3. To create the national base of vehicles and working tools for deep sea, operational and available on a permanent basis.

4. To provide a unique meeting space of excellence for the public and private scientific-technical community to accelerate research and innovation, to explore and contribute to the sustainable management of the deep ocean.

5. To provide training programs, from technicians to scientists, including specific formation and training to use the facilities and working devices, and access the deep ocean.

6. To test a public scientific-technical organization that can effectively manage highly skilled teams, complex and expensive instrumental devices and their relationship with innovative companies and socio-economic public and private institutions.

Finally, a practical feature is the capacity to respond to accommodation needs on-site. The platform will offer accommodation for about 30 persons with air-conditioned single and double cabin-type bedrooms and all expected amenities for long duration experiments - meeting rooms, restaurant, fitness center etc. The platform will be autonomous in terms of energy and water supply, and the strictest environmental standards shall be applied for inner and outer needs and activities. Operations are planned to start end of 2011.

THE NEMO PROJECT STATUS

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I. INTRODUCTION

Starting from 1998 the NEMO collaboration has carried out R&D activities aimed at developing and validating key technologies for a cubic-kilometre scale underwater neutrino telescope [1]. A first phase focussed on site investigation and characterisation studies as well as the development of a suitable detector concept.

The NEMO detector concept is based on semi-rigid vertical structures (towers) composed of a sequence of 10 m long horizontal structures in marine grade aluminium (bars). Each of these has six optical modules and contains instrumentation for positioning and monitoring of environmental parameters. A tower, which consists of 20 such structures interlinked by a system of ropes is anchored to the seabed and kept vertical by appropriate buoyancy on the top. The spacing between storeys is 40 m, while an additional spacing of 150 m is added between the anchor and the lowermost storey.

The power and readout is provided by a light-weight electro-optical cable that is kept separated from the system of tensioning ropes in order to reduce interference with the mechanical structure. Fibre optic technology is used for data transfer.

The towers are connected through a network of undersea cables and junction boxes and a single main electro-optical cable to shore. The towers are connected to the junction boxes through underwater wetmateable electro-optical connectors operated by a remotely operated vehicle (ROV).

The R&D activities of the NEMO collaboration consist of two successive phases. During Phase-1 a junction box and a demonstrator tower was installed at a test site close to Catania at a depth of 2000 m to verify the technologies.

The Phase-2 project, which is currently under construction, aims at installing an infrastructure, comprising a 100 km electro-optical cable already deployed, a shore station and a full scale tower, at the Capo Passero site at a depth of 3500 m.

For more than a decade, the feasibility of neutrino astronomy with a detector in the deep sea has been investigated in three pilot projects, ANTARES, NEMO and NESTOR. In each of these, different configurations and techniques have been explored.

These projects have provided a wealth of information on the technologies required for a large deep-sea neutrino telescope and constitute the KM3NeT consortium.

II. RESULTS AND DISCUSSION

Technical aspects under realisation on Phase-2 will be presented with particular attention to:

- Junction Boxes and Tower Prototype
- Power and Data Transmission [3]
- Connection System
- The KM3NeT Status

III. CONCLUSIONS

An underwater infrastructure is under realization on the deep sea site selected by the NeMO collaboration as a candidate for the installation of the km3 neutrino telescope.

All the activities carried out up to now by the NeMO collaboration will converge to the KM3NeT technical design of the European telescope detector in the Mediterranean sea.

IV. REFERENCES

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ESONET NOE : STATUS OF THE PROJECT

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The ESONET NoE project is now running for more then two years and will be continued at least until February 2011. we will present the first results.

6 demonstrations were funded and are running: LIDO, Marmara DM, Momar DM, MODOO, LOOME and AOME on seven of the proposed sites. They will allow to demonstrate the interest of permanent observatories and contribute to the definition of the implementation plan for these sites.

Standardisation efforts are progressing well. A guide for underwater intervention was published. Groups are working on “smart sensors” in Spain, France and Germany. All these results will discussed during the second “best practices meeting on Octobet8-9th.

A first draft of the “ESONET label” was established. It has to circulate between partners for approval.

SEAFLOOR OBSERVATORIES FROM EXPERIMENTS AND PROJECTS TO THE EUROPEAN PERMANENT UNDERWATER NETWORK EMSO

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Abstract - The establishment of a global network of seafloor observatories will help to provide the means to understand the ocean, and the complex physical, biological, chemical, and geological systems operating within it. This is a challenge for the opening decades of the 21st century. The EC experience on seafloor monitoring is outlined since the early stage (beginning of '90s). In particular, the attention is focused on the GEOSTAR experience, describing the technical characteristics and the sensors used in experiments. Some recent projects are detailed. Finally, the European effort towards permanent underwater network EMSO, one of the large-scale research infrastructures included in the ESFRI Roadmap, is also discussed. All the previous activities are framed in this context.

Keywords - multidisciplinary seafloor observatories, experiments and projects, European underwater permanent network (EMSO).

I. INTRODUCTION

The ocean exerts a pervasive influence on Earth's environment. It is therefore important that we learn how this system operates. Understanding the ocean, and the complex physical, biological, chemical, and geological systems operating within it, is a challenge for the opening decades of the 21st century. The establishment of a global network of seafloor observatories will help to provide the means to accomplish this goal. A fully comprehensive definition of the term "seafloor observatories" was given for the first time by the NRC report "Illuminating the Hidden Planet. The future of Seafloor Observatory Science", where we could read: "…an unmanned system, at a fixed site, of instruments, sensors, and command modules connected to land either acoustically or via a seafloor junction box to a surface buoy or a fibre-optic cable…" [1]. The main technical characteristic of a seafloor observatory is a two-way communication between platforms and instruments and shore. Seafloor observatories can have as possible configurations: 1) autonomous, 2) acoustically linked, and 3) cabled [2].
A global network of seafloor observatories will provide a powerful tool to understand the ocean and the complex physical, biological, chemical, and geological processes. Much of seafloor observatory research is indeed interdisciplinary in nature and has the potential to greatly advance relevant scientific sectors, such as: 1) the role of the Ocean in climate; 2) dynamics of oceanic lithosphere and imaging the Earth's interior; 3) fluids and life in the Ocean crust; 4) coastal ocean processes; 5) turbulent mixing and biophysical interactions; and 6) ecosystem dynamics and biodiversity [2]. Seafloor observatories can thus offer Earth and Ocean scientists new opportunities to study multiple, interrelated natural phenomena over time scales ranging from seconds to decades, such as: a) episodic processes; b) processes with periods from months to several years; c) global and long-term processes. Episodic processes include, for instance, volcanic eruptions, deep-ocean convection at high latitudes, earthquakes, tsunami, and biological, chemical and physical impacts of storm events.
The most technologically advanced countries, have launched a large number of projects and programmes addressed to long-term and multiparameter seafloor monitoring [2, 3]. Canada, USA, Japan, Taiwan and Europe are the major actors. In Canada the major component of this effort is NEPTUNE [4]. In USA the OOI a NSF Division of Ocean Sciences program [5] has launched the RSN [6]. One of the most recent Japanese projects is DONET [7]. In Taiwan the project MACHO to develop a submarine cabled observatory off-shore eastern part of the island [8].

II. THE EC GEOSTAR EXPERIENCE

The European experience on seafloor monitoring started in early '90s with the EC MAST Programme. Feasibility studies commissioned by EC were addressed to identifying the scientific requirements [9] and to establishing the possible technological solutions for the development of seafloor observatories [10]. In parallel, other studies and activities, such as DESIBEL [11], were carried out at EC level, aimed at defining needs and expectations for long-term investigations at abyssal depths.
Since 1995, INGV ran a scientific and technological programme for the development of deep-sea observation systems for geophysics, oceanography and environmental sciences. This programme was initially funded by the EC within the 4th and 5th FP through the two projects GEOSTAR (1995-1998) and GEOSTAR-2 (1999-2001) [12, 13, 14, 15, 16, 17]. Two paths were followed after the GEOSTAR experience: the development of other single-frame observatories devoted to specific applications and the enhancement of GEOSTAR as principal node of a network of seafloor observatories. These paths have led to the availability of other five GEOSTAR-class observatories and to the first European prototype of a deep seafloor observatory network. The information for all the developed single-frame observatories is shown in Table 1.

Platform	Overall dimensions (m) (L x W x H)	Weight (kN) (in air)	Weight (kN) (in water)	Depth rated (km)
GEOSTAR	3.5 x 3.5 x 3.3	25.4	14.2	4
SN1	2.9 x 2.9 x 2.9	14.0	8.5	4
SN2 (MABEL)	2.9 x 2.9 x 2.9	14.0	8.5	4
SN3	2.9 x 2.9 x 2.9	14.0	8.5	4
SN4	2.0 x 2.0 x 2.0	6.6	3.4	1
GMM	1.5 x 1.5 x 1.5	1.5	0.7	1

Table 1 - Relevant information for the six observatories

SN1 is addressed to seismological, oceanographic and environmental measurements, and was initially developed between 2000 and 2002 within the GNDT Italian programme. In 2005 it has become part of the cabled underwater infrastructure off Eastern Sicily (NEMO-SN1) [18], first real-time node of the future permanent underwater network, EMSO [19]. GMM, built within the EC ASSEM project (2002-2004) [20], is devoted to seafloor gas monitoring [21, 22]. Another single-frame system, MABEL (now SN2), was developed for polar sea applications within the framework of the Italian PNRA [23]. It just finished the experiment in the Weddell Sea (Antarctica), where it was deployed late 2005 and recovered late 2008 using the R/V Polarstern of AWI.
Within the framework of the EC ORION-GEOSTAR-3 project (2002-2005) [2, 3, 17], GEOSTAR was implemented to act as the main node of an underwater network of deep-sea observatories of GEOSTAR-class with the capability of (near)-real-time communication. In addition to this main node, two more observatories, with the function of satellite nodes (SN3 and SN4), were built and equipped with geophysical and oceanographic sensors.
The parallel running of the EC ORION-GEOSTAR-3 and ASSEM projects has given us the chance to integrate one of the ORION nodes (SN4) in the shallow water ASSEM system during the pilot experiment in Corinth Gulf. This integration was to demonstrate the compatibility of the two seafloor networks and the chance to operate a "coast-to-deep-sea" monitoring system in the near future.

III. TECHNICAL CHARACTERISTICS OF THE GEOSTAR SYSTEM

GEOSTAR system is designed as a stand-alone autonomous seafloor observatory, based on three main sub-systems [24]: A) the Bottom Station (BS), which is the frame equipped with sensors, power and Communication Systems (CS); B) the CS hosted by BS; C) MODUS, which was specifically designed to handle the BS from the sea surface during the deployment/ recovery operations, and operates like a simplified ROV.
GEOSTAR is capable of long-term (more than one year in stand-alone mode) multidisciplinary monitoring at abyssal depths. At present, the maximum operative depth is 4,000 m.

A. Bottom Station

The BS, a four-leg marine aluminium frame (Fig. 1, bottom), hosts a wide range of sensors, able to collect multidisciplinary data on the same spot. It also contains the battery pack (primary lithium), electronics mounted inside titanium vessels, hard disks for data storage and the underwater part of the communication systems. The BS mission is driven and controlled by a central DACS unit to allow the management of a complete scientific mission with a wide set of data streams and tagging each measurement according to a unique reference time provided by a central high-precision clock [2, 3, 17, 25].

B. Communication Systems

Two independent CS were originally developed for GEOSTAR, based on different principles [26]. The first one consists of buoyant data capsules, named Messengers (MES), releasable upon surface command or automatically, when filled

of data or in case of emergency. Two types of MES are available: a) expendable (data storage capacity 64 Kbytes); b) storage (data storage capacity larger than the expandable, 40 Mbytes). The capsules can transmit via ARGOS satellites their position at sea surface and small quantities of data. The second CS is based on a bi-directional vertical acoustic link with a ship of opportunity or moored buoy. A surface relay buoy, equipped with a telemetry unit and radio/satellite transmitters, assures the (near)-real-time communication between a shore station and the observatory on the seafloor [2, 3, 16, 17, 26].
The most recent communication link implemented on the GEOSTAR-class observatories was through the cabling: a proper interface between platforms and electro-optical cables was implemented on the SN1 observatory. This determined the realisation of the first real-time seafloor observatory in Europe, NEMO-SN1 off Eastern Sicily [18]. This area was identified as one of the key-sites for the nodes foreseen in the previous ESONET-CA [27] and the on-going ESONET-NoE [28] EC projects and in the EC-FP7 Research Infrastructure project EMSO [19].

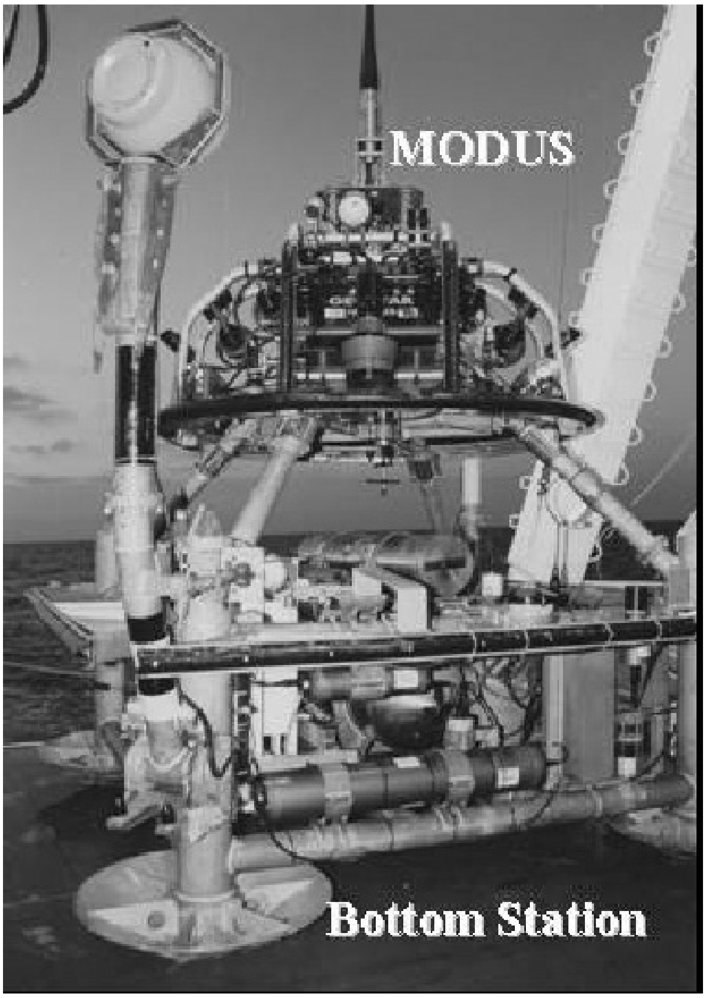

Fig. 1 - GEOSTAR BS (bottom) and MODUS (top)

C. MODUS

Accurate and safe positioning at seafloor, re-entry and recovery capabilities of the BS are ensured by the dedicated cable suspended module MODUS (Fig. 1, top), developed and built at TUB and TFH Berlin [29]. MODUS is a sub-sea intervention shuttle operating in deep seas while it is connected to a surface vessel with an umbilical, which provides power, bi-directional data-transfer via F/O telemetry and carries the load induced by the system during operation. MODUS was conceived to be driven by a ship-board operator and initially could be moved only horizontally by means of two thrusters as needed during the BS recovery. For deep-sea missions the MODUS was enhanced with the inclusion of two additional thrusters to power the horizontal movements, one transponder and one altimeter to check MODUS location at depth from the sea surface, and sonar to identify the BS location during the recovery. The MODUS frame is also equipped with video cameras for visual seabed inspection. This system is able to carry up to 30 kN at abyssal depths.

D. Sensors

All the instruments have a unique time reference, given by the use of a single high-precision clock (stability 10-9 ÷ 10-11). From 1998 to 2008, many experiments have been performed using the sensors listed in Table 2. The total amount of data has exceeded 300 Gbytes (binary data), equivalent to greater than 3600 operative days (>10 years).

Sensors	Typical sampling rates
3-C broad-band seismometer	100 Hz
hydrophone (geophysics)	100 ÷ 2000 Hz
hydrophone (bio-acoustics)	96 kHz
gravity meter	0.1 ÷ 1 Hz
scalar magnetometer	1 sample/min
3-C fluxgate magnetometer	1 sample/s
APG	1 ÷ 15 s
DPG	1 ÷ 15 s
precision tilt meter (X, Y)	10 Hz
3-C single-point current meter	2 ÷ 20 Hz
ADCP	1 profile/h
transmissometer	1 sample/h
turbidity meter	1 sample/h
CTD	1 sample/10 min (or /h)
nuclear spectrometer	1sample/4, 6, 8 h (stand-alone) 1 sample/30 s (real-time)
CH4 sensor	1 Hz
H2S sensor	1 sample/10 min
O2 sensor	1 sample/10 min (or /h)
chemical analyser (pH/eH)	1 sample/6 h
water sampler (off-line)	1 sample/500 s ÷ 1 week
(48 bottles)	

Table 2 – List of sensors used in seafloor experiments

IV. RECENT PROJECTS

A. Western Ionian Sea Observatory

SN1 was the first observatory based on the GEOSTAR technology. From October 2002 to May 2003 SN1 successfully completed the first long-term experiment off-shore Catania (Southern Italy, Eastern Sicily) at 2105-m depth in autonomous mode without any permanent acoustic or physical connection with the sea surface. SN1 was equipped with a vertical acoustic link to allow the remote request of the observatory data from a ship of opportunity and the retrieval of segments of acquired time series. During this experiment SN1 recorded about 15 Gbytes of data, mainly seismic. The high quality of the acquired data was demonstrated, definitively validating the procedure to deploy seismometer, de-coupling its housing from the frame coupling the instrument with the seabed [30]. The seismic events recorded only by SN1 opened new insights on the knowledge of the Ionian Basin seismicity [31].
After this experiment, SN1 was fitted with a fibre-optic telemetry interface so as to be compatible with the electro-optical cable owned and deployed off-shore from Catania by INFN and related with particle physics experiments. The cable layout is shown in Fig. 2.

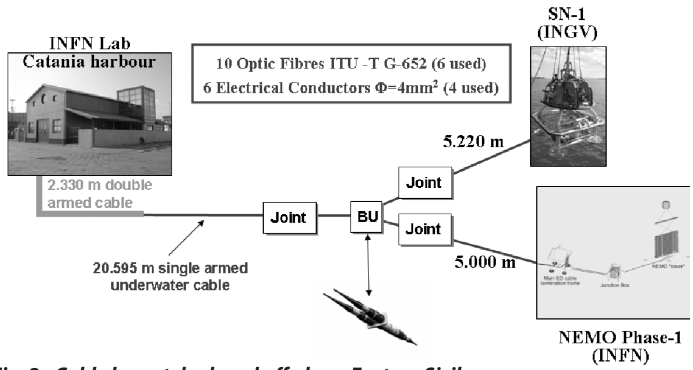

Fig. 2 - Cable layout deployed off-shore Eastern Sicily

In January 2005, the observatory was deployed by MODUS using the C/V Pertinacia of Elettra Tlc. in the same site of the first mission (about 25 km East of Catania at 2060 m w.d.) and connected to the submarine cable thus becoming part of the underwater infrastructure NEMO-SN1. These activities were performed under an agreement between two major Italian scientific institutions, INGV and INFN [18].
SN1 receives power from the shore, can communicate in real-time with the shore station inside Catania harbour, and is integrated in the INGV land based networks. NEMO-SN1 is the first real-time seafloor observatory in Europe and one of the few in the world.
At the end of April 2008, SN1 was recovered after 3 years and 3 months by MODUS using the C/V Certamen of Elettra Tlc. The observatory will be refurbished, adding sensors and functionalities, particularly taking into account geo-hazards and bio-acoustics. It is planned to be re-deployed and re-connected to the cable within 2009. These activities are performed in the frame of the PEGASO project funded by "Regione Siciliana", and the LIDO Demonstration Mission (LIDO-DM) funded by ESONET-NoE [28].

B. Iberian margin Observatory
The EC NEAREST project [32] proposes to place the sensors directly on the tectonic source to be able to monitoring the movements and to immediately recognise a tsunami. The area is the Gulf of Cadiz (Portugal) in which the destructive and tsunamigenic 1755 earthquake occurred destroying Lisbon [33]. During this project, GEOSTAR was installed in August 2007 south-west of Cape St. Vincent at over 3200 m w.d. and recovered in August 2008 always using R/V Urania of CNR. In this experiment, GEOSTAR was equipped with geophysical instruments and oceanographic instruments, and with a new prototype of "tsunameter". This tool has been appositely designed to operate in areas that generate tsunami waves in order to send automated alert messages. The tsunameter is based on a double check of seismic and pressure signals and keeps into account the seafloor movements. It is planned to continue this experiment re-deploying GEOSTAR in the same site in Autumn 2009 using the new Spanish ship, R/V Sarmiento de Gamboa, thanks to the LIDO-DM.
The Gulf of Cadiz is a key area defined by ESONET/EMSO as the future location of a permanent deep-sea observatory and NEAREST missions are considered a pilot implementation of this node.

D. Marmara Sea Observatory
The Marmara Sea developed along the highly active, right lateral strike-slip North Anatolian Fault, which produced devastating historical earthquakes along its 1600-km length [34]. The last destructive earthquake occurred at the eastern end of the Marmara Sea (1999 MW 7.4 Izmit and MW 7.2 Duzce earthquakes). The major earthquakes, that seriously struck Istanbul and occurred on the segment of the North Anatolian lying in the Marmara Sea, are since XVI century: 1509 (MW 7.2), 1566 (MW 7.3), 1754 (MW 6.8), 1766 (MW 7.2), 1894 (MW 6.8) and 1963 (MW 6.8) [35].
In 2008 the Marmara-DM was approved in the framework of ESONET-NoE [28]. This DM entitled "Multidisciplinary Seafloor Observa-tories for Seismogenic Hazards Monitoring in the Marmara Sea" aims at contributing to the establishment of optimized permanent seafloor observatory stations for earthquake monitoring in the Marmara Sea. Among the multiple activities planned in the Marmara-DM, a multidisciplinary seafloor observatory (SN4, Fig. 3) will be deployed in the eastern part of the sea at the westernmost end of the fault rupture caused by the 1999 Izmit earthquake using the oceanographic vessel R/V Urania of CNR. This experiment initially will last 1 year starting from autumn 2009 and we intend to continue over the time depending of the resources that will be available. Its major scientific goal is to contribute to the knowledge on the relationship between gas seepage and earthquake occurrence It is well known that gas migration and surface gas anomalies, seepage and even eruptions of mud volcanoes, substantially increase in connection with earthquakes (e.g., [36], [37]).
The Marmara-DM is a first step towards the realisation of a permanent long-term monitoring system fully integrated with the land-based stations, node of EMSO.

V. EMSO and ESONET-NoE
In Europe the effort for realising permanent underwater network is being supported by the EC through EMSO, an European-scale infrastructure of underwater observatories, constituting a widely distributed infrastructure for long-term monitoring of environmental processes related to ecosystem life and evolution, global changes and geo-hazards [19]. Parallelly another relevant European initiative is running, ESONET-NoE project, that aims at boosting the integration of the European Ocean Sciences community interested in observatories and comprises more than 50 European universities, research institutes, companies involving 14 countries and about 300 scientist, engineers and technicians [28]. EMSO infrastructure is included in the ESFRI Roadmap [38] and will constitute the sub-sea segment of GMES [39] and GEOSS [40].
EMSO nodes are placed in specific marine sites on the European Continental

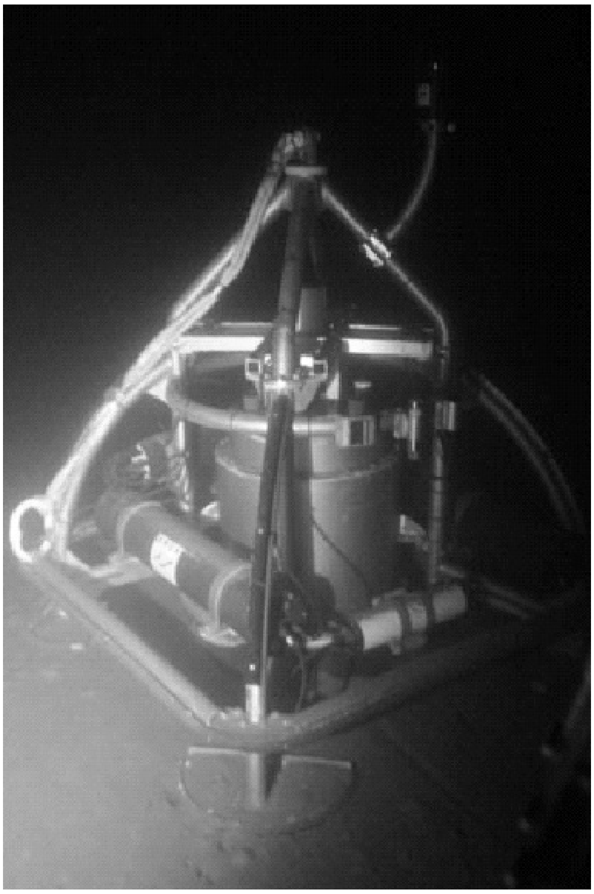

Fig. 2. SN4 on the seafloor of the Gulf of Corinth (400 m w.d., April-November 2004) in the frame of ASSEM [20].

Margin from the Arctic to the Black Sea through the Mediterranean Basin (Fig. 4). The design and development of the nodes depend upon the geographical location, the scientific and operational requirements. Two basic models can be envisaged for the nodes: stand-alone acoustically linked observatory and cabled observatory. However hybrid configurations could be adopted according to the site characteristics. The nodes will be equipped with a common set of sensors for basic measurements and further sensors for specific purposes.
EMSO will be transformative by addressing interdisciplinary research priorities in:
• Physical oceanography: water mass characteri-sation, thermodynamics, ice cover, climatology, and impacts on climate change;
• Geoscience: transfer from Earth's interior to the crust, hydrosphere and biosphere, fluid flow and gas seepage through sediments and gas hydrate, non-living resources, sediment transfer to deep-sea and climate change;
• Geo-hazards: earthquake and tsunami hazard, volcanic hazard, slope stability;
• Biogeochemistry: global carbon cycle and elemental cycling within the ocean through both physical and biological processes;
• Marine ecology: distribution and abundance of sea life, ocean productivity, biodiversity, ecosystem function, living resources, and climate feedbacks.
EMSO will allow to understand:
• the environmental processes as the geo-, bio-, and hydro-sphere interactions;
• the temporal evolution (short-, medium- and long-term, periodic and episodic events) of the oceanic circulation, earth processes, deep-sea environment and ecosystems.
EMSO will take advantage of the synergies between the scientific community and the industry and will contribute to a significant improvement of marine technologies and the development of strategies for improving European capacities and competitiveness in ocean sciences and technologies.
The rationale for EMSO infrastructure is based on the following issues:
• Scientific: the sea as key element to understand the dynamics and evolution of the Earth components;
• Technological: maturity of methodology and approaches for deep-sea observations (i.e., long-term time series);
• Strategic: environmental control for preservation (habitat, biodiversity), mitigation of hazards, new resources exploitation;
• Cultural: strengthening the ERA.

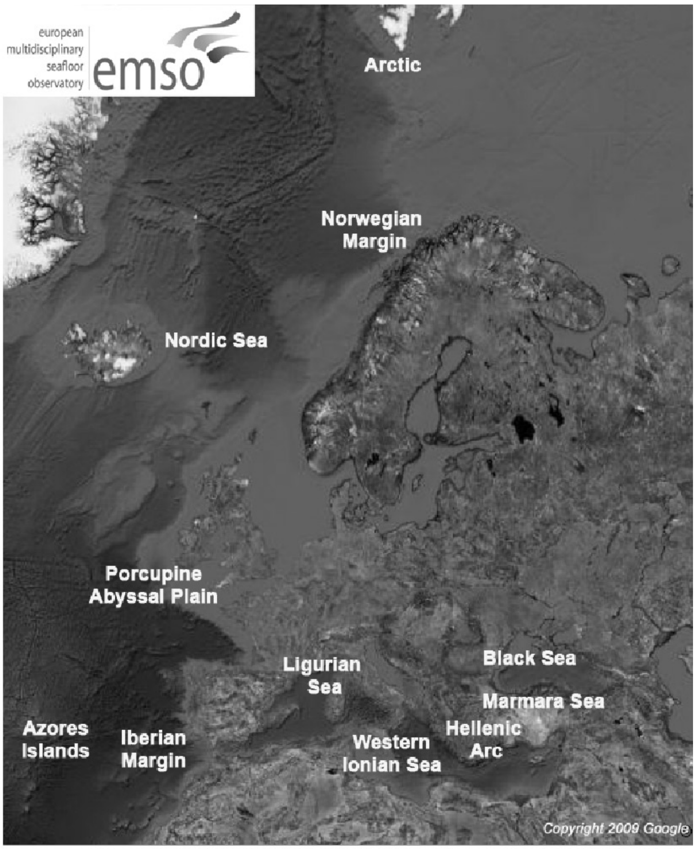

Fig. 4. Map of the EMSO nodes

EMSO is presently in the Preparatory Phase (EMSO-PP) with a project of EC-FP7. This project will establish the legal entity EMSO which is able to manage the scientific, technical, logistic and administrative components of the infrastructure. EMSO-PP has started in April 2008 and will run for 4 years.

VI. ACKNOWLEDGEMENTS

The Authors wish to thank those institutions involved in the European and Italian projects (A) GEOSTAR (EC), (B) GEOSTAR-2 (EC), (C) ASSEM (EC), (D) ORION-GEOSTAR-3 (EC), (E) NEMO-SN1 (IT), (F) MABEL (IT), (G) NEAREST (EC), (H) ESONET-NoE (EC), (I) EMSO-PP (EC):

INGV (CO: A, B, D, E, F, I; PA: C, G, H)
ISMAR-CNR (CO: G; PA: A, B, D, E, H)
Tecnomare SpA (ENI Group) (PA: A, B, D, E, F, H; SC: C, G)
TFH (PA: A, B, D, E, F, G, H)
TUB (PA: A, B, D, E, F)
IFREMER (CO: C, H; PA: A, B, D, I)
SER (PA: A, B, D, H; SC: C)
IFSI-INAF (PA: E; SC: B, D, G)
IPGP (PA: B, C, H)
HCMR (PA: C, H, I)
INFN (CO: E [NEMO]; PA: E [SN1], H)
FFCUL, UTM-CSIC (PA: G, H, I)
LOB-CNRS (PA: A, B)
INOGS (PA: E, F)
KDM, IMI, UGOT, NOCS, UiT, ITU, NIOZ (PA: H, I).
IFM-GEOMAR (PA: D)
Patras University, CAPSUM, NGI, FUGRO (PA: C)
University of Roma-3, Catania, Messina, Palermo (PA: E)
AWI, UBO, UGR, IM, CNRST, XISTOS (PA: G)

Thanks to: Claudio Viezzoli, Marcantonio Lagalante and Carmine Capua (marine logistics). Special thanks to: Capts and the crews of R/V Urania, M/P Mazzarò, C/V Pertinacia, R/V Polarstern and C/V Certamen.

CO = Co-ordinator; PA = Partner(s); SC = Sub-contractor

V. ACRONYMS AND ABBREVIATIONS

ADCP - Acoustic Doppler Current Profiler
APG - Absolute Pressure Gauge
ASSEM - Array of Sensors for long-term SEabed Monito-ring of geo-hazards
AWI - Alfred-Wegener-Institut für Polar und Meeresfors-chung
CAPSUM - CAPSUM Technologie GmbH
CNR - Consiglio Nazionale delle Ricerche
CNRS - Centre National de la Recherche Scientifique
CNRST - Centre National pour la Recherche Scientifique et Technique
CSIC - Consejo Superior de Investigaciones Cientificas
CTD - Conductivity, Temperature vs Depth
DACS - Data Acquisition and Control System unit
DESIBEL - DEep-Sea Intervention on future BEnthic Laboratory
DM - Demonstration Mission
DPG - Differential Pressure Gauge
DONET - Dense Oceanfloor Network system for Earthqua-kes and Tsunamis
EC - European Commission
EMSO - European Multidisciplinary Seafloor Observatory
ENI - Ente Nazionale Idrocarburi
ERA - European Research Area
ESFRI - European Strategy Forum on Research Infrastru-ctures
ESONET-CA - European Seafloor Observatory Network-Concerted Action
ESONET-NoE - European Seas Observatory Network-Network of Excellence
FFCUL - Fundação da Faculdade de Ciências da Universidade de Lisboa-Centro de Geofísica da Universidade de Lisboa
FP - Framework Programme
FUGRO - FUGRO Engineers
GEOSS - Global Earth Observation System of Systems
GEOSTAR - GEophysical and Oceanographic STation for Abyssal Research
GEOSTAR-2 - GEOSTAR 2nd Phase: Deep-sea mission
GMES - Global Monitoring for the Environment and Security
GMM - Gas Monitoring Module
GNDT - Gruppo Nazionale per la Difesa dai Terremoti
HCMR - Hellenic Centre for Marine Research
IFM-GEOMAR - Leibniz-Institut für Meereswissenschaften an der Universität zu Kiel
IFREMER - Institut Français de Recherche pour l'Exploitation de la Mer
IFSI - Istituto di Fisica dello Spazio Interplanetario
IM - Instituto de Meteorologia Divisão de Sismologia
IMI - Irish Marine Institute
INAF - Istituto Nazionale di Astrofisica
INFN - Istituto Nazionale di Fisica Nucleare
INGV - Istituto Nazionale di Geofisica e Vulcanologia
INOGS - Istituto Nazionale di Oceanografia e Geofisica Sperimentale
IPGP - Institut de Physique du Globe de Paris
ISMAR - Istituto di Scienze Marine
ITU - Istanbul Teknik Universitesi
KDM - Konsortium Deutsche Meeresforschung e.V.
LIDO - LIstening to the Deep Ocean
LOB - Laboratoire d'Océanologie et de Biogéochemie
MABEL - Multidisciplinary Antarctic BEnthic Laboratory
MACHO - Marine Cable Hosted Observatory
MAST - MArine Science and Technology
MODUS - MObile Docker for Underwater Sciences
NEAREST - Integrated observations from NEAR shorE Sources of Tsunamis: towards an early warning system
NEMO - NEutrino Mediterranean Observatory
NEPTUNE - North East Pacific Time-series Underwater Networked Experiments
NGI - Norges Geotekniske Institutt
NIOZ - Stichting Koninklijk Nederlands Instituut voor Zeeonderzoek
NOCS - National Oceanography Centre Southampton
NRC - National Research Council
NSF - National Science Foundation
OOI - Ocean Observatories Initiative
ORION-GEOSTAR-3 - Ocean Research by Integrated Observation Networks
PEGASO - PotEnziamento di reti Geofisiche e Ambientali SOttomarine
PNRA - Programma Nazionale di Ricerche in Antartide
ROV - Remotely Operated Vehicle
RSN - Regional Scale Nodes
SNn - Submarine Network n ($n = 1 \div 4$)
SER - SERCEL Underwater Acoustic Division (former ORCA Instrumentation)
TFH - Techniche FachHochschule Berlin
TUB - Technische Universität Berlin
UBO - Université de Bretagne Occidentale
UGOT - Goteborgs Universitet
UGR - Universidad de Granada, Instituto Andaluz de Geofísica

UiT - University of Tromsø
UTM - Unitat de Tecnologia Marina
XISTOS - XISTOS Développement S.A

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TIME BASE STABILITY OF OCEAN BOTTOM SEISMOMETERS (OBS)

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Abstract - During the past decades, Ocean Bottom Seismometers (OBS) have played a key role in permanent seismic activity monitoring at sea as well as allowing a better understating of the earth interior. Data collected by the instrument can provide information on the ocean bottom sub-layers down to a depth of 40 km beneath the ocean floor. The accuracy of the results directly depends on the temperature stability of the crystal used as the main time base of the equipment.
This paper presents the study of temperature stability of a Seascan module in real environmental conditions. By means of a climate chamber, temperature tests of a Seascan module were carried out and crystal temperature stability was calculated.

Keywords - Ocean Bottom Seismometer (OBS), stability, temperature.

I. INTRODUCTION

Over the past few decades, Ocean Bottom Seismometers (OBS) have gained special attention by the geo-scientific community. They are autonomous instruments that are deployed on the sea-bed up to depth of 6000 meters, where they collect sea floor vibration and water pressure data. The OBS is equipped with two main sensors: a tri-axial geophone composed of three SM6 accelerometers placed at right angle (one for each axis) inside aluminium housing, which collects the ocean bottom vibration, and a hydrophone that registers water pressure data. A side arm holds the geophone during the freefall and drops the sensor when the OBS is on the sea floor. The datalogger, battery pack and other necessary electronic modules are placed inside a glass sphere which is sealed by means of a vacuum holding both semi-spheres together [1]. Fig. 1 shows a picture of the OBS.

In passive seismology, the equipment collects ocean floor vibrations caused by a natural source (earthquake), where the objective is to determine the magnitude and location of the activity. Passive seismology demands an autonomy of about one year, but when the OBS is used in a sea-floor observatory, it is powered through a marine cable and has no power limitations.

Fig. 1. Ocean Bottom Seismometer (OBS)

In active refraction experiments, a series of OBSs are deployed on the sea-bed and an artificial source (compressed air-gun) is dragged by the oceanographic vessel in order to generate acoustic signals every certain time during the experiment. The generated signal travels to bottom of the sea as well as through the earth being reflected and refracted by different ocean bottom sub-layers. These signals are collected by the OBS sensors, time stamped and stored in a compact-flash memory card.

When the experiment is over, an encoded acoustic signal is sent from the ship to the OBS which releases the anchor weight used to sink the instrument to the bottom of the ocean and the OBS rises to the surface due to its structural floatability.

In active seismology, after data processing in the lab, a map of the sea-bed down to a depth of 40 km beneath the ocean floor can be obtained, giving information on the width and material of each layer. In this case, the parameter that provides this information is the velocity of sound through different layers, which is estimated by accurate knowledge of the elapsed time between an acoustic signal generated by the artificial source and data collection by the OBS. It is known that the velocity of sound in the water column is 1500 m/s approximately [2]. While, air-gun shot timing is controlled by a GPS (Global Positioning System) [3] on the ship, the OBS has no access to such a signal for time synchronization during the entire experiment. The OBS clock is synchronized with a GPS signal prior to its deployment and clock time drift is calculated after OBS recovery by using the same signal. In the signal processing stage, data time marks are corrected assuming that the time drift of the OBS is linear during the experiment. While, marine institutes have put great effort in improving the data quality by minimizing the noise performance of the datalogger, the time mark correction of the data which has a direct effect on the final sound velocity model through the earth layers, has not been investigated in detail. This paper takes steps towards time drift characterization of ocean Bottom Seismometers by finding their temperature stability under real environmental conditions.

II. RESULTADOS Y DISCUSIÓN STABILITY CHARACTERIZATION

The main environmental parameters that affect the crystal oscillator output frequency are [4]:

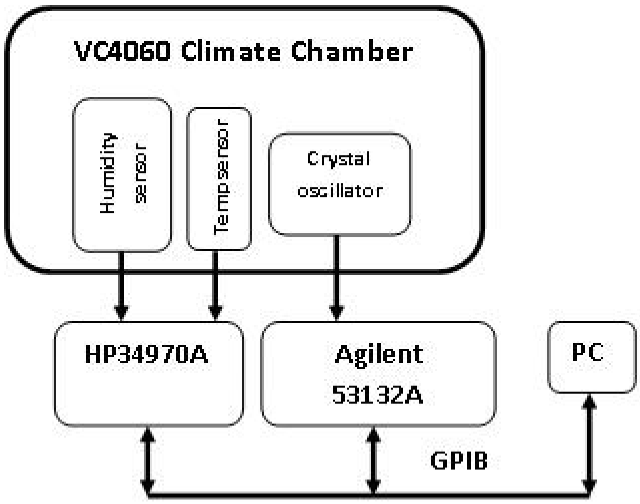
1-Temperature, humidity and Pressure
2-Acceleration effects
3-Electric and magnetic fields
4-Ionizing and radiation effects
5-Aging, warm-up and retrace

Due to design and operation of the OBS, the main parameter that is taken into account is temperature. As mentioned in the previous section, all the electronic modules are placed inside a glass sphere housing sealed under vacuum. The pressure inside the housing remains constant during the entire experiment and therefore does not affect the crystal oscillator. The OBS is designed to move at constant velocity of 1 m/s during the free fall and rising stage eliminating the effects of acceleration on the crystal. The time base module is placed inside a shielded box minimizing the effects of electro-magnetic fields and no ionization nor radiation takes place inside the instrument during the experiment. Parameters as aging and warm-up are given by the crystal manufacturer and frequency retrace does not affect the data as we are dealing with a time drift (time difference).

The crystal oscillator is placed inside a VC4060 environmental chamber where temperature is controlled.

In order to know the temperature close to the Seascan module, a temperature sensor is placed beside it and 4-wire measurements of the sensor is carried out. A HP34970A datalogger is used to measure the temperature and an Agilent 53132A universal counter with a temperature stability of 2.5 x 10-9 was used to measure the Seascan output frequency (125Hz). In order to obtain an improved resolution, frequency is measured within a time gate of 1s. The overall measurement system is controlled by a PC through a GPIB bus, where software in LabVIEW 8.5 takes measurements every 10 seconds. Fig. 2 shows the measurement system in the lab:

(Next Page) ***Fig. 2. Measurement system block diagram***



During the tests, the temperature profile is configured to simulate the OBS real operation:

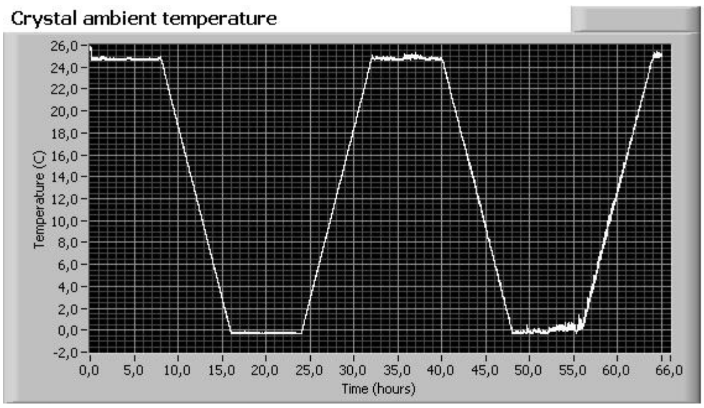
1-From 25 oC to 0 oC in 8 hours
2-At 0 oC constant for 8 hours
3-From 0 oC to 25 oC in 8 hours
4-At 25 oC constant for 8 hours

This profile was cycled twice to show data consistency. The time base module stability is calculated as:

$$Stability = \frac{f_i - f_{nom}}{f_{nom}}$$

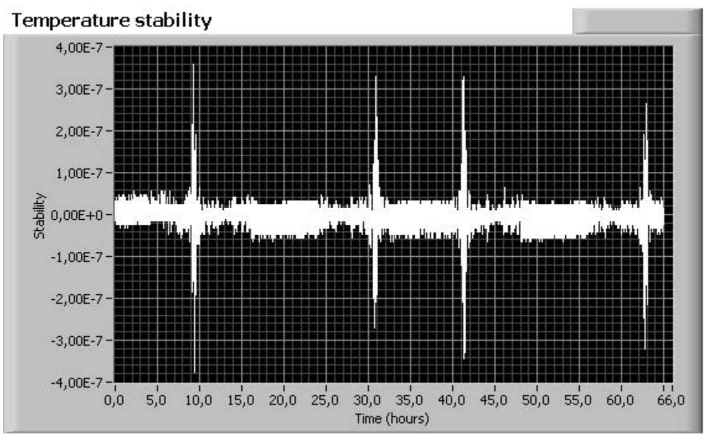
III. RESULTS

Figures 3 and 4 show the temperature profile and stability results of the test described in section 2 respectively. The test period was 65 hours.



(above) Fig. 3. Crystal ambient temperature during the test

(below) Fig. 4. Stability of the time base module



These figures show that the stability data are highly symmetrical and its mean value is ±1.3x10-8. Furthermore, when the temperature goes through 21 oC, the stability increases dramatically. In crystal oscillators, the temperature stability is highest at the turn over temperature [5]. At this temperature, the stability changes polarity. In order to find the turnover temperature of the Seascan module, The static frequency-Temperature (f-T) characteristic is found as:

$$\frac{\Delta f}{f_{nom}} = a_0 + b_0(T - T_0) + c_0(T - T_0)^2 + d_0(T - T_0)^3$$

Where T0 is 25 oC for an AT.-cut crystal. Figure 5 shows the f-T characteristi c of the time base module when the temperature is increased from 0 oC to 25 oC:

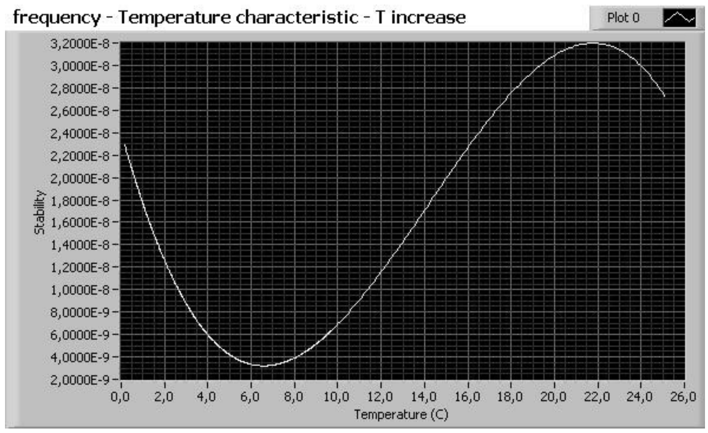


Fig. 5. f-T characteristic of the time base module.

The temperature coefficients of frequency
are found to be:

a_0= 2.75 x 10-8
b_0= -2.92 x 10-9
c_0= -5.32 x 10-10
d_0= -1.64 x 10-11

Figure 5 shows that the f-T characteristics has a maximum at 21 oC (turnover temperature). The turnover temperature depends on the quartz property and its angle of cut.

IV. CONCLUSIONS

In this paper, the stability of a time base module used in most Ocean Bottom Seismometers (OBS) is investigated. The temperature was set to simulate the OBS operation and the mean stability is figured at ±1.3x10-8. The stability degrades around the crystal turnover temperature (21 oC). The f-T characteristics of the module is found by a 3rd order polynomial curve fit. In future work, the data presented in this paper will be used to characterize the time drift of Ocean Bottom Seismometers.

ACKNOWLEDGEMENT

The work presented in this paper was funded by the reasearch projects: Caracterización de Sistemas Mediante Tecnicas Acústicas Multicanal (DPI2007-66615-C02-02) and Sismómetro Marino de Profundidad (PET2007_0240) and is the result of our collaboration with Tecnoterra associated Unit of Consejo Superior de Investigaciones Científicas (CSIC).

V. Referenciases

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SEABED SEISMIC COUPLING – TESTING AND EVALUATION PROBLEMS

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Summary - Coupling of gravity deployed Ocean Bottom Seismometer multicomponent sensors has been an issue for at least 30 years, and remains largely an empirical art rather than a science. There are a number of reasons why it retains it elusive nature ;- the environment is generally hostile and all operations have to be conducted remotely, the nature of the seabed is highly variable from place to place, so that it is impossible to directly compare results from different sites, but largely because making detailed in-situ comparisons of a number of sensors accurately deployed in controlled deep sea conditions adjacent to each other is extremely costly. This paper considers some of these problems, and ways in which coupling can be evaluated in the laboratory, and the limitations that result. Variations of the internal sensor geometry also affect the sensor response in deployed sensors.

The history of multicomponent sensor packages for Seabed seismics has been marked by many designs that can be seen on a cursory inspection to offer poor coupling fidelity, and rather few designs that inspire much confidence. The basic reason for this poor design lies in a failure of designers to understand intuititively the properties of the seabed. This can largely be traced to the difference between the properties of seabed materials we observe when we handle them in the lab or in shallow water muds, and the mud properties as they affect seismic waves. Put simply, all our physical experience of mud is related to its properties ABOVE the yield point, whereas seismic signals received are invariably in the elastic range well below these levels. Because of this, designers have failed to take account of the seabed as a very springy undamped material. Once one accepts the intuitive idea that seabed mud behaves like a sheet of foam rubber, the true nature of the problem becomes evident.
I first became aware of the complexity of seabed coupling through an unplanned comparison of two cylindrical 3 component seismometers – one deployed on end and one on its side. Since the physical sensor difference was gross and there were several sensors of each type, it was not necessary to account for minor variations in the depth to which each sensor sank in the mud, or of local variations in mud properties within the area. Where intercomparisons are designed to investigate differences between several sensors that have been designed carefully for good coupling, these minor differences may well mask significant differences between different designs. Even if a good intercomparison can be made, and significant differences in sensor response are evident, these may well only apply on that particular seabed and with that deployment technique.
Planning a good comparison test in a real seismic environment requires either a large enough number of each sensor type to give statistically meaningful results, or some means of carefully controlling and monitoring the deployment and orientation of each sensor to ensure that it is deployed in its optimum way. Achieving this degree of control almost certainly requires a R.O.V. to deploy and check instruments and is thus very costly. Either way, a good intercomparison is real conditions is a complex and costly operation and yields information related to that particular environment only.

One alternative to 'real world' testing is to reproduce a piece of seabed in the laboratory and use this for tests. The first complication is that we are moving from a real environment where the seismic wavelength is small compared to the physical dimensions of our 'laboratory' to a situation where the test facility is a very small fraction of a seismic wavelength. This inevitably means that the interaction of our model seabed with its boundaries is of comparable complexity to the interactions of the sensor with the 'seabed'. We must then consider how we are to generate and apply our test excitation to simulate the seismic arrivals. This is not as easy as it might seem:- in the real world seismic signals of interest consist of 'pressure' (p) waves and 'shear' (s) waves that both arrive substantially vertically. In the laboratory model we have to substitute direct physical vibration in such a way so that we can control or compensate for spurious motions introduced by our simulated seismic wave. Assuming that we can impart a controlled, known motion to some external boundary of the 'seabed', we have to be able to measure the actual motion of the material surrounding the sensor. Some idea of the complexity of this problem can be gained by thinking of the complexity of the motion of a bowl of jelly (American: jello) when the bowl is shaken!
This complexity when using a simulated soft deep sea mud highlights one of the limitations of conventional geophones:- To describe completely the motion of a rigid body in 3 dimensional space requires 6 independent components – conventionally we chose the set of 3 translations and 3 rotations about orthogonal axes. A 'standard' geophone has only 3 components, orthogonal x and y horizontal components and z vertical component and so does not respond to rotations about these axes – i.e. when correctly positioned it measures translations corresponding to the principal directions of the (theoretically perfect) seismic signals and has minimal sensitivity to spurious rotations. A number of industry seismic geophones, however, use a Galperin configuration, which consists of a set of 3 orthogonal sensors oriented symmetrically about a vertical axis so that each inclines at 37.3 degrees to the horizontal. In this configuration the sensors respond to both xyz translations AND rotations about x and y axes but not about z. Furthermore the response to rotations depends upon whether the sensors in the Galperin configuration converge upward or downward.
These differences between sensor configurations, combined with the complexity of the expected motion within the test volume mean that we have to measure and record all 6 components of motion for as much of the system as we can – at least for the simulated seabed in the region in which the sensor is sited, and preferably also of the sensor itself, if necessary by adding small external sensors. When this is taken into consideration, it means that any recording system monitoring the experiment will need a minimum of 12 channels and probably 18 to 24 to stand a chance of capturing the expected motion.
An alternative to shaking the whole test volume is to put small shakers within the sensors and effectively measure the inverse coupling of the sensors. This approach has been used and does give some information about the coupling, but of course introduces a whole new set of complications.
So far we have assumed that we can find a material that will simulate deep sea mud. Conventionally it has been assumed that china clay can be mixed with water and settled and possibly subsequently de-watered to give the required strength to simulate a particular seabed mud. However, there is increasing evidence that first few metres of the seafloor owes its physical properties more to biological activity than to the inert materials it mostly consists of. Recent analysis of mud from offshore Angola, for instance, suggests that the top few meters of mud have all passed through the digestive tracts of seabed worms, and been packaged into protein wrapped bundles that retain their effective low strength properties until the gravitational load a few meters down overcomes the strength of the bundles. It is therefore doubtful whether lab tests can ever be reliable indicators of deep sea performance.
Taken together this represents a formidable challenge to any attempt to quantify the coupling of a seabed sensor package. Field tests are inevitably of limited validity, complex and expensive. Lab tests result in extremely complex motions and the analysis of large volumes of data. One possible solution is currently being investigated – a seismic test range on inter-tidal mud where a small source and reference geophones can be used to generate and monitor a simulated shear wave and a number of sensors can be compared, not necessarily at the same time.

UNDERWATER SEISMOMETER VALIDATION

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Abstract - This work verifies and validates the calibration in a marine geophone by means of a hyperbaric chamber before and after the pressure underwater laboratory test. The objective is to characterise the transfer function according to the frequency of coupling between the geophone and the sediment. It is possible to observe the geophone coupling variations through the sediment after the test inside the water pressure at the equivalent of 200 metres depth.

I.INTRODUCTION

In marine seismic prospecting, the seismometer acquires the vibrations of the seabed. The waveforms can be artificially generated at an oceanographic vessel on board and registered by the OBS (Ocean Bottom Seismometer), which can record natural seismicity too. With appropriated mathematical algorithms, the cortical distribution can be deduced (speed, deepness); the geological properties of the rocks and constitutive layers can be studied as well. The OBS measures the refracted vibrations of the seabed by means of a geophone with three orthogonal sensors GS11 and frequency range from 0.1 to 100 Hz, in order to investigate the composition and stratification of oceanic subsoil.

II.MEASURES IN THE LAB

The initial test is to calibrate the geophone without sediment with a shaker table, put inside the hyperbaric chamber; moreover, in order to obtain its transfer function of voltage output according to vibration in m/s, at the end calibrate in the same conditions and orientations like a first calibration.

To characterise the underwater performance and the sediment interaction with the geophone we need a precise model to obtain the real answers.

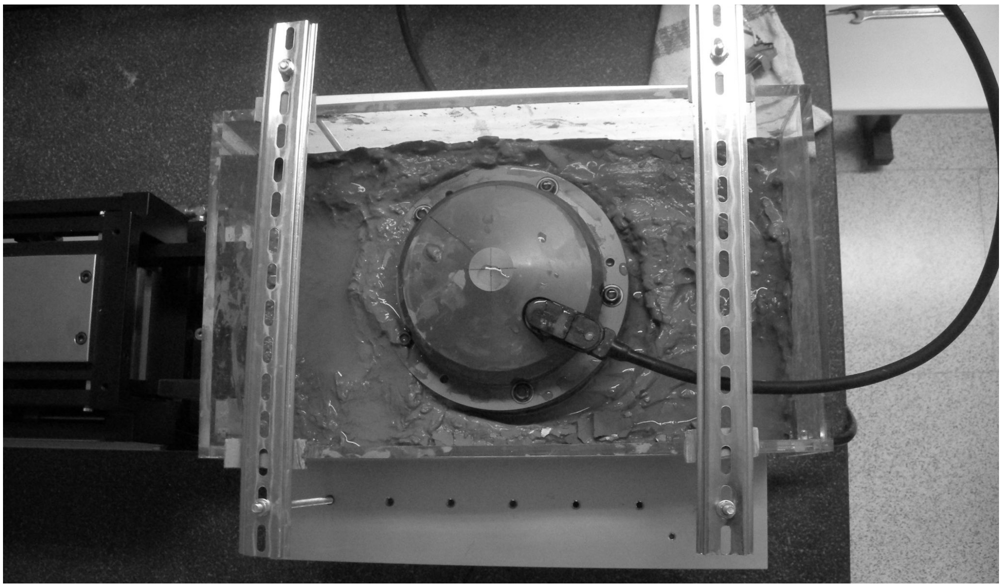

Fig.1 Sediment box and geophone in a shaker

The similar calibrations of geophone channels through the sediment on the shake table are tested (figure 1).The next process is to put the sediment box and the geophone inside the hyperbaric chamber at 20 atmospheres of water pressure to measure the output of the geophone sensors to know its performance, changes and response underwater at a depth of 200 meters.

The last process is to calibrate once more the sensors of the geophone through the sediment and compare it with the first calibrations both under the water and without water, in the exactly same conditions of the initial tests.

The second calibration results in the geophone channels get the similar sensibility transfer functions, which are compared in figure 2 and we can observe the same values and some change of frequency of maximum in the H2 channel sensibility.

III.RESULTS AND DISCUSSION

We can observe in figure 2 that the geophone supported the water pressure and worked correctly underwater thanks to airtight structure and its sensibility is the same after the underwater test. The sensibility is practically the same (±3%) when testing the sensor geophone, except at highest frequency due to a resonant effect in the shaker and its support structure.

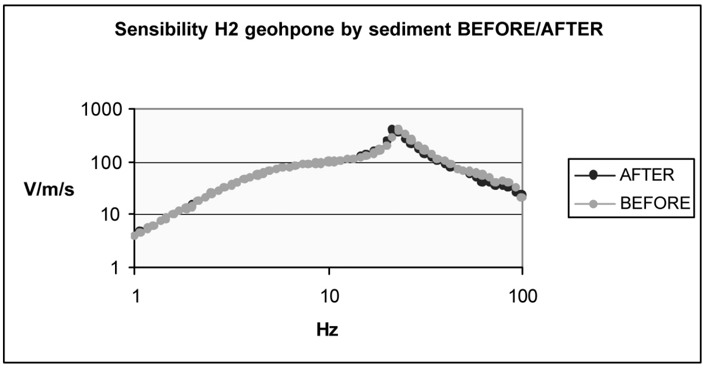

Fig.2 Compared sensibility H2 channel geophone by sediment

The results showed the good behaviour of the geophone designed structure and validates the design in the real test in underwater conditions that do not change the sensibility of the geophone and the coupling sensibility after extreme pressures such as oceanic trenches of 6000m.

ACKNOWLEDGMENTS

Special thanks to the project Signal Transmission in Light and Autonomous Underwater Sensors (CTM2004-04510-C03-00) funded by the Spanish Research and Technology Management Unit (DGICYT), as a continuation of the project New Generation of Light and Autonomous Underwater Sensors-SENSUAL (Ref:REN2000-1016-C02-01/02) which is a joint work between Technical University of Catalonia (UPC), Marine Technology Unit (UTM) and Technical University of Navarra (UPN) Tecnoterra Associated Unit.

THE ICTINEU 3 PROJECT: A MODERN MANNED SUBMERSIBLE FOR SCIENTIFIC RESEARCH AND INTERVENTION

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Abstract - This paper describes the current state of Ictineu 3, the first project of Ictineu Submarins S.L., which aims at designing, building and operating a modern manned submersible for scientific research and intervention at a maximum depth of 1200m. This will be the first manned scientific submersible to be built and operated in the Iberian peninsula since the Ictíneo of Narcís Monturiol, and will help reduce the gap in our ocean exploration and intervention capabilities as well as pay a tribute to its old ancestor. This new submersible will employ state of the art technologies in areas such as material engineering, energy storage, navigation, control, and communication systems. Its main applications will range from deep seabed research, science dissemination, environmental protection, and archaeology to salvage operations and support to the offshore industry. The first sea trials are scheduled for the second half of 2010.

Keywords - Manned submersibles, Ictíneo, Monturiol, propulsion systems, navigation and control systems, sensor platforms, ocean exploration, structural design.

I. INTRODUCTION

In June 1859, Narcís Monturiol launched the Ictíneo submersible in Barcelona's harbour, the first operative civil submersible in history. The Ictíneo (7m long, 10 tons displacement) could fit up to six people and made 69 successful dives without incidents. Later in 1864 a second Ictíneo was built (17m long, 72 tons displacement) which employed an anaerobic engine able to produce heat for propulsion and breathable oxygen among other cutting edge technological solutions [1][2][4]. After 150 years, the company Ictineu Submarins S.L. is building the Ictineu 3, a modern scientific manned submersible which will help reduce the gap in our deep sea exploration and intervention capabilities as well as pay a tribute to Narcís Monturiol [6].

II. ICTINEU 3 DESIGN AND CAPABILITES

Ictineu 3 is conceived as a modern manned submersible which will incorporate innovative materials and advanced manufacturing techniques, efficient and environmentally friendly power systems, intelligent management and control systems and the most advanced technologies in safety, positioning, navigation, communication, sensing and data logging. It will be a highly versatile tool conceived to be adapted and modified for each specific customer mission needs and as newer technological solutions become available. A submersible that will play a central role in any scientific mission to be imagined under-seas. The first sea trials are scheduled for the second half of 2010.

The Ictineu 3 is a small and light weight manned submersible with high capabilities. Its main specifications are listed in Table 1, and a 3D model is shown in Fig.1. It will dive safely down to 1200 meters, making it one amongst the ten deepest submersibles in operation at present. It will be capable of carrying one pilot and two passengers, with an operative autonomy of 10 hours. Although a typical mission lasts between 3 and 6 hours, it will have reserve oxygen tanks and an emergency life support autonomy for 5 days. At the front, a big acrylic viewport (Ø1200 mm) will provide the crew with an exceptionally wide field of view, excellent for high quality photography and video capturing.

From the operational point of view several milestones have been fixed. The reduced size and a wide front viewport will provide easy and comfortable operation, as well as getting very close to the working area. The hydrodynamic shape has been designed for both optimal navigation and for safety reasons (e.g. avoiding stuck into nets). The capability to fully empty the diving tanks at surface will provide 600 mm between the design water line (dwl) and the entry hatch. This height together with the external shape design will allow passengers to get in and out the submersible once it is in the water, in good weather conditions.

General specifications	**Propulsion**		
Operating depth	1200 m	Main electric thrusters	4 x 2.7 kW
Weight in air	5.000 kg	Maneouvring thrusters	4 x 1.25 kW
Dimensions	4.8 x 1.9 x 2.8 m	Batteries	
Pressure hull diameter	1.7 m	Main battery group	Li-ion 4 x 70Ah 120V
Crew	1	Secondary group	Li-ion 160Ah 24V
Passengers	2	Safety	
Air and oxygen	Emergency life support	10 days	
Air	4 x 40 l (700 bar)	Jettisonable weight	500 kg
Oxygen	2 x 10 l (200 bar)	Total buoyancy capacity	1580 kg
Emergency oxygen	2 x 40 l (200 bar)	Emergency buoy	1800 m spectra rope
Dynamic characteristics	Equipment		
Cruising speed	1.5 knots	Sonar	Echosounder, Forward looking
Maximum speed	4.5 knots	Robotic manipulators	2 x 6 DoF
Range	10 NM	Lights	LED 1000 W
		DVL	RDI 300 kHz
		Acoustic Positioning	USBL

Table 1: Main specifications of Ictineu 3 submersible

The maximum dimensions (4,8 x 1.9 x 3 m) will allow to load the submersible in a standard open top container so that it will be possible to transport it on the road with a conventional truck, by train or by ship without requiring special transportation. The use of composite materials will allow to reduce the weight, still meeting the certification requirements: all the exterior hull, the water tanks and many supports/reinforcements will be carbon fibre/epoxy resin composites. Given its reduced weight (5 tonnes) it can be operated with standard launch and recovery systems on harbours and from most oceanographic vessels.

Thrusters / Batteries

The submersible will be equipped with brushless DC thrusters: four for propulsion and four for manoeuvring. The main propulsion power source is a set of high power Lithium ion polymer batteries which provide up to 34kWh. They will be hosted into the outer pads for safety reasons. These new generation batteries will also determine a weight reduction of around 85% compared to the standard lead acid batteries. The resulting power to weight ratio is highly favourable as compared to other submersibles of similar characteristics.

Navigation and control systems

Thanks to an advanced navigation system, the position and attitude of the sub will be known with high precision in real time which will allow for fine bathymetric surveying and scientific data georeferencing. The navigation system includes inertial, DVL, and acoustic positioning (USBL) together with state of the

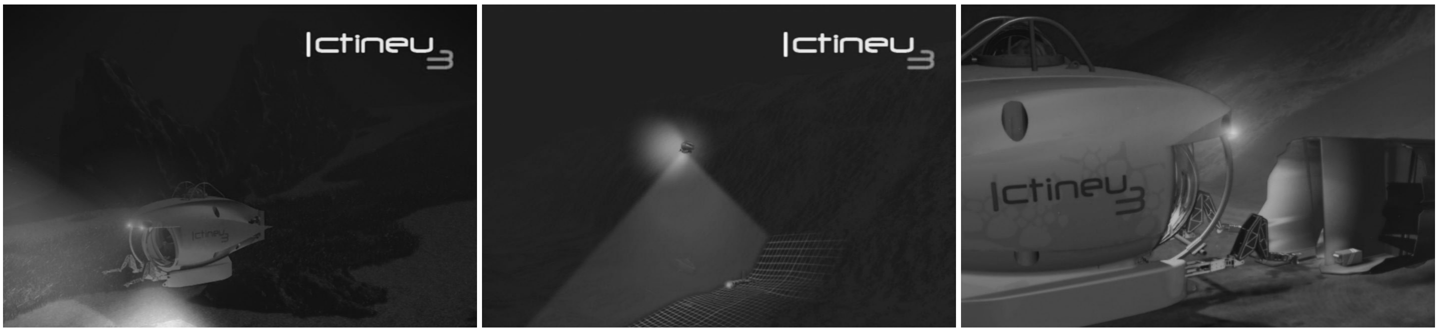

Fig.1: Ictineu 3 possible missions, from left to right: archaeological photo-mosaic, fine scale bathymetric surveying, and black box recovery.

art signal processing and state estimation techniques. An acoustic link will allow for simple data exchange and voice communications between the submersible and the surface. Advanced control systems will be designed to enhance the sub capabilities and free the crew from cumbersome tasks. State of the art robust, fault tolerant, and nonlinear control techniques will be implemented to perform station keeping, path following, heading, depth, and altitude control.

Safety

To achieve the highest safety warranties, the submersible design and construction process will be certified and classified by Germanischer Lloyd authority. To keep safety as high as possible and allow the submarine to escape from possible entanglement (nets, wrecks, remains), several redundant emergency systems will be implemented. The soft ballast (diving) tanks (600l) can be quickly emptied injecting pressurized air (700bar), determining a quick ascent. If this is not enough, a drop lead weight (500kg) can be gradually released to reduce the weight and increase buoyancy. A safety buoy can be manually released from inside the pressure hull, reaching the surface with a 1800m long, 3.5 tonne tensile strength, spectra rope. The two robotic manipulators will be ejectable in case they get stuck. Emergency oxygen tanks and carbon dioxide scrubbers will provide 5 days of emergency vital support.

III. CONCLUSIONS

In this paper, the main characteristics and current state of the Ictineu 3 project have been presented. The Ictineu 3 is being built in the Catalan Royal Shipyards, a XIV century building that hosts the Maritime Museum of Barcelona. The construction process started at the beginning of 2009 and the first sea trials are expected in the second half of 2010. More information can be found at www.ictineu.net

IV. ACKNOWLEDGEMENTS

We would like to acknowledge the Museu Marítim de Barcelona, Departament de Medi Ambient i Habitatge de la Generalitat de Catalunya, Centro para el Desarroyo Tecnológico Industrial, Obra social de la Caixa, Caja Navarra, Fundación Española para la Ciencia y la Tecnología, subprograma Torres y Quevedo, and Caixa Terrassa for their support.

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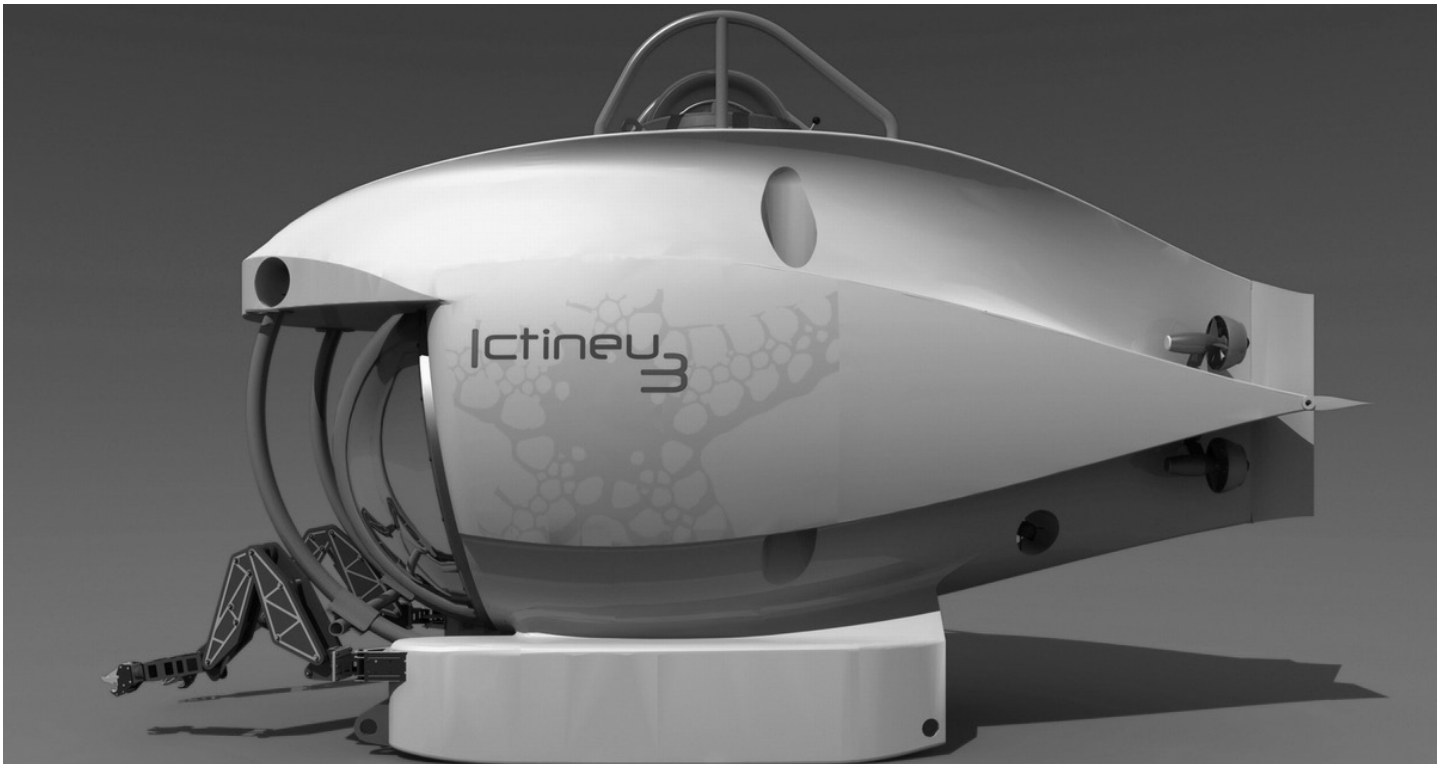

Fig.2: 3D representation of Ictineu 3 submersible

POSE-BASED SLAM WITH PROBABILISTIC SCAN MATCHING ALGORITHM USING A MECHANICAL SCANNED IMAGING SONAR

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Abstract - This paper proposes a pose-based algorithm to solve the full SLAM problem for an Autonomous Underwater Vehicle (AUV), navigating in an unknown and possibly unstructured environment. The technique incorporate probabilistic scan matching with range scans gathered from a Mechanical Scanned Imaging Sonar (MSIS) and the robot dead-reckoning displacements estimated from a Doppler Velocity Log (DVL) and a Motion Reference Unit (MRU). The raw data from the sensors are processed and fused in-line. No priory structural information or initial pose are considered. The algorithm has been tested on an AUV guided along a 600m path within a marina environment, showing the viability of the proposed approach.

Keywords - Underwater Navigation, AUV, EKF, SLAM, Imaging Sonar.

I. INTRODUCTION

In spite of the recent advances in AUV navigation techniques, robustly solving their localization in unstructured and unconstrained areas is still a challenging problem. The last decades, a number of studies in mobile robotics had developed techniques to address the localization problem with very promising results. In particular, the so-called Simultaneous Localization and Mapping (SLAM) techniques have been broadly and successfully applied to indoor and outdoor environments [1].

This paper is proposing an extension of the MSISpIC [2] algorithm in the pose-based SLAM framework. MSISpIC incorporate scan matching techniques to estimate the robot relative displacement between two configurations, by maximizing the overlap between the range scans gathered by a MSIS sensor.

II. SLAM ALGORITHM

A DVL and a low cost gyrocompass are used for dead reckoning while a MSIS is used for sensing the environment. The MSIS needs few seconds to complete a 360o sonar scan but in that time, the vehicle is moving giving deformed scans as a result. Two Extended Kalman Filters (EKFs) are used, one for tracking the robot position during the image grabbing and another to estimate the past history of the poses occupied by the robot at the end of each scan.

The first EKF using a constant velocity model with acceleration noise and updated with the velocity and attitude readings from the DVL and the gyrocompass respectively, is used to track the AUV position during the few seconds needed to gather a full polar image with the MSIS. This trajectory is used to remove the motion induced distortion of the acoustic image as well as to predict the uncertainty of the range scans prior to register them through the pIC [3] algorithm.

Then the initial robot pose is stored in a second augmented state extend Kalman Filter (ASEKF) used to estimate the full robot trajectory, while the first EKF is reset to start a second scan. Once the second scan has been completed, the probabilistic scan matching algorithm adapted to the MSIS sensor is used to register both scans, improving the estimation of the robot displacement between the scans. The corrected robot displacement is then compounded with previous scan pose (from the ASEKF) to get the current scan pose, which is used to augment the state. Each new pose of a scan is compared with previous scans that are in the nearby area and if there is enough data overlapping, a new scan match will put a constrain between the poses updating the ASEKF. These constrains help to identify and close the loops which correct the entire previously trajectory bounding the drift.

III. EXPERIMENTAL RESULTS

The method described in this paper has been used with a dataset obtained in an abandoned marina located in Sant Pere Pescador, on the Catalan coast [4]. This dataset is in a structured environment but our algorithm does not take into account any structural information neither features.

The survey mission was carried out using ICTINEUAUV [5] traveling along a 600m path equipped among others with DVL, MRU and MSIS sensors. Fig. 1a, shows the trajectory and the map estimated using the dead-reckoning method. Fig.1b, shows the trajectory and the map estimated with our SLAM algorithm. In these figures, the estimated trajectory is plotted on an ortophotomap together with the DGPS ground truth for comparison. It can be appreciated that the dead-reckoning estimated trajectory suffers from an important drift which is drastically reduced when our algorithm is used.

IV. CONCLUSIONS

This paper proposes an extension to the MSISpIC algorithm in the pose-based SLAM framework. MSISpIC is able to perform underwater scan matching using a MSIS. To deal with the motion induced distortion of the acoustic image, an EKF is used to estimate the robot motion during the scan. Each full scan pose is maintained in a second filter, an augment EKF and is cross registered with all the previous scan posses that are in a certain range applying the pIC algorithm. The proposed method has been tested with a real world dataset including DGPS for ground truth. The results show substantial improvements in trajectory correction and map reconstruction.

V. ACKNOWLEDGMENTS

This research was sponsored by the Marie Curie Research Training Network FREEsubNET, MRTN-CT-2006-036186, http://www.freesubnet.eu.

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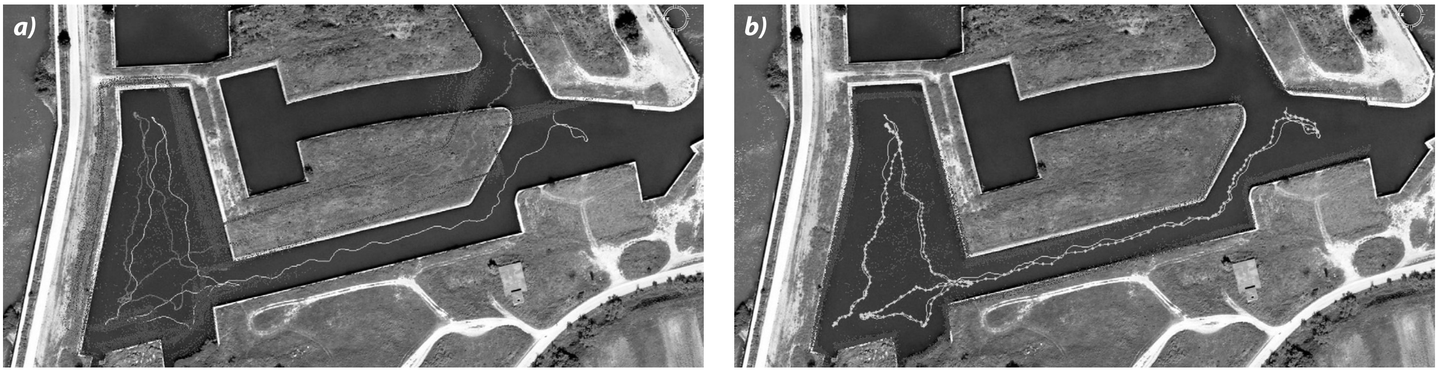

Fig 1: Results: a) Trajectory and map generated with dead reckoning (red). DGPS trajectory (yellow) used as a ground truth. b) Map and trajectory (dotted cyan) generated with the SLAM algorithm.

DATA COMMUNICATION AND CONTROL SYSTEMS IMPLEMENTATION IN THE OBSEA

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Abstract – In this paper is described the system that controls the connected devices in a subsea observatory. The control system is constantly monitoring the internal and external components of the observatory detecting operating faults and acting automatically in consequence.

Keywords - OBSEA, control system, SNMP, underwater communications

I. INTRODUCTION

More and more, needs for higher resolution, volume of information and longer data series are increasing in the oceanographic observation. In some applications, traditional observation systems such as autonomous oceanographic buoys and measures taken from oceanographic ships present serious disadvantages respect costs, volume of data delay of data or autonomy of the batteries. The new cabled underwater observatories can be modular, flexible and can be adapted to different uses and requirements to satisfy the requirements of the scientific community. The OBSEA [1] project (Expandable Seafloor Observatory) is a collaborative task, between CSIC (Consejo Superior de Investigaciones Científicas) [2] and UPC (Universitat Politècnica de Catalunya) [3], to design and develop a seafloor observatory placed in front of the Vilanova i la Geltrú (Spain) coast. The OBSEA structure consists in two stations: the Shore Station and the Subsea Station. The management servers in charge of status monitoring and data recollection are placed in the Shore Station. In the Subsea Station are all the oceanographic instruments and related electronics for its power supply, communications and control. The data servers at Shore are continually storing the information and providing the interface toward the world, giving controlled access to the scientific community.

II. SYSTEM DESCRIPTION

Shore Station

As can be seen in figure 1, Shore Station is composed by the management servers, that are monitoring and controlling the status of all elements in the system, the data servers, which are storing and serving the acquired information, the communications system, which transmits the information through the submarine optical fiber, and the power system in charge of providing the necessary electrical power to the submerged elements.

The power system, is equipped with a cluster of AC/DC converters producing up to 320Vdc and 11Amps. The communication system is the Ethernet network of switches and optical fiber necessary to transmit data to the Marine Station. Finally, the control system contains the servers with the management and data storage software, which monitors and controls the connected devices.

Subsea Station

The Subsea Station in the point where are connected the different oceanographic instruments types according to the needs of our scientists, such as seismometer, CTD (Conductivity Temperature Depth), sensors for measurement speed, turbidity or existing amount of chlorophyll in the water. The Subsea Station will be in charge to supply the energy to the instruments, transmit its data to ground, control the status of all elements, and transmit it to the control server. Likewise, the Subsea Station consists of the same three systems that Shore Station power, communication, and control systems:

Power System formed by the emergency batteries and 5 switching converters: 2 of 300/48V and 3 of 48/12V.

Communications system: Formed by two industrial Ethernet switches in charge of the optical interface towards the submarine cable and simultaneously the connection of the signals of the sensors and control system.

The submarine control system is composed by a platform from Dycec[4] that integrates a microcontroller of 32 bits ColdFire MCF5282[5]. This unit has the necessary functions to implement SNMP protocol (Management Protocol). This device monitors and controls the energy system, atmosphere and electric parameters, as well as performs the connection control of external instruments, and ensures the right running of subsea observatory.

In figure 1, we can see a scheme of general configuration of the station.

Control system of the subsea station

The control system is the one in charge of the supervision and control of several environmental and electrical parameters to maintain the correct operation of the subsea observatory. The system accepts commands and generates alerts using SNMP protocol and alternatively through a console RS232 communication for emergency operations.

In order to develop the control algorithm of the Subsea Observatory is necessary to obtain data from different measurement devices. For this reason, two peripheral from "National Control devices" have been included in the system: AD1232PROXR and XR16xDPDT [7]. The first one contains analogical to digital converters, which samples and quantifies the incoming signals from measure-

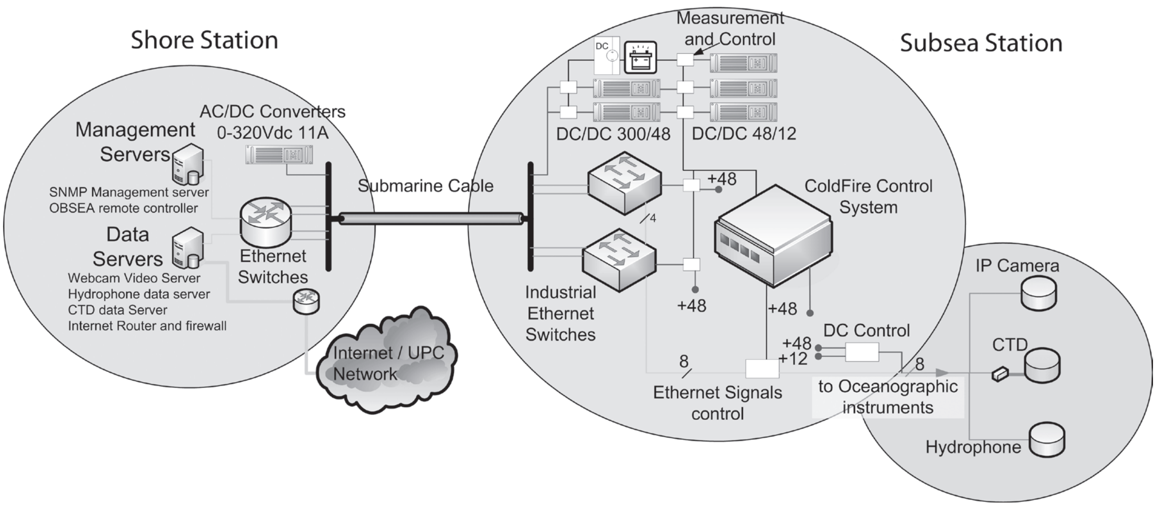

Fig. 1 General diagram

ment devices. The second element contains relay drivers to control all the devices. The communication with these boards is performed through one serial RS232port, as is shown in Figure 2.

SNMP Control system

SNMP[8] is a standard protocol commonly used in networking. It is part of the TCP/IP family protocols and allows the system administrators to supervise a network function, as well as to look for and to solve the possible problems. Two types of elements shape the protocol, an agent and a manager. In our case the agent is running in the control system of Subsea Station to manage and monitor the node, but all the other network elements also have its native SNMP agent. The manager is the software that is executed in the Shore Station, which

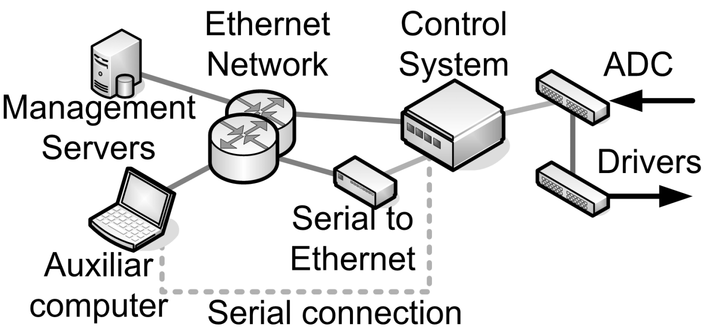

Figure 2 Diagram of the subsea control system

is entrusted to monitor the network; his task consists of consulting the different agents which are in the nodes.

The internal algorithm of the control system is in charge of these actions:
•To feed and control the operation of the oceanographic instruments connected to the Subsea Station.
•To assure that not used connectors are always free of voltage.
•To establish the connection/disconnection of instruments in water.
•To avoid that an external instrument can affect the internal operation of station.
•To monitor internal atmosphere for thermal control and leakage detection.
•To monitor and control all internal components.

III. OBTAINED RESULTS

The observatory OBSEA was commissioned on May 19th of 2009 with 3 oceanographic instruments (CTD, hydrophone and submarine camera). From that moment it is completely operative and working correctly. But before, some laboratory tests were executed consisting of behavior simulation of the Subsea Station elements using an Iberco [9] 20 bar hyperbaric chamber. First tests were executed to verify the used materials resistance and watertightness of the equipment infrastructure. In figure 3 as can be seen one of the hyperbaric chamber tests. Another set of tests has been done also to verify all the electronic components individually and connected together obtaining by this way optimal configurations for communications equipment, adjusts of power supplies and calibration coefficients for analog to digital converters. A high stress test has been done also to certify that control software is stable under all the possible conditions and situations.

IV. CONCLUSIONS

In the submarine observatories the system of data-acquisition and control is one of the fundamental parts. In this way, parameters and variables needed by the scientist are retrieved with this acquisition system
The control system entrust at any moment that the Subsea Station works correctly. Before failure or wrong operation from the observatory elements, the control system acts sending alarms to the Ground station.
Thanks to OBSEA project is possible to obtain all data and variables from different sensors types through SNMP and have them monitored at any moment. This monitoring must be friendly for the technician who is supervising the connected devices operation of the stations. At present OBSEA project is working perfectly and in the future is expected to increase the number of underwater nodes.
For more information visit http://www.cdsarti.org or http://www.obsea.es.

V. ACKNOWLEDGMENT

The project OBSEA is being founded from the Spanish Ministry of Education and Science (MEC) with the projects "Interoperabilidad en redes de sensores marinos y ambientales" CTM2008-04517/MAR and "Prototipo preliminar de Observatorio Submarino Expandible Cableado" EMSO CAC-2007-09. The authors acknowledge the support of the Telefonica representatives Jorge Rubio, Isabel Alcober and Francisco Fernandez Veigas, also to Mariano Santos from Tyco Marine, and Lluís Sales from Prysmian Cables y Sistemas.

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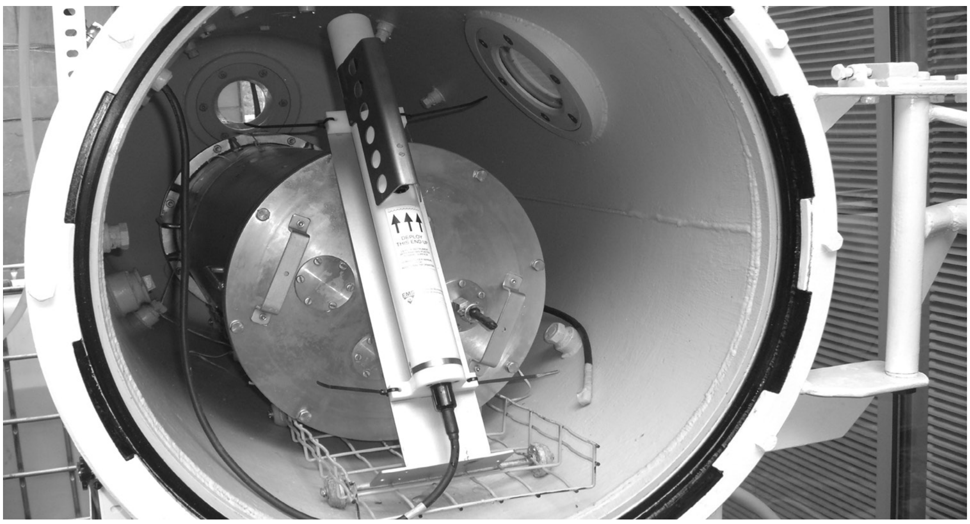

Fig. 3 Hyperbaric chamber

PRESSURE HULL DESIGN AND CONSTRUCTION OF THE MANNED SUBMERSIBLE ICTINEU 3

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Abstract – This paper describes the design and construction of the pressure hull of Ictineu 3, a manned submersible with a maximum operative depth of 1200m. The design and manufacturing process of a pressure hull is a cumbersome engineering challenge because of the extreme pressure conditions and extremely low tolerances required by the certification agency. The pressure hull has been calculated and designed under the ASME PVHO-1-2007 and Germanischer Lloyd rules, and Finite Element Method (FEM) simulations have been performed. It will be tested in an autoclave at a test pressure corresponding to 1440m. The pressure hull is composed of an stainless steel body with two acrylic spherical sectors, one is the top hatch and the other is a large front window that will provide the crew an exceptional wide field of view. The steel has been spefically selected due to its excellent mechanical properties and its high corrosion resistance.

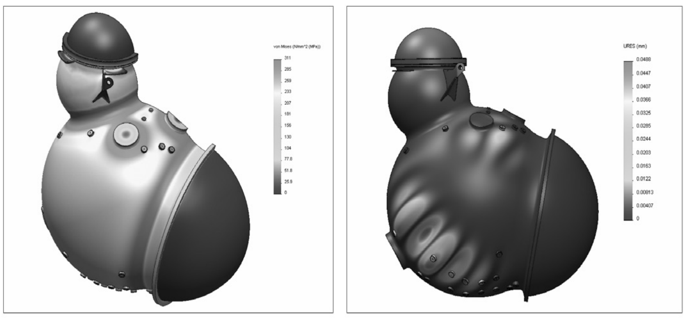
Keywords – pressure hull, austenitic-ferritic steel, pressure test, deep drawing, heat treatment

I. INTRODUCTION

Ictineu 3 is the first project of Ictineu Submarins S.L., a scientific manned submersible designed to operate at a maximum depth of 1200m and carry three people. The most critical part in the design of a manned submersible is the pressure hull, which must hold the external pressure, and therefore, its design must be done accordingly to strict rules. In this project Germanischer Lloyd has been chosen as the certifying agency so whole submersible has been designed under their rules and the ASME PVHO-1-2007ones. Moreover, every step of the construction process must be certified and subject to strict quality controls that will provide high precision allowing to meet very low tolerances. Two major difficulties have had to be solved in this project: from one side the selection of the right material and the calculation of the pressure hull; on the other side the definition of the manufacturing process for the two spheres to satisfy the tolerances required.

II. THE PRESSURE HULL

A preliminary study was realized to select the most suitable shape and material with the aim to obtain the lightest possible pressure hull maintaining the safety. The sphere is the solid with the minimum surface/volume ratio, hence the most suitable geometry to withstand an external pressure with a minimum weight:



this is why a sphere has been chosen to host the three crew members. On top of the main sphere (Ø 1700mm) there is a second one (Ø 800mm) with an acrylic hatch, through which people can access and leave the submersible. At the front of the main sphere, a large PMMA window (Ø1200mm) enables the crew with a wide field of view. For the spheres, a special steel was selected after a thorough research and calculation among different materials such as two different titaniums, six different steels and two types of carbon fiber/epoxy composites.
Finally the selected material is an austenitic-ferritic steel with high Cr, Ni and Mo content compared to a standard austenitic steel (e.g. AISI 316), suitable for marine application because of its high corrosion resistance. This chemical composition gives the material special properties: high yield strength (Rp0,2 ≥ 530MPa), high ultimate tensile strength (Rm ≥ 730MPa), high elongation (A5=35%). From the mechanical point of view this material is comparable to a high strength steel (e.g. HY-80) but with far superior corrosion resistance. Another advantage is that it is not magnetic, with no interferences with the surrounding equipments (e.g. compass).
The calculation via FEM (Fig.1) has been performed for the design pressure (12,1MPa) and as well for the collapse pressure (20,9MPa). A buckling analysis showed a high safety factor under the collapse pressure.

The Steel Spheres.

The manufacturing of the pressure hull of the Ictineu 3 is being carried out among several specialized factories with previous experience in pressure hulls construction. The selection took many months as there are few workshops in Europe that were able to do manufacture the different parts and most of them were not able to guarantee the specified tolerances. To obtain the two spheres, a steel plate 46mm and 30mm thick respectively was used. After the deep drawing and the heat treatment of the dished heads (Fig.2), a machining process is necessary to meet the "out of roundness" tolerance. The sphere is obtained welding together two heads along the equatorial line. The welding process has to be carried out by certified welders, with low heat input and very low interpass speed, in order to avoid deformation of the steel along the welding line. Once the reinforcing flanges and penetrators are welded, the two spheres are assembled together through a reinforcing ring: this object, closed with the two acrylic windows, represent the pressure hull of the Ictineu 3. The mechanical tests and dimensional checks are carried out under the strict supervision of a Germanischer Lloyd Surveyor.

The Acrylic Viewports

The acrylic is a thermoplastic with excellent environmental stability and low water absorption (0.25% in 24h). It is almost completely transparent (92% light transmission) and it has a lower density (1.19kg/dm3) and an impact strength higher than the glass. For all these reasons it has been used for underwater applications for the last 60 years with excellent results. An extensive study for the acrylic windows has been performed, according to [1], [2], [3]. The aim was to design suitable windows for external view, able to withstand the design pressure (12,1MPa) in a wide range of conditions: from cold to hot regions, with a considerable temperature variation (-15/+50ºC).
The design temperature is 18ºC, considering the mean value in between internal (24ºC) and external temperature (12ºC) at the design pressure. The design service life is 20 years or 10,000 pressure cycles [1], [2]. The two windows are spherical sectors, with opening angles of 150º (main dome) and 160º (top hatch). They weigh 500kg and 45kg respectively and they will be tested together with the steel structure at 14,5MPa inside a hyperbaric chamber, with a 1,2 safety factor compared to the design pressure (12,1MPa).
The Ictineu 3 will be the first submersible for 1200m with such a big acrylic window, all the submersibles for similar or higher depths have only small portholes up to Ø200mm.

III. SUMMARY

Thanks to extensive search in materials, calculations and FEM simulations, a very light pressure hull has been achieved. This will result in a very lightweigh submersible with capabilities for three people and a big acrylic window under 6 tones, compared to the 8 to 12 tones for similar vessels. The construction of the pressure hull is due to be completed at the end of 2009. After the pressure test in an hyperbaric chamber, all the submersible systems will be fitted and the outer hull will be mounted. The first sea trials of the Ictineu 3 submersible are scheduled in the second half of 2010.

IV. ACKNOWLEDGEMENTS

We would like to acknowledge the Museu Marítim de Barcelona, Departament de Medi Ambient i Habitatge de la Generalitat de Catalunya, Centro para el De-

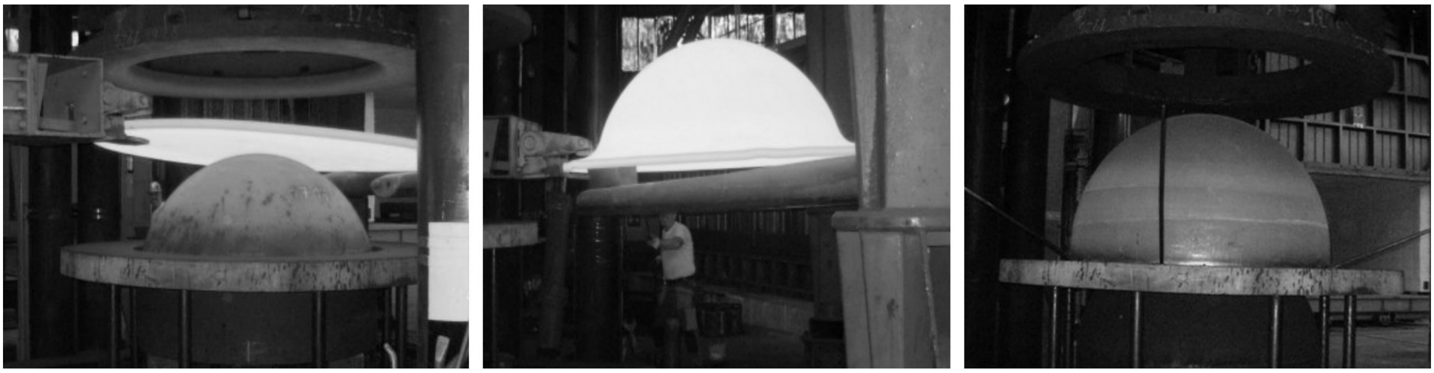


Fig. 2. Deep drawing of one hemispherical dished head

sarroyo Tecnológico Industrial, Obra social de la Caixa, Caja Navarra, Fundación Española para la Ciencia y la Tecnologia, Subprograma Torres Quevedo, and Caixa Terrassa for their support.

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ANT COLONY OPTIMIZED PLANNING FOR UNMANNED SURFACE MARINE VEHICLES

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THE PROBLEM:

This paper presents some results achieved from a preliminary study on the use of the Ant Colony Algorithm to plan feasible optimal or suboptimal trajectories for an autonomous ship manoeuvring. The scenario, for this preliminary work, comprises only open sea manoeuvres. The goal involves obtaining the least time consuming ship trajectory between to points, departing from the start point with arbitrary initial speed and attitude values and arriving to the end point with predefined speed and attitude values.

The specific dynamic of the ship imposes typical restrictions to its manoeuvrability. In the present case, the non-holonomicity, the rate speed/turn radius, and the imposed forward-only propulsion of the ship make up the main restrictions to the ship movement. For long distances, the problem could be tackled as a classical navigation problem, in which, for the most part of the ship trajectory, techniques such inertial navigation should be enough. The problem arises at short distances when it becomes a manoeuvring problem. In this case to obtain a optimal, --in some cases just a feasible--, trajectory could be a difficult problem.

A WAY OF SOLUTION:

In recent years, several innovative optimisation techniques, based on heuristic search methods have been developed and proved in very different scenarios. Among them, the so called bioinspired algorithms, such the Ant Colony Optimisation or the Artificial Bee Colony Algorithm result particularly attractive by their capacity to solve complex optimisation problems in which, other classical techniques are unfeasible or difficult to implement.

The aim of the present work is to prove the viability of one of these techniques to obtain the trajectory of an autonomous ship in the manoeuvring scenario described above. To accomplish this goal, a simplified dynamical model of a ship, considering only three degrees of freedom (surge, sway and yaw) was employed. The propulsion was modelled as a trimable waterjet system, which plays also the role of the rudder. Both, speed and course are controlled by a classical PID system, which stabilizes the course and speed, according to preset values of the PID constants. A more complete description of this model will be provided in the full paper.

Ant Colony Optimisation algorithms are based in the way in which ants are capable of finding the shortest path from a food source to their nest. Ants deposit a certain amount of pheromone while walking. When any ant searches a path to follow in its search for food, it prefers, in a probabilistic sense, the trails rich on pheromona. As far as shorter paths can be followed faster, the shorter the path the larger the number of ants that cover it by unit time. As a result, the shortest (optimum) path becomes more and richer on pheromona, and more a more ants follow it. Although the process tends to converge with time to the best way found by the ants, the probabilistic nature of the ants path election, makes easier to avoid get trapped in local minima far from the optimal solution and it allows, once the algorithm has found a feasible solution, to improved it towards the optimum.

In the robotics context it is usual to divide the problem of robot motions into two steps: first to get an optimal path (path planning), according with certain cost criteria, and then making the robot follow the path (path following). It may be difficult for the robot to follow the path, due to the dynamic characteristics and restrictions of the robot itself.

In our case we propose to solve the motion problem in one step, so the path planning includes the robot dynamics and restrictions.

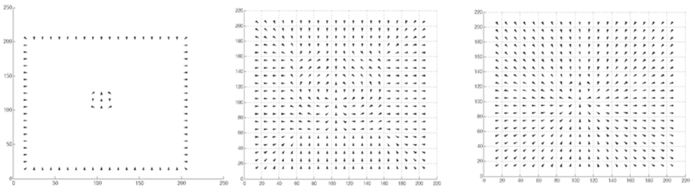
Now, the original ant colony algorithm doesn't consider any particular dynamics for the ants' movements. It just assigns an elapsed time proportional to the length covered by the ant in its movement towards the goal. Our contribution here is to add dynamics -the dynamics of the ship- and restrictions to the algorithm. In this way the trajectories obtained are feasible. The ants behave as ships.

In the original algorithm, the ant colony is composed by an arbitrary number of ants. They are sent from the nest, which represent the starting point of the quest, in random directions. The ants follow straight paths until they reach an obstacle, then a new random direction is selected. When any ant reaches the goal, it marks the track followed from the nest to the goal.

CELLULAR AUTOMATA FOLLOWED BY ANT COLONY:

Due to the nature of the manoeuvring problem, the space of search is really large to find not only the optimal but also a feasible solution, following a whole random search. Therefore we propose a way to guide the search. The idea is to use cellular automata.

To apply cellular automata the manoeuvring area is divided into square cells. Each cell is assigned a motion direction (an arrow). Each cell is an automaton. The 2-dimensional set of automata is represented as a matrix. A goal is marked. The automata have transition rules, so after iterations of matrix multiplications the automata draw flow "potential" lines towards the goal. The paper will explain in detail this part of the proposed procedure. Let us put a sequence of figures, following the evolution of the computations:



start ***in the middle*** ***final***

On the same grid used by the cellular automata we put now the ants.

In each cell the heading marked by the cellular automata is taken as the centre of a probability distribution. When an ant reaches a cell, it throws a dice with the probability distribution given by the cell to select its new motion heading. And so on from cell to cell. The ant could eventually reach the target, or not. If no, when the distance to the target is really far the ant is killed. If the ant gets the target with correct attitude, the ant is also killed and the centre of the probability distribution in every cell is shifted towards the successful heading.

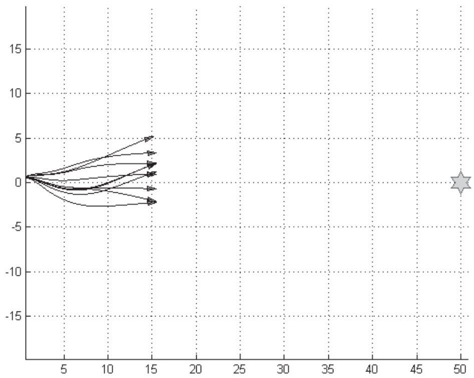


Fig. 2 Initial phase of the search. The ants are going to pass two cells (the cell occupy 4 squares in the Matlab grid).

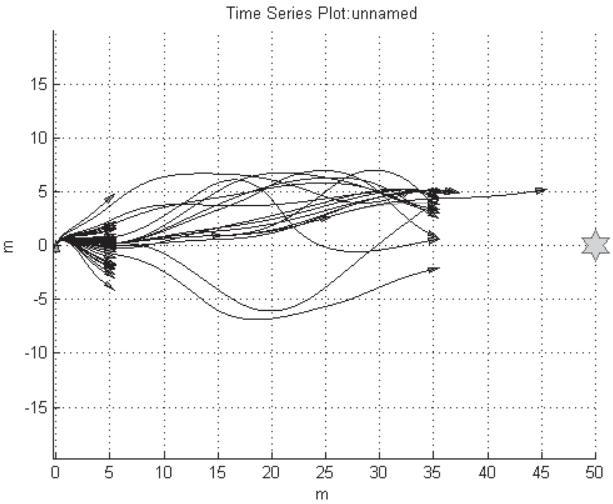


Fig. 3 Shows two consecutive generations of ants.

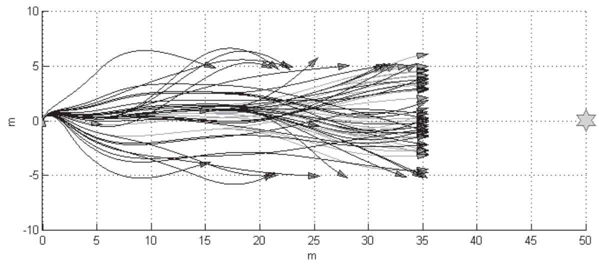
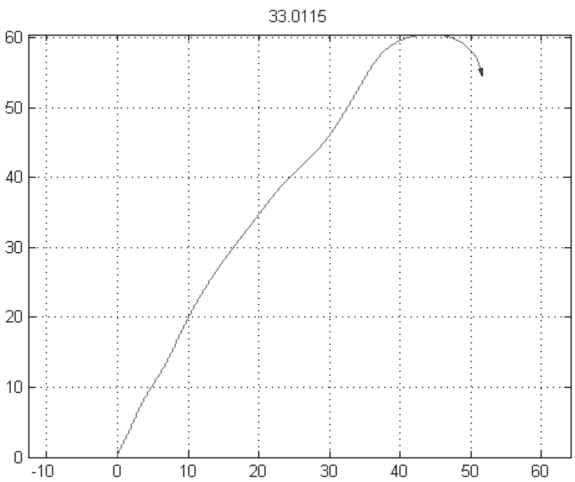


Fig. 4 Shows another more advanced stage of the search.



CONCLUSION

The paper introduces a path planning method with guaranteed feasible manoeuvring trajectories for ships. The new procedure has two steps: first with cellular automata and second with ant colony optimization.

The results obtained thus far are encouraging. In the next future we plan to add shallow waters to include a kind of corridor restrictions to the problem.

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CLASSIFICATION OF MATHEMATICAL MODELS TO COMPUTE USEFUL IN THE TREATMENT OF IRRIGATION DISTRICT MEXICO 03

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Abstract - In this paper offers a comparative analysis and classification of mathematical models and the Saint-Venant ARMAX model, and determine which is more useful for the computation applied to control systems in the first section of the main irrigation canal in the hydraulic operation Irrigation District 03 Tula Hidalgo, Mexico (DR03), The aim of this work is to obtain a mathematical model previously assessed and analyzed with respect to other, applied to the same hydrological phenomenon. reproducing with sufficient accuracy to control the characteristics of a network of microcontrollers, high-performance electronic devices, their function is the type of workstations and philosophy client - server, taking advantage of the benefits of distributed systems prone to reduce the complexities that are have a mathematician with other control devices, the network is working through the standard RS-485, and in addition to the microcontroller is included in the network, a personal computer which is responsible for performing the functions of a server.

I. INTRODUCTION

It is now known that almost all the water on our planet is in the form of salt water in the oceans. Only 3 percent of global water resources are freshwater, two thirds of whom come from the snow and ice in polar and mountain regions, so the fresh water constitutes only about 1 percent of the resources total water (www.fao.agua for sustainable food production, poverty alleviation and development rural.htm). The water needs careful management, which in turn requires effective public policies and regulatory frameworks. Rivers, lakes and lagoons of Mexico. Mexico's water resources consist of rivers, streams, lakes and lagoons, as well as underground storage and large masses of ocean water. There is a lot of watersheds, especially in areas where the mountains are in direct contact with the sea and the dry Altiplano endorheic, but the number of large basins that cover large parts of the country is small (INEGI, 1995 , and UNAM, 1990). where A (x, t) is the area of cross section of the channel Q (x, t), flow (discharge) side (q> 0: entry, q <0: Output); V (x, t), the mean water velocity in section A, and (x, t), the water level, x the longitudinal distance in the direction of flow, g, the acceleration of gravity, t, time; Sf (x, t), the slope of friction.

II. METHODOLOGY

A problem common to all methods is the numerical approximation of the terms advectivos, which generate spurious oscillations destabilize the solutions, particularly when these terms are dominant. In this work of classification models using the method of structural system, identifies a model that presents a variational formulation Petrov-Galerkin finite element which has as its key feature to add an integral term in the solution of variational Galerkin. The observed advantage of such formulation is that numerical stabilization is built from the dynamic equations. The original formulation is discontinuous in time, but particular cases also continued to represent options are explored numerically in (Carbonel, 2008). EQUATION: Moving and The flow with free surface along a canal or a river channel cross-section is described by the system of differential equations of hyperbolic type (Dronkers, 1969; Meissner, 1978):

$\delta Q / \delta x + \delta A / \delta t = 0$ (1) And whereas $Q = Av$ $\delta A = T\delta y$

The equation (1) becomes $A\delta v / v T\delta x + \delta y / \delta x + \delta y / \delta t = 0$ (2)

t y x where are the independent variables of time and space along the longitudinal axis of the channel respectively, g is the acceleration of gravity, q the flow rate or velocity, h the surface level of the flow with respect to the reference level (NR), a is the depth, and A is the section area, as shown in Figure 2.

Evaluation of mathematical model equations of Saint - Venant in the irrigation canal of the dam Taxhimay. When the channel is fed laterally with a supplementary spending "q" per unit length, equation (1) can be written

$$\delta Q/\delta x+T\, \delta y/\delta t=q \quad (3)$$

$$\delta v/\delta t+v\, \delta v/\delta x+g\, \delta y/\delta x+g\, \delta z/\delta x+gS_f=0 \quad (4)$$

The result obtained from these experiments allowed the team to two things: a) For the present project was initiated a comparative analysis of two schemes Saint - Venant implicit in the paper, another for the ARMAX model, implemented in the first stretch of the main irrigation canal "Imperial de Aragón", belonging to the Hydrographic Confederation of the Ebro, Spain, using the procedure of identification of systems from the design of the experiment to validate the model and considering the prior knowledge about the system and which will be another similar work. In particular this involves: b) Attention to extreme cases through the Saint-Venant equations, without further amended, provide satisfactory results. Results. As noted methods and mathematical models that have been classified as a movement of continuity and simplify the fundamental equations of Saint - Venant hydrological methods have been called, in which no detail is required in the solution for the entire length of the channel. product of this research is to design and that a network of microcontrollers in order to implement the advantages of high processing speed, the availability of electronic devices with high performance, type of work stations and philosophy client – server. In this research was to implement systems for monitoring local area networks bring various benefits such as alternative solutions. • A reliable operation in real-time hydrological phenomena. • It would allow the correction of flaws in computer programs used in the network. • Starts a step towards establishing a methodology to ensure a smooth reliable operation of the LAN microcontroller applied to the sensors to monitor the irrigation canal. • With the monitoring software, it can be concluded that the deficiencies found in the network are predictable. • The connection protocol, by its nature at the time it receives a signal error in the checksum of the header, it asks the sender to retransmit computer data packets may be corrected and recorded. • The construction of a software model itself, with two forms of representation, a graph and the other by means of expressions of entering and leaving the network channel with a friendly interface. The prediction error microcontroller network software will be possible if the signals were obtained from the algorithmic model of Saint - Venant suitable. Ie identifying stochastic phenomena such as cavitation, leakage, among others, and use the input and output matrices, and thus make inference to predict and quantify errors.

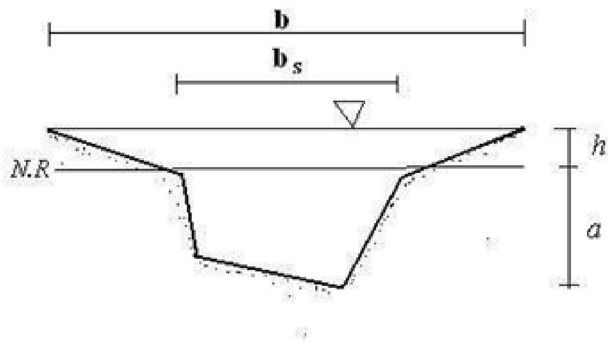

Fig. 1 Sectional area.

AUTONOMOUS VEHICLE DEVELOPMENT FOR VERTICAL SUBMARINE OBSERVATION

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Abstract – This work proposes the development of an ocean observation vehicle. This vehicle, a hybrid between Autonomous Underwater Vehicles (AUV) and Autonomous Surface Vehicles (ASV) moves on the surface of the sea and makes vertical immersions to obtain the profiles of a water column according to a pre-established plan. Its design provides lower production cost and higher efficiency. GPS navigation allows the platform to move along the surface of the water while a radio-modem provides direct communication links and telemetry.

Keyword – Autonomous Underwater Vehicle, Vertical Profiler, Computer Embedded

I. MECHANICAL DESIGN OF THE VEHICLE.

The vehicle has a double hull. The outside hull, made of fiberglass, is not watertight but it provides a good hydrodynamic characteristic. On this structure the steering and propulsion mechanisms are attached.. A propulsion engine, of the company Seaeye, has been located on the stern of the vehicle and individual Seabotix(™) engines are located on the sides of the hull. When these engines are used, the course of the vehicle can be altered [1] [2]. A watertight cylindrical module is located inside the outside hull. It houses the immersion actuator and the electronics control, as well as the power supply provided by the batteries. Figure 1 shows the design of the vehicle.

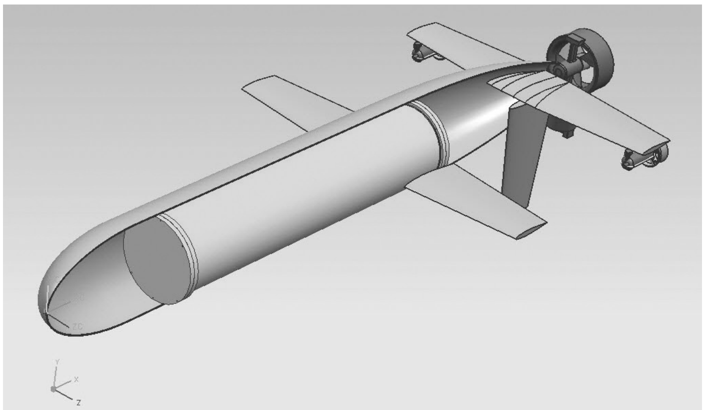

Fig.1. Design of the vehicle.

Outside Hull Design of the Vehicle.

The outside hull design is based on the Myring equations [3] that describe a body contour with a minimal drag coefficient for a given finesse ratio (body length/maximum diameter). Myring's pParameters classifies body types by code of the form a/b/n/θ/0.5d. This vehicle has the code 15/55/2/0.4365/5. Figure 2 defines the parameters used to obtain the code and the Table I shows the dimensional parameters used. Finally, three stabilizers according to a NACA 63-012a profile, have been designed on the proportions of the outside hull.

Inside Hull Design of the Vehicle.

The watertight module is a cylinder made in 6063 aluminium with hard anodized treatment and designed to withstand 30AT, although the nominal pressure is 3AT.The cylinder dimensions are 250mm diameter and 1100mm long, and is covered in aluminium. An o-ring guarantee watertightness.

The connection of the antennas and engines with the interior of the module is done through SubConn connectors. The watertight module houses the immersion actuator and the electronics control, as well as the power supply provided by the batteries. The design of the emersion and immersion equipment is composed of a commercial pneumatic stainless steel cylinder with a displacement of 1500cm3 and a linear electrical actuator which can cover a maximum distance of 200mm and a thrust force of 3KN.

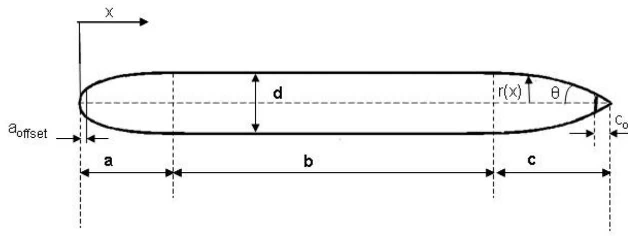

Fig. 2. Myring Profile: vehicle hull radius as a function of axial position

Parámetro	Valor	unidad
a	325	mm
aoffset	0	mm
b	1116	mm
c	924	mm
coffset	70	
55	mm	
n		n/a
θ	2	radianes
d	326	mm
lf	1441	mm
l	2365	mm

Table 1. Myring Parameters for the vehicle

II. ELECTRONIC DESIGN OF THE AUTONOMOUS NAVIGATION CONTROL SYSTEM.

The autonomous navigation control system is made up of an embedded computer and the necessary elements for communication, navigation and propulsion and safety. Data acquisition system, composed of a CTD for the temperature acquisition, depth and conductivity of the water column, are also included [4].

Communication between the vehicle and the station located on shore is bidirectional and a Farell Instruments(™) industrial modem T-MODC48 has been used. Its features include a data rate of 4800 bps and a configurable carrier power of 100mW/5W that allows a maximum range of 10km.

A PC/104 embedded computer (PM-6100 AEWIN) makes up the central control of the vehicle. This is of limited size, weight and power consumption (max 12W). It is managed by a Windows XP operating system stored in a compact flash memory which provides good protection from vibration.

The propulsion control system is a SSC32 Lynxmotion driver that transforms the RS232 signal from the PC/104 in a modulated PWM signal that acts on the engine power drivers.

The navigation system is a digital compass and a three-axis inclinometer, PNI TCM-2.6, It is a 3-axis tilt-compensated compass-heading module with electronic gimballing to provide accurate heading, pitch, and roll measurements over a ±80° tilt range. The navigation system also has a global positioning system GPS, Magellan DG14TM, which provides the precise location of the vehicle during a mission.

The safety system includes a pressure transducer HPS DS2806, which provides the measure of absolute pressure, from which is possible to know the depth of the AUV. The low cost sSensor is resistantce to corrosion, which allows a pressure variation from 0 to 10 bars. It also has a 4000 HIH sensor capable of detecting variations of 1% of relative humidity, which can detect a small flaw in the watertightness of the inside module. Finally, it has the LM3916 component to measure the voltage level of the vehicle battery.

III. CONCLUSIONS

An observation platform has been developed which is able to navigate on the surface of the sea making vertical immersions to obtain water column profiles. The vehicle has a double hull, a fiberglass exterior with a profile that provides a good hydrodynamic characteristic, and a watertight inner module built in aluminum. Also, an autonomous control system for the vehicle has been designed and implemented. Its proper operation has been tested in the laboratory. Now, all elements of the structure of the vehicles are being assembled and then a test of navigation at sea will be performed.

ACKNOWLEDGMENT

This work has been funded by the Spanish Ministry of Education and Science and the European Union (FEDER), project nº: CTM2006-12072/MAR.

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FAULT TOLERANT ACTUATION FOR DORADO CLASS AUVS

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Abstract - This paper describes a new control surface actuating design for the Monterey Bay Aquarium Research Institute (MBARI) Dorado class AUVs. The intent was to increase reliability as part of obtaining the goal to greatly increase access to the Arctic Ocean. The new actuating mechanism is part of creating a robust and economical solution towards increased reliability and fault tolerance. Specifically, as part of developing the ALTEX Autonomous Underwater Vehicle (AUV) for Arctic research with basin scale endurance, the concept for under ice missions was redundancy in critical areas. As the development of the DORADO systems progressed from the original ALTEX concepts, added drivers came from the operations group looking for more useable volume in the aft section.

The DORADO vehicle is guided using an articulated tail steering section. The tail is comprised of a ducted propeller acting as control surfaces and propulsion, in contrast with the more traditional fin control surfaces used by most vehicles. This approach was taken to be more robust to impacts as experience using Odyssey IB vehicles showed the control surfaces damaged during launch and recovery were the number one failure by far. As predicted by analysis the design also improved propulsion efficiency. Also worth noting is that this entire tail system stays inside the 21" diameter of the main vehicle body. The new system being developed is unique in that it keeps all of the key propulsion and actuators but eliminates the current gimbaled tail through the use of what we refer to as a false center. While several new components are being developed, the objective is to leverage the existing technology to the degree possible and allow for an inexpensive as well as direct swap into existing systems.

The new steering mechanism uses a Three Actuator False Center Control solution. The design was first modeled and tested for feasibility. After passing the preliminaries, the decision was made to build a full-scale sea going unit. We now have that system built and in bench testing, ready to swap in for at sea testing in the very near future. We've already demonstrated that the new design offers a superior use of space yielding more useable volume for other equipment. The model demonstrated the added redundancy that we will duplicate at sea. We believe the design is very robust and has a broad range of uses in long duration unattended operations where fault situations must be dealt with by the autonomous system. In this paper we will discuss our progress to date, our current test efforts, and the near term future uses of this new control section for DORADO science vehicles.

Keywords: Control surfaces, Tailcone, Dorado, AUV, autonomous platforms, fault tolerant actuation

I. INTRODUCTION

MBARI's Dorado Class Autonomous Underwater Vehicles (AUV's), Figure 1, are both propelled and steered by a single thruster mounted at the rear of the vehicle [1]. The usual fins for rudder or elevator control have been replaced by a tailcone using a ring wing with foil section support struts. Turning the vehicle is accomplished by moving the articulated tailcone, which consists of the propeller, shroud, and motor mounted in a gimbaled mechanism driven by two linear actuators. The gimbal consists of an outer ring that rotates about the vertical axis (providing rudder control or yaw), and an inner ring that rotates about the horizontal axis (providing elevator control or pitch) [2]. The main computer, naviagation and controls of the core AUV are contained in the tail of the vehicle, The needs of the Dorado program were therefore primarily concerned with developing a robust, versatile AUV tail section.

Additionally, the DORADO vehicles are required to support a broad range of missions. The use of modular sections made this possible, but it also puts requirements on the core vehicle systems, in particular the tailcone. For example, roll stability is critical to multibeam mapping and is a high priority, so any tailcone advancements are required at a minimum to maintain the current capabilities. A second key requirement is the tailcone must be capable of accepting the frequent adjustments to the vehicle control gains. The control gains are altered as the reconfigured length varies due to adding or removing modules installed for various missions.

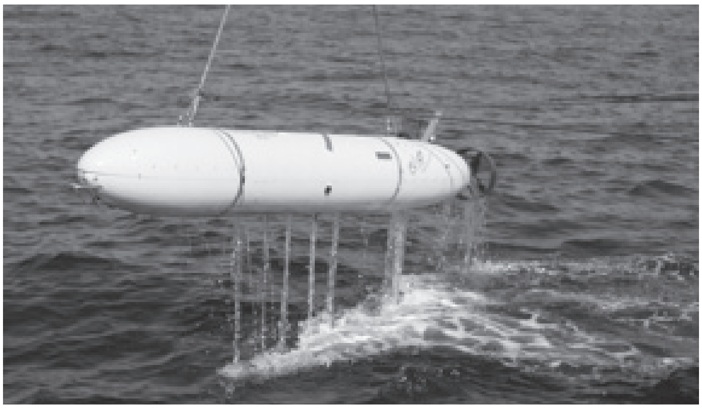

Fig.1: An early version of DORADO during development

SUPPORTING A VERY LONG ENDURANCE AUV

Extended operations are constantly a discussion with AUV users and builders. This makes sense since the cost of data can go down significantly if the platforms being used can work longer. MBARI's initial motivation came from the need for extended operations in the Arctic basin, the Atlantic Layer Tracking EXperiment (ALTEX) program. This program was first funded through a NOPP grant that started in 1998, and starting the in summer of 2000 the primary funding to complete the AUV and perform the arctic mission came through the National Science Foundation (NSF).

The objective of the NSF funded effort was to greatly increase access to the Arctic Ocean by creating and demonstrating a safe and economical platform capable of basin-scale surveys. However working under the ice with no ability to find and repair problems was seen as a serious situation that should be addressed if possible. The desire to find a suitable solution is what prompted the original False Center Tailcone concept.

ORIGINAL TAILCONE BUILD

The original tailcone concept was created at MBARI in 1999 for the three-actuator false center mechanism. Schedules and responsibility to build an entire AUV called for simplification wherever possible. The False Center actuation concept was shelved in favor of a simpler gimbaled system that offered easier software, one less motor controller and a mechanism more readily understood by the external collaborators and funding agencies. Other pressure to keep the two-actuator design came from the industrial vendor who eventually bought the patent rights from MBARI. So, the gimbaled version for the tailcone was built by the MBARI /Dorado AUV team, Figure 2. There have been years of successful missions, with well over 15,000 kilometers logged including several successful missions underneath the Arctic ice. However the original questions persisted: What can be done if an actuator fails? Can we add fault tolerance while not deteriorating actuator positioning? Is smaller packaging possible? In the current design if one of the two actuators fails and the AUV is in open water, the vehicle will abort its mission and should eventually float back to the surface [3]. However if that AUV is deep under the arctic ice the story is very different. Both of these scenarios pose a problem, because aborting a mission and not having ready access to recover the vehicle means loss of data, possible loss of the vehicle, and the obvious loss of the invested funds for the mission [4].

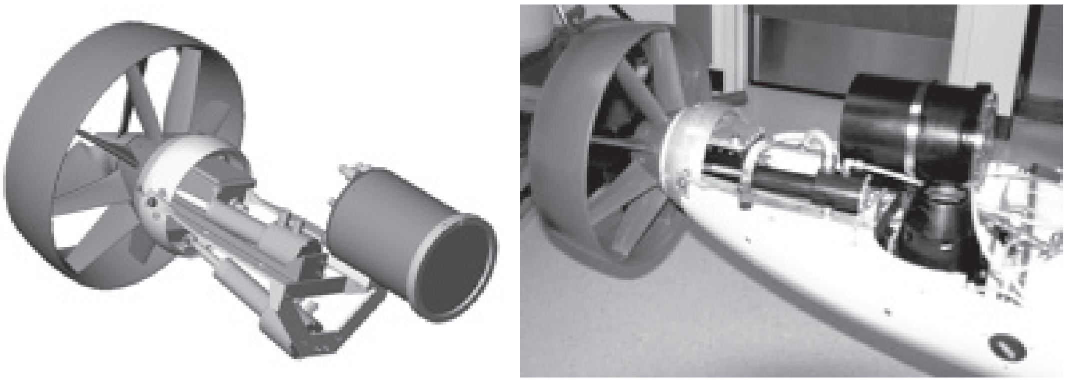

Figure 2: The original DORADO/ALTEX Gimbaled Tailcone Assembly

The current design is also constrained by the physics of the gimbaled mechanism requiring that at least one of the actuators be mounted on the inner gimbaled hub for rudder control. These attachment points are fixed locations and cannot be changed if the actuator is to work. This inflexibility of mounting angles greatly reduces the ability to place additional sensors in the tail section of the AUV. Furthermore the current gimbaled mechanism means one actuator "rides" on the other actuator and therefore has to swing through an open volume. Accomplishing this uses a large amount of volume in the rear section of the AUV.

NEW TAILCONE ACTUATION DESIGN

There are three primary issues to address by removing the gimbaled components that are required to handle the changes in kinematics. The first issue to address is the torque induced on the actuators. The second issue is the requirement to shift the pivot point for actuation when any given actuator might fail. The last issue is recognizing the fault and reacting appropriately.

Prior to investing a great deal of effort a project to develop a tabletop model of a three-actuator mechanism including the linkages, propeller mount and the control box was undertaken, Figure 3. We identified the key requirements for the new tailcone and then solved the issues in a manner that could accomplish the results in a real application. The requirements included the ability to carry the thruster and transfer the load into the hull, be able to meet or exceed the response of the current mechanism, use the same or less power, reduce the size, weight and electrical noise, and be able to achieve 20-25° of elevator and rudder control.

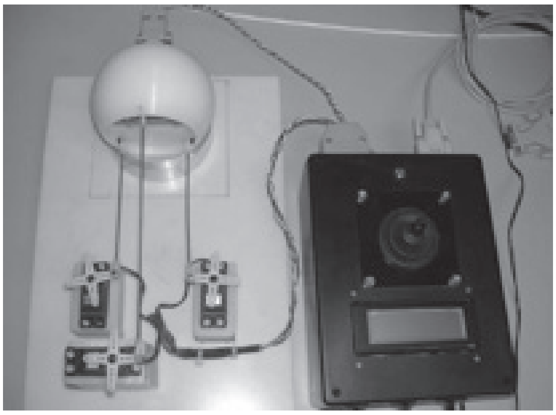

Figure 3: The desktop model of the False Center Mechanism to identify requirements

Based on the successful model tests, a full-scale unit was developed. Part of the development included new actuators that simulate the motions of the current units used to control the gimbaled tailcone. The full-scale unit also incorporates the ducted propeller and propulsion drive motor with a gear reduction unit. Because of the lack of vehicle hull mount points for bench top testing a framework was also constructed to imitate the mounting points of the DORADO style vehicles as seen in Figure 4.

II. RESULTS

The rotational matrix and failure software is now written and desktop testing is beginning. Using a simple system of driving the motors by joystick, the mechanism operates as designed and properly addresses the issues of binding, shifting center of motion, rotational load handling, and creates the additional volume desired. Further testing is underway and the results are expected to allow for sea trails in the near future.

Although the primary goals have been achieved to some extent, two others goals are ready for testing but at the time of this writing yet untested. One is the approach of taking a failure in this tolerant system and implementing the algorithm that moves each motor in turn to properly identify the error and remap the commands to new actuations outputs. The second is the demonstration of small incremental motions that minimize the error in pitch and yaw due to a distance error from the true-center of rotation that is mechanically fixed in the gimbaled solution.

III. CONCLUSIONS

The desk top prototype successfully modeled the concept to: effect servo mo-

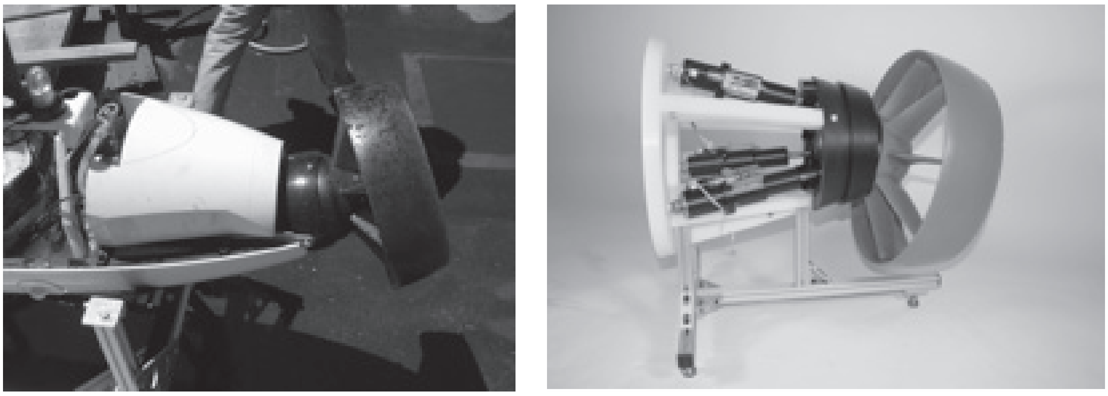

Figure 4: External comparison of the Gimbaled Tailcone and the False Center Tailcone

tor positioning, read in sensor position on a serial ComPort, display actual vs. desired angles, and look at the motions when shifting pivot centers in a simulated failure. The three-actuator mechanism model showed some modifications were required to fully enable its implementation as a fault tolerant system. The expected spherical cradle mechanism demonstrated by unconstrained simple construction that a false center can create out-of-plane movement. This movement has to be managed but without increased actuator strength, power, or any potential for binding in the event of failure of one of the actuators.

The system requires further testing but the strictest requirements for stable control should be easily achievable. As per design, the method of handling this is to limit the full range of motion if any of the motors fail, but maintain a suitable degree of control to complete a mission. Using this approach also takes advantage of the changing lever arm length thereby reducing motor strength demands. It is possible this approach will also reduce the size of the actuators required to operate a DORADO. With propulsion and control being a large part of a DORADO power budget we are exploring this further as the next phase of upgrades that could result in increased endurance and science payload as well as being more tolerant of failures in the field.

ACKNOWLEDGEMENTS

The David and Lucile Packard Foundation
Knute Strietlien for Ducted Ring Wing Analysis
Cheri Everlove for MBARI Internship Build of Concept Model
Bluefin Robotics Inc. for production version of the gimbaled tailcone

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INTEGRATION OF OPTICAL AND ACOUSTIC SENSORS FOR 3D UNDERWATER SCENE RECONSTRUCTION

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Abstract- Combination of optical and acoustic sensors to overcome the shortcomings presented by optical systems in underwater 3D acquisition is an emerging field of research. In this work, an opti-acoustic system composed by a single camera and a multibeam sonar is proposed, providing a simulation environment to validate its potential use in 3D reconstruction. Since extrinsic calibration is a prerequisite for this kind of feature-level sensor fusion, an effective approach to address the calibration problem between a multibeam and a camera system is presented.

Keywords - optical and acoustic fusion, multibeam sonar, underwater 3D reconstruction, calibration

I. INTRODUCTION

Three-dimensional underwater reconstructions allow the analysis of the temporary evolution of marine ecosystems, as well as the morphology of the underwater seafloor. In order to obtain 3D information, scene key points from multiple underwater views (either supplied by multiple cameras or by a single moving camera) can be used to extract 3D estimates. However, while optical approaches provide high resolution and target details, they are constrained by limited visibility range. Underwater sonars can operate in larger visibility ranges and provide 3D information even in presence of water turbidity conditions though at expense of a coarse resolution and harder data extraction. Hence, a promising emerging area of underwater 3D reconstruction has started to study the combination of data exploiting the complementary nature of optical and acoustic sensors. Despite the difficulty of combining two modalities that operate at different resolutions, technology innovations and advances in acoustic sensors have progressively allowed the generation of good-quality high-resolution data suitable for integration and consequently the related design of new techniques for underwater scene reconstruction. The main works combining some type of sonar (acoustic camera, single beam sounder, multibeam…) and vision data [1,2,3,4,5] have been reviewed showing that data integration is performed at a feature level, basically through geometrical correspondences and registration. In this way, a crucial problem becomes the data alignment (or sensor calibration) problem which allows data from one sensor to be associated with the corresponding data of the other sensor.

II. PROPOSAL OF OPTI-ACOUSTIC SYSTEM

The proposed system is constituted by a camera and a multibeam sonar that will be attached to the vehicle rigid frame in order to acquire images and profiles of the vehicle's underlying seafloor. Hence, we want to take profit of the acoustic sensor to obtain seabed range information, while the camera is used to gather other features such as color or texture. In order to later combine information from both sensors its configuration must be such that part of the swath from the multibeam sonar intersects the projection area of the image.

A simulation environment has been created in order to perform tests using simulated camera and multibeam data. System sensors have been geometrically modeled using the standard pinhole camera model and a multibeam simplified model reduced to a number of beams equally distributed along the total aperture of the sonar. These models have been parameterized with the values of the real sensors mounted in our AUV, a Tritech Super SeaSpy camera and a DeltaT multibeam sonar from Imagenex. Within simulation environment, the mapping between acoustic profiles and optical images can be established applying the rigid transformation matrix that relates the two sensors. Thus, given an acoustic profile, composed by a set of target points, each with a certain 3D position, we can project it onto the optical image plane, obtaining the depth (and eventually also the reflectivity value) with reference to the image plane. The potential use of this mapping to robustly characterize features becomes evident since a feature could be described by an interest point descriptor from the image but also by a particular depth and a specific acoustic reflectivity.

Besides, a straightforward approach considering ideal calibration and navigation data has been implemented to demonstrate that a calibrated camera-sonar system can be used to obtain a 3D reconstruction of the seafloor. Supposing the camera center of projection at the each of the corresponding locations with respect to the multibeam, the images can be reprojected over the bathymetry thus giving a 3D reconstruction of the terrain which comprises both range and visual information. However, this approach would rarely have a good performance in real conditions since data accuracy of typical navigation systems far exceeds the intrinsic accuracy of the sonar. Then, an appropriate SLAM algorithm should be designed in order to enforce local and global consistency within navigation data and sensor measurements to yield superior mapping results.

III. EXTRINSIC CALIBRATION BETWEEN A CAMERA AND A MULTIBEAM SONAR

In order to obtain the relative position and orientation of the multibeam and camera coordinate systems we sought for a calibration method that does not rely on explicit opti-acoustic matches, since we experimentally tested that the establishment of these correspondences is a nearly impossible task due to the different resolution of both sensors and the noise of the acoustic data. Since we assume a simplified multibeam model, our problem might be considered similar to a calibration of a camera-laser system, so we tried to adapt a calibration procedure presented by Zhang and Pless [6] to calibrate a camera and an invisible laser range finder. Some simulations have been performed to evaluate the suitability of the method using the geometrical modeling of the sensors previously described. Gaussian and uniform noise has been added to the multibeam points simulating the accuracy of our real multibeam, showing that the method can effectively perform the extrinsic calibration of the sensors.

IV. CONCLUSIONS

In this work, we have presented a first step towards the integration of optic and acoustic information for the three-dimensional reconstruction of underwater scenes. An opti-acoustic system composed of a camera and a multibeam sonar has been proposed, providing simulations to validate its potential use both in the establishment of robust features and the 3D reconstruction of environments. In order to calibrate the system an approach originally developed for a calibration of a laser range finder and a camera has been considered.

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SMALL SCALE UNDERWATER CHANGE DETECTION

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Automatically detecting changes between images is nowadays of common use in remote sensing. It is used with aerial imagery to monitor and understand our environment, with medical imagery to help doctors to diagnose, or using video surveillance cameras to detect movements in a scene. Unfortunately, change detection algorithms suffer from different constraints. They require highly accurate geometric and photometric registration and for this reason, they have never been used with underwater imagery in the past.

Several underwater application fields would benefit from automatic change detection, e.g. benthic habitat monitoring, deep water geological exploration, mapping of archaeological sites, supervision of geothermal and volcanic activities, or area monitoring after sudden impacts from natural or human catastrophes. The study of benthic areas benefits from recent progress in underwater technology, allowing the deployment of optical cameras for systematic surveying. However, the underwater environment can significantly degrade the quality of the acquired images. Scattering effects and non-uniform lighting result in differences in intensity levels of the same scene point in the images. Moreover, because of the rapid attenuation of light and the scattering effects, the images have to be taken at short range, and the area of interest cannot generally be acquired in one single view. Therefore, it is necessary to acquire a sequence of images covering the interest area and register them into a photomosaic to gain a global perspective of the sea floor. Unfortunately, acquiring images at short range also emphasizes the parallax effects of the 3D relief. Also, the source of artificial light in deep water or the sun flickering in shallow water makes the illumination of the scene non-uniform. These constrains are in opposition with the requisites of the change detection algorithms.

In this paper, we present a method to deal with the constraints of the underwater medium for finding changes between sequences of underwater images.

One of the main problems of underwater medium for automatically detecting changes is the low altitude of the camera when taking pictures. This emphasise the parallax effect between the images as they are not taken exactly at the same position. In order to solve this problem, we are geometrically registering the images together taking into account the relief of the scene.

In fact, the relief of the benthos and the camera poses (positions and orientations) are estimated from one sequence, the modelled sequence, using a structure from motion algorithm developed by our group. This algorithm allows recovering the accurate position of a large set of 3-D points but requires high overlap among the images and a good calibration of the camera. Once the 3D model obtained, a new image, the target image, can be matched with the 3D model in order to find its camera pose. With the pose of the target image and the 3D model known, it is possible to interpolate a 3D position for each pixel of the target image. These 3D positions can then be back-projected into to the modelled sequence in order to generate a set of new registered images. This is warping the textures of the modelled images as if they were seen from the target camera pose. These images are aligned with the target sequence taking into account the computed 3D relief. With this method, each target image can be compared with all the images of the modelled sequence.

Another problem of underwater medium is the different intensity response of a scene point. This can be due to non uniform lighting from the source of artificial light or sun flickering effect within a sequence but also to the usage of different camera when acquiring the sequences. In order to solve this issue, we developed a photometric matching technique that locally specifies the histogram of the registered images by taking the target image as reference.

Now that for each target image, a set of registered images that are corrected for illumination has been generated, it is possible to compare them. The different changes masks obtained are combined together by a voting scheme in order to obtain one more accurate change mask per target image. The accuracy of these change masks is strongly dependant on the accuracy of the 3D model.

In the final masks, some false positives may be triggered. False positives are changes detected in areas that did not change, due to inaccuracies of the 3D model. With a perfect 3D model, the images would be perfectly registered but the structure from motion algorithm is not able to model moving structures. Moreover, when no points can be match in the images due to low contrast, no 3D points can be estimated. Fortunately, the areas that are not properly modelled can be detected. In fact, when back projecting the non accurate 3D positions of the target image pixels, they will be in different scene points in the modelled sequence. This means that the differences between the registered images themselves are telling us what are the areas poorly modelled. The changes detected in these areas can be discarded.

Finally, two masks are generated for each target images. One is representing the areas that have changed and the other one is representing the areas that are not properly modelled. As the target images are most likely overlapping, there is redundant information in the masks. As the 3D positions are know for each pixel of the target images, these masks can be combined in two 3D masks of the whole surveyed area. This is also improving the overall accuracy of the change detection and makes it easier to analyse large sequences of images.

TRINOCULAR SYSTEM FOR 3D MOTION AND DENSE STRUCTURE ESTIMATION

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Abstract – The relief of the seafloor is an important source of data for many scientists. In this paper we present an optical system to deal with underwater 3D reconstruction. This system is formed by three cameras that take images synchronously in a constant frame rate scheme. We use the images taken by these cameras to compute dense 3D reconstructions. We use Bundle Adjustment to estimate the motion of the trinocular rig. Given the path followed by the system, we get a dense map of the observed scene by registering the different dense local reconstructions in a unique and bigger one.

Keywords – 3D motion, 3D reconstruction, trinocular system.

I. INTRODUCTION

Underwater images are a very rich source of data for scientists who study biological and geological processes of sea floor. Among other uses, underwater imagery can be used to construct image composites referred to as photo-mosaics. Photo-mosaics are widely used in many different study areas such as geological surveys, mapping and detection of temporal changes and autonomous vehicle navigation. Up to date, mosaicing has been carried out in 2D, providing a large two-dimensional composite image of the surveyed area. However, most of the regions of interest for the scientific community are located in areas with 3-dimentional relief.

In this paper we present an optical system to model complex 3D objects of the ocean floor. This system will be the basis for automatic detection of changes in the morphology of many underwater objects in the future, allowing understating geologic, tectonic and sedimentologic processes in the seafloor.

II. DESCRIPTION OF THE IMAGE ACQUISITION SYSTEM

The image acquisition system, here after called trinocular system, is basically composed by three cameras, a processing unit (a standard PC) to control the image acquisition process and inputs of the user, two hard-drives to store the images and also a screen to give feedback to the user. All these elements are encapsulated inside four cylindrical steel containers: one for the processing unit and one for each camera.

Given the poor lightning conditions of the underwater environment (due to light absorption and scattering) the selected cameras have a high light sensibility. As the purpose of the images taken by the system is to be used as input for a stereo reconstruction algorithm, we must ensure that the images are taken at the very same instant. In order to achieve this goal, we use the standard Parallel Port of the processing unit to simultaneously drive the three trigger signals and, by means of additional circuitry, we buffer and distribute these signals to the serial trigger port of their corresponding camera.

III. IMAGE PROCESSING

In order to obtain a 3D reconstruction of the scene, we use a variant of the Match Propagation (MP) algorithm proposed by Quan et. al. in [1]. This algorithm uses a stereo pair of images and a set of initial seed matches between them to propagate the correspondences. This propagation is based on the assumption that the neighborhood around valid correspondences still shows sufficient texture to contain other reliable matches.

To obtain a reliable set of seed correspondences, we use some of the well known algorithms for point detection, description and matching (like SIFT or SURF), followed by a RANSAC consistency check.

Next, we apply a modified version of MP by performing a deeper search for each pair of points considered to be a good match. Instead of just accepting this correspondence we use the information of the third camera in order to verify whether the correspondence is also valid for the third view of that point. Epipolar geometry is used to efficiently locate the position of that point in the third image as the intersection of the epipolar lines coming from the location of that point in the first and second images.

Once the MP algorithm is applied, the resulting set of correspondences is matched at subpixel level through interpolation. Afterwards, we apply a simple triangulation for each match to retrieve its 3D position.

IV. CREATION OF A DENSE MAP

In order to get all the reconstructions for each stereo set of frames, we use a stereo tracking algorithm to recover the pose of the camera system for each time instant over the sequence. In addition, we use a Sparse Bundle Adjustment method (based on [2]) to estimate the trajectory followed by the trinocular system. The cost function of the Sparse Bundle Adjustment minimizes the reprojection error of the tracked points.

Having the path followed by the trinocular system and the dense local point clouds computed with the algorithm described section 3, we are able to register all these point clouds in a common reference system obtaining a dense map. This dense map is a unique and bigger dense reconstruction covering a larger area than the local ones. Figure 1 illustrates the preliminary results obtained in a non-underwater environment.

V. CONCLUSIONS

A new system for 3D modeling of the underwater sea-floor has been presented. We have developed a hardware system to acquire sequences of triplets of underwater images, and we have introduced a processing scheme to get an accurate dense 3D map from the captured set of images.

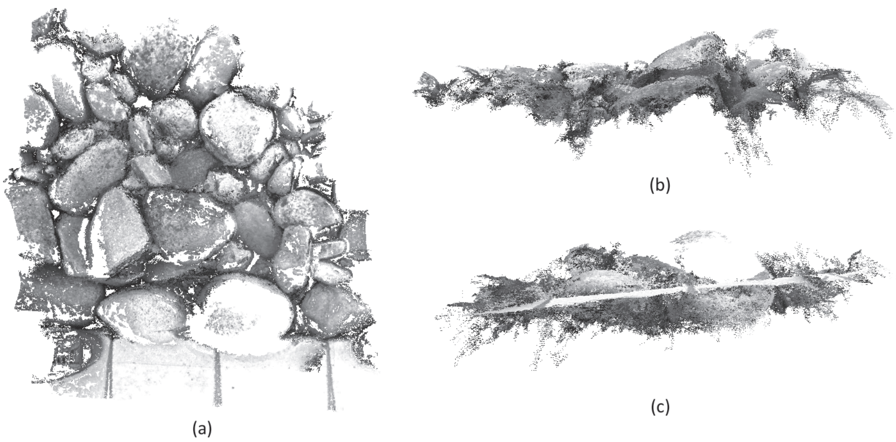

Fig. 1. Three views of a dense 3D map obtained from a set of local dense 3D reconstructions, where (a) is the plan, (b) the side view and (c) the main view.

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TOWARDS THE ECOLOGICAL DREDGER

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Abstract – The dredging is a process that intrinsically damages the aquatic environment. Suctioning part of the aquatic bottom surface suppose not only change the ecosystem but it endanger the life of the animal and plant species. Nowadays, there is doing a lot of efforts to improve the ecological aspect of the dredging process. In this work, we propose the introduction of machine vision techniques to obtain this improvement, using hyperspectral imaging. The performed tests show that is possible to reduce the environmental impact applying these techniques in two points of the dredging process.

Keywords – Dredging, computer vision, hyperspectral imaging, ecological dredger

I. DREDGING PROCESS

The dredging work refers to removing mud or residues from the aquatic bottom, extracting them and disposing at a different location. In order to perform this job, different types of dredger are available. One of the widely used [1] is the trailing suction hopper dredger (TSHD), which diggs up the bottom using pressurized water, extracts the material using a suction tubes and transports this suctioned material to other point. The dredging could have several targets, like the construction and the cleaning of the waterways or harbours.

II. ECOLOGICAL ASPECTS

Usually the dredging work is perceived as a non-ecological process which damages the aquatic life [2]. This is thought because the aquatic bottom material extraction is done in a very aggressive way. Frequently, the dredging zone contains contaminant materials which are digged up without a full control over the action.

Nowadays, environmental studies are the main way in order to minimize the ecological damages [3]. These provide a chemical characterization of the materials after a laboratory analysis, so that this data is not available at the very moment of the digging and suctioning tasks. Other ways to improve the process are focused, for example, on the efficient design of the suction drag head.

III. OUR CONTRIBUTION

Our work is centered on improve the ecological aspect of the dredging, applying new machine vision techniques. To this aim. we are working on hyperspectral imaging in the dredging process. The performed research is mainly focused on two parts of the whole process: the suction drag head and the hopper tank.

In the drag head, we propose the use of hyperspectral imaging in the 400 nm - 900 nm wavelength range which is the appropriate range to be used for underwater measurements as the absorption coefficient of the water gets its lower value at 400 nm.

From the captured images we performed a first basic processing selecting the three most discriminative bands from the whole spectra in order to be able to properly distinguish among the different materials.. In the laboratory tests performed with this basic approach, we could difference between three elements which were underwater: the test aquatic floor, a metal piece and some organic elements (underwater plant). There is a clear usage of this advance: It will be possible to determine if in the dredging zone exist some metallic element (like an anchor) which could damage the dredger or if it exist some special water plant species and be capable to avoid an ecological damage.

The second kind of research was focused in the dredged mud which is in the hopper. In this place, we have tested the possibility of including a hyperspectral camera sensitive i the near infrared range (NIR), exactly between the 900 nm and 2500 nm wavelength. This range provides great amount information about the chemical composition of the materials. Unhopefully, the absorption properties of the water prevents for the use of this range bands inside the water. Because of this, we propose the use of these bands outside the water. In this case, we achieved optimistic results. We can distinguish between different kind of muds by the means of their different concentrations of contaminant elements (zinc, cadmium, mercury and lead).

The tests we performed consist of finding the separability between four different mud samples. With this target, we created a model [4], in order to distinguish those four classes. For this purpose, a sample of each class of mud is obtained and processed spectrally and spatially. From this processing, a characteristic vector is extracted from each sample. This vector contains spectral information (which characterizes the chemical information of the sample), as well as spatial information. Spatially, the mud is composed with various elements like small stones, shells or sand. This fact means that each pixel of the mud hyperspectral image have a different chemical composition. Thanks to the spatial processing, we can generalize the information of a determinate mud, so its characteristic vector is going to identify the mud better than if it only had taken into account spectral information. The next step is the feeding of a specific Gaussian classifier with this characteristic vectors. Finally, this trained classifier was able to easily distinguish between the first four muds.

This advance has a clear application in an ecological dredger. During the dredging process, is possible to detect the kind of mud that is being suctioned and actuate consequently. For example, if the dredger is suctioning a kind of mud with a high concentration of contaminant elements, those elements could be dispersed along the whole marine environment. So, in this case, the objective will be to reduce the pressure of the suction in order to decrease the environmental contamination, and have an accurate control on the suctioning process.

IV. CONCLUSIONS

Hyperspectral imaging applied to the dredging works is an effective way to improve the ecological aspect of the process in a trailing suction hopper dredger. We have proposed the introduction of the hyperspectral cameras in two key points of the dredging chain. The performed laboratory tests show us that, in the suction drag head, we can detect the kind of the ecosystem that exist in the aquatic bottom and avoid damage it. These tests also show that using hyperspectral imaging in the hopper tank, we can detect if the suctioned mud is contaminant and actuate in consequence.

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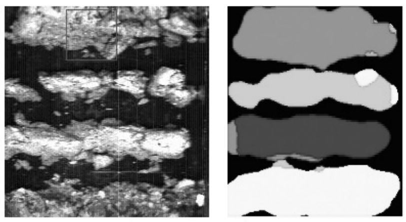

TELECOM SUBMARINE CABLES, A BUSINESS COMPATIBLE WITH THE ENVIRONMENT PROTECTION

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Abstract –All playing agents in marine operation:, telecoms, cable manufactures and cableship operators, are more and more involved in making their increasingly watched and regulated activities to be compatible with sustainable and live oceans.

Keywords - Marine operations, submarine cables, cableship, telecommunication networks, environment protection

I. INTRODUCTION
Fiber optic submarine cables are the backbone of voice and data international telecommunications networks.
Almost 100% of transoceanic Internet traffic is sent via submarine cable.
Cable manufacturers, telecoms, cableship operators and National Authorities are together in the awareness of reaching the final objective that cables as much as marine operations involved both in installation and maintenance of submarine systems developed on the high seas as well as on the coastal areas have a neutral to benign effect on the marine environment

II. SUBMARINE CABLES FOOTPRINT
Fiber optic submarine cables used on telecommunications are small.
Deep-ocean types without protective armour are typically 17-20 mm. diameter.
Armoured fibre-optic cables may reach 50 mm diameter
Their small diameter means that their "footprint" is small, especially when compared to other submarine structures: oil-gas pipelines, fishing trawls,..

III. SUBMARINE CABLES COMPOSITION
They are composed of non-toxic materials that are stable in sea water.
Industry is under increasing environmental scrutiny.
Independent, authoritative academic study to verify submarine cables are benign using scientific techniques:
•To determine if, and to what extent materials leach from cables
•To investigate the nature and extent of colonization of marine growth on cables
•To investigate potential organic compound release from submarine cables
•To determine if submarine cable is a suitable material for construction of artificial reefs

IV. SUBMARINE CABLES, SUBSTRATES FOR MARINE ORGANISMS
Submarine cables form artificial hard substrates, which have provided scientists with some valuable information about colonization, recruitment and growth of sessile deep and high sea organisms.
Underwater images or recovered cables show that submarine cables soon after laid become a suitable support for a great range of marine creatures.
Industry desire to gain approval for the use of recovered submarine cable in the construction of artificial reefs.

Figure 1. Anemones on submarine cable
Courtesy: Monterey Aquarium Research Institute

V. CABLE PROTECTION ZONES
The great majority of failures on submarine cables take place in sallow or medium depth waters and because of human activity (fishing or anchoring).
As protection for submarine cables, protection zones are established alongside the cables, when fishing and anchoring activities restricted or banned in areas with a high risk of failure.
Cable protection zones may act as marine sanctuaries to improve diversity and fish stocks and prevent illegal fishing.
VI. MARINE OPERATIONS

Figure 2. Submarine cable on seabed

A wide range of actions in installation and maintenance of submarine telecommunications systems, cable and seabed survey, cable lay, recovery and repair, dredge with grapnel, cable or zones buoying, use of submarine vehicles, professional divers support, heavy machinery on beach or coastal interventions,…frequently involve the presence of human and technical resources in the marine or coastal environment.
Frequently, repair marine operations take place under global maintenance agree-

Figure 3. Cableship

ments (ACMA Atlantic Cable Maintenance Agreement, MECA Mediterranean Cable Maintenance Agreement).
Specific clauses that are reflected on the cableship procedures are included in the text of those agreements and undergone to periodic audits.
Residues refuse collection for recycling
All over the cableship containers for all type of materials and chemical products are deployed.
Scrapping of wasted materials:

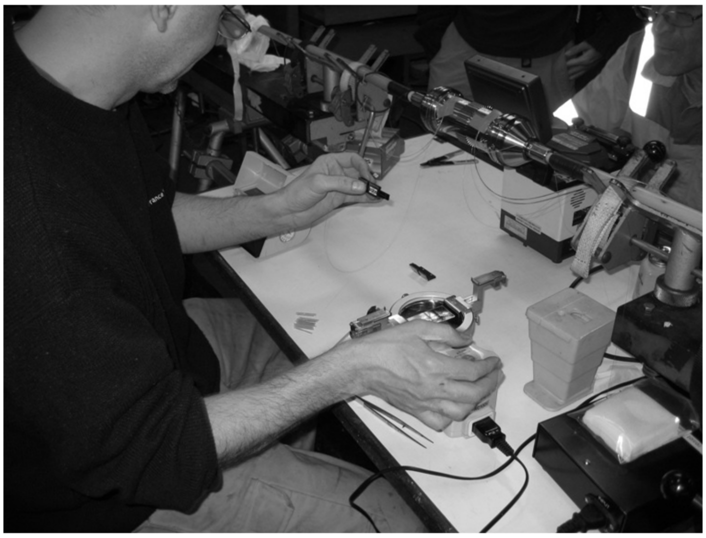

Figure 4. Container for fiber optic waste collection

Discarded sections of cable or splices recovered discarded over the repair are unloaded and transferred to specialized and authorized companies for scrapping.
Planning and Prevention of Chemical and Toxic Spillage.
Apart from during sailing controls, cableships have to go for refit every year, when all systems are strictly checked and controlled.

VII. LEGAL, PAPERS AND REPORTS

National Jurisdiction
Cable routes and Landing Points are submitted to national authorities, undergone environmental potential impact analysis.
International Legal Framework
Rights and duties of states with respect to protecting and conserving living marine resources biodiversity beyond national jurisdiction are contained in an array of legally binding global and regional agreements.
MARPOL
The MARPOL Convention is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes.
The Convention includes regulations aimed at preventing and minimizing pollution from ships - both accidental pollution and that from routine operations - and currently includes six technical Annexes.
UNCLOS United Nations Convention on the Law of the Sea
It is often referred to as the “Constitution for the Oceans” the legal framework applicable to all activities in the oceans and seas.
The laying of cables is recognized in UNCLOS as a traditional high seas freedom, a right conditioned by UNCLOS´s to protect and preserve the marine environment.
Recommendation to cable industries is “to avoid routes through areas hosting sensitive deep-see ecosystems or areas of scientific or historic interest” while further research about the potential impact on environment.
ICPC International Cable Protection Committee
The principal purpose of ICPC is to promote the safeguarding of submarine cables against man-made and natural hazards, guarantying to share the seabed in harmony with others.
ICPC also provides a forum for the exchange of technical, legal and environmental information pertaining to submarine cables.
Members co-operate closely with fishing, undersea mining, oil and gas, dredging, and other offshore industries utilizing the seabed in an effort to reduce the number of incidents of damage to cables.
ICPC monitors the evolution of international legislation where submarine cables are concerned and lobbies for change when it is appropriate to do so. It also leads projects and programs that are deemed beneficial for the protection of submarine cables.

VIII. CONCLUSIONS
Significant anecdotal evidence points to cables being benign
Independent, authoritative academic study to verify submarine cables are benign using scientific techniques
Industry under increasing environmental scrutiny
Evolving International Legal and Policy Regime
Environmental protection measures already in procedures, and contracts.

IX. ACKNOWLEDGEMENTS
The author specially acknowledges Telefónica España for the total support received to MarTech09 participation.
The author acknowledges the support of ICPC Secretariat for their contribution with valuable presentations and reports.
The author acknowledges France Telecom Marine, Tyco Marine, Elettra and Global Marine for their documentation and procedures information contribution.

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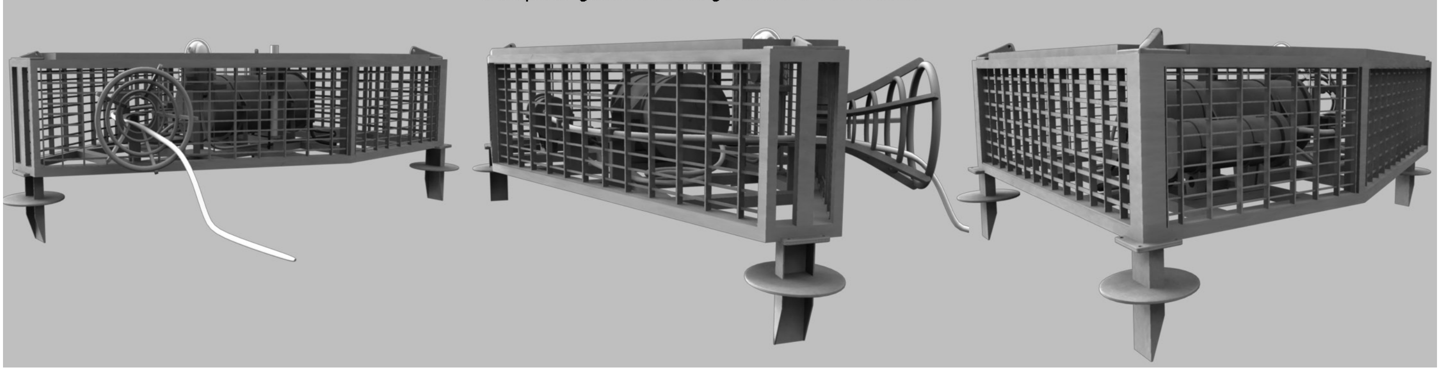
Computer generated image of the OBSEA node.

WIDE-ANGLE REFLECTION AND REFRACTION SEISMIC PROFILE FROM THE OUTER PART OF THE GULF OF CADIZ: NEAREST-SEIS CRUISE.

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Abstract- We will explain the first interpretations from a marine refraction and wide-angle reflection seismic profile acquired in the outer part of the Gulf of Cadiz in November 2008, in the framework of the NEAREST-SEIS cruise

Keywords- wide-angle reflection, refraction, Gulf of Cadiz, seismic hazard, NEAREST project.

INTRODUCTION

The Gulf of Cadiz is located in the SW Iberian Margin and horsts the present-day convergent boundary between the Eurasian and the African plates (4.5-5.5 mm/yr) [e.g. 1, 2]. The region is characterized by an intense seismic activity of moderate magnitude [e.g. 3], although large historical and instrumental events (Mw ≥ 8.0) have also occurred [e.g. 4, 5].

Numerous marine geophysical cruises have been carried out in the region during the last 20 years [e.g. 6, 7] to advance the knowledge of its complex geodynamic evolution. One of these cruises (NEAREST-SEIS) was carried out in October-November 2008, in the framework of the EU-FP6 Nearest project aiming at evaluate the feasibility of a tsunami early warning system in the area. Two wide-angle reflection and refraction seismic profiles using for the first time the pool of Ocean Bottom Seismometers (OBS) acquired by the Marine Technology Unit (CSIC) together with landstations were acquired during the cruise (Fig. 1A). The main objectives of the NEAREST-SEIS cruise were to provide information about the geometry of the crust-mantle boundary and the physical properties of the crust, revealing the deep geometry of the main faults, and identifying the nature of the crust and the limits of the different crustal domains in the region. In this paper we show samples of the data acquired with the new Spanish OBS, we describe the processing made, as well as the first results obtained from the preliminary analysis of the profile P1.

DATA AND METHODS

The NEAREST-SEIS cruise took place from 27th October to the 13th November 2008 onboard the Spanish R/V Hesperides (P.I. V. Sallarès). We acquired two wide-angle reflection and refraction seismic profiles (Fig. 1A) using a set of 30 Ocean Bottom Seismometers (OBS) for the profile P1 and 15 OBS for the profile P2, as well as complementary acoustic (swath bathymetry and sediment profiler) and gravity data. The OBS pool consisted on 17 short period instruments of LC2000 model, recently acquired by UTM to the Scripps Institution of Oceanography (La Jolla, US), and 19 MicrOBS model from Ifremer and Université de Bretagne Occidentale. The seismic source consisted of an airgun array with total of 7 Bolt airguns (model 1500LL), organized in 2 arrays. The main array was approximately 12 m long and the secondary consisted of a single gun towed off the stern on amidships. The capacities of the guns deployed during this survey were 500, 1000, 500, 255, 265 and 1000 c.i. in the main group, and the other was of 1000 square inches on amidships, for a total volume 4520 c.i. The separation between guns was of 2.5 m between plates and of 0.8 m in the case of the cluster that consists of the 255 and 265 c.i. guns, all of them working at a depth of 12 m [7]. The water wave arrival was used to relocate the instruments in the seafloor using an in-house developed grid search algorithm. The processing sequence included: de-bias; a whitening deconvolution (0.5); a butterworth band pass filter (4-18 Hz); and Automatic Gain Correction (an equalization of the traces in the time domain). The data have comparable quality in both types of instruments.

PRELIMINARY INTERPRETATION OF THE MODEL

The data identified in the record sections have been used to construct a travel-time tomography model along the two profiles. Aside from the instruments, data and processing sequence, in this work we present also an example of the information that can be obtained with a dense array of OBS. The selected profile is P1, which extends 356 km with NW-SE trend from the Tagus Abyssal Plain, over Gorringe Bank, across the Horseshoe Abyssal Plain and the Coral Patch Fault, up onto Coral Patch Ridge and finally to the fold and thrust belt in the Seine Abyssal Plain (Fig. 1A). In terms of apparent velocity we identified the following four domains from the recorded sections: a) in the Tagus Abyssal Plain (TAP) we identified a moderately thick layer (1-2 km) of low velocity sediments (<3 km/s) on top of a very high-velocity basement (> 7 km/s); b) in the Horseshoe Abyssal Plain (HAP) we identified a moderately thick layer (1-2 km) of low-velocity sediments (<3km/s) on top moderately thick layer (1-2 km) of higher-velocity sediments (3-4 km/s), and this on top of a high-velocity basement (>7 km/s); c) the Gorringe Bank (GB) appears similar to the Horseshoe Abyssal Plain but titled to SE; and d) the Seine Abyssal Plain (SAP) where we identified a moderately thick layer (1-2 km) of higher-velocity sediments (3-4 km/s) on top of a lower velocity basement (>5-6 km/s).

CONCLUSIONS

The cruise can be considered as a success in the sense that it has allowed acquiring a unique data set of Wide-Angle Seismic (WAS) data along two long profiles crossing most of the potentially seismogenic/tsunamigenic structures off the SW Iberian Margin. It is important to note that all the OBS that were deployed during the full survey were successfully recovered, and all of them recorded continuously during the airgun shooting phase. The airgun array was proved to be efficient enough to produce seismic energy at the low frequencies required to record identifiable signal at the long distances characteristic of WAS experiments, regardless of the limited capacity of the source in terms of size and power of compressors. The data recorded with both types of OBS have comparable quality. The processing applied to the dataset has significantly improved the quality of these, allowing us to identify seismic phases up to more than 150 km from the OBS in some cases. From the first interpretations of the data we have divided the study area into four domains based on the apparent velocity observed in the recorded sections: the TAP, the HAP, the GB and the SAP.

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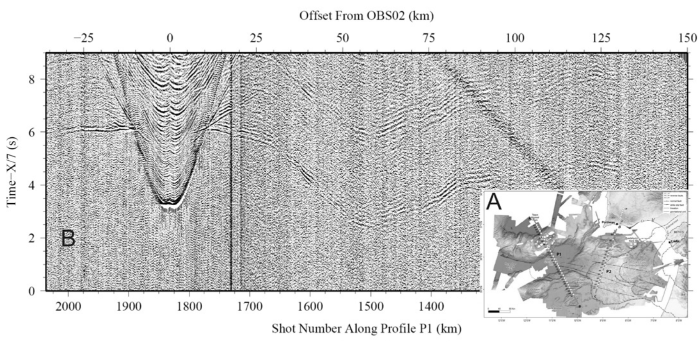

PALEOSEISMOLOGY OF ACTIVE FAULTS BASED ON MULTISCALE SEISMIC IMAGING

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Abstract – The study of active structures offshore requires very-high resolution seismic imaging in order to observe the most recent layers below sea floor. In the other hand, high penetration methods are necessary to observe deeper reflections for understanding the evolution of the structure throughout the time. The aim of our study is to establish the seismic potential of the offshore segment of the Carboneras Fault, Eastern Betics, based on multiscale seismic imaging. Three different scale methods have been acquired and are compared here: very-high-resolution sub-bottom profiler TOPAS, very-high-resolution single-channel seismic (Sparker) and high-resolution multi-channel seismic. From seismic profiles, faulted Quaternary layers suggest that the Carboneras Fault is active. Sediment coring and dating analysis are used to consider ages for key reflectors observed in TOPAS profiles, and a change in the vertical slip-rate through the Quaternary is inferred.

Keywords – Carboneras Fault, Alboran Sea, active tectonics, multiscale imaging, high-resolution seismic

I. INTRODUCTION

Seismic data is commonly used to identify active faults, to study their seismic parameters, and to relate faulted horizons with the historical and instrumental earthquake record. High-resolution seismic reflection profiles (<3 km depth penetration and 2.5 m of vertical resolution) are excellent to investigate the tectonic setting identifying its faulting pattern. Very high-resolution seismic data (<100 m depth penetration and 15 cm of vertical resolution) images the uppermost portions of major faults and its seafloor surface ruptures, being useful to relate them with past earthquakes.

Seismic systems with different resolution and penetration are used to investigate active faults in the Southeastern Iberian Margin, where the compression between the African and Eurasian Plates is characterized by a moderate seismicity and a slow NW-SE convergence (4-5 mm/yr). However, some major events occurred in the past, such as the 1522 Almeria earthquake (Intensity IX), affecting large areas in the western Mediterranean. The Carboneras Fault Zone (CFZ), an onshore-offshore active sinistral strike-slip fault [1], has been proposed as an epicentral area according to evidence of seafloor ruptures in high-resolution acoustic and seismic data.

II. METHODS

Selecting a seismic source implies a trade-off between penetration, which demands lower frequencies (e.g. boomer, airgun, watergun), and resolution, which requires greater bandwidths (e.g. 3.5 kHz sounder, parasound, chirp) [2]. To image the geometry of the offshore segment of the CFZ with different scales of resolution and penetration, three seismic systems were selected: the airgun source, the sparker source and the chirp pulse source.

During the IMPULS survey carried out during spring 2006, a high-resolution multichannel seismic (MCS) system was implemented for the first time in the RV Hesperides and 46 high-resolution MCS profiles were acquired along and across the CFZ in water depths ranging from 100 to 1700 m. The source, a 10 m long airgun array, was specially designed to enhance high frequencies, up to 300 Hz. To record the seismic data, a "GeoEel" digital streamer from Geometrics (California, USA) with 300 m of active section and 48 channels was used. The multichannel data, acquired at 1 ms sample rate, was processed at the Unidad de Tecnologia Marina (UTM-CSIC) processing laboratory. The flow sequence, after re-sampling from 1 to 2 ms and picking the top mutes, included a FK filter (between 20 and 200 Hz) to reduce spatial aliasing and a bandpass filter minimum phase (20-25-170-200 Hz). The NMO correction with a constant velocity of 1700 m/s due to the reduced length of the streamer was applied to the data. On preliminary seismic images, three main seismostratigraphic units were identified: Neogene basement, lower, and upper sedimentary units. An analysis of velocities from commercial seismic lines helped to assign the velocity range to each of the seismic facies for a Fast Explicit migration to better constrain the geometry.

Simultaneously, during the IMPULS cruise, a total of 60 profiles of high-resolution Simrad TOPAS (TOpographic PArametric Sonar) seismic profiler were acquired in order to observe the shallowest geometry of the fault. The TOPAS PS18 is a high-resolution sub-bottom profiler with parametric effect. It uses a primary frequency of 18 kHz, and a secondary frequency of 1 to 6 kHz. The maximum vertical resolution obtained is 0.2 ms, and the bandwidth range from 4º to 6º. The selected source was a Chirp pulse wavelet with frequencies of 1.5 – 5 kHz. The trace length was 300 ms with a sampling frequency of 16000 kHz and a pass band filter of 2 kHz was applied.

In summer 2008, very high-resolution single-channel seismic (SCS) data were collected on the frame of the EVENT-SHELF experiment onboard the RV Garcia del Cid. Five profiles across the CFZ in the shelf were acquired to see the onshore-offshore link of the fault, where shallow water prevents a fine MCS image. It also provided accurate morphostructure images in the sub-surface and the upper geometry of the fault. The seismic system used was a "GEO-SPARK" source from GEO-RESOURCES company (Rotterdam, The Netherlands) able to acquire data with 30 cm of resolution up to 1.5 km water depth and with 400 m of penetration below seabed. A 6 kJ Sparker system was used, triggered every 2 s. The receiver was composed of 9 m long, 24 hydrophones single-channel streamer. The first processing of data implied a change of polarity because the system uses a negative electric discharge pulse in order to reduce the wear of the tips. The processing sequence continued with debias, minimum bandpass filter (350-1500 Hz), AGC (10 ms window), gain constant (1-3 dB depending of the profile) and spherical divergence to recover the loss of energy. Finally, an automatic or manual "swell filter" depending on the seafloor topography has been performed.

III. RESULTS AND CONCLUSIONS

Seismic profiles show a great variability of structures along the fault zone, in part due to the interaction between "en echelon" traces: positive flower structures can be observed at the shelf, southwards simple reverse faults block the gullies draining from the shelf, and complex compressive structures appear at the southern segment like pressure ridges slowly dimed towards the south and finally buried by hemipelagic sediments. The high-resolution IMPULS MCS profiles allow identifying up to 7 seismostratigraphic units above the Messinian uncomformity. Correlations with ODP and commercial wells, together with sea level variation curves will provide estimate ages for the key reflectors delimiting those units, and will help to understand the evolution of the CFZ since the Miocene. Preliminary 0,04 mm/a dip-slip rates is obtained based on a approximately 112 m displaced reflector depicting the base of the Early Quaternary sequence (2,6 Ma).

TOPAS profiles show detailed stratigraphic information on the uppermost meters below the seafloor (80 to 100 m at an assumed sediment velocity of 1.5 km/s) providing a good control of recent activity over the Quaternary sedimentary architecture and depicting the shallowest geometries of the CFZ. Fault scarps and displaced reflectors evidence recent activity and a decrease of the fault activity towards the south, where Holocene sediments overlay the fault zone. From existing sediment core analyses from the Almería channel [3] sedimentation rates are calculated and slip rates can be obtained from TOPAS displaced reflectors. Profiles from the north segment of the fault shows a highly reflected horizon displaced 21 metres vertically suggesting a dip-slip rate of 0,14 mm/a for the Late Quaternary time. Similar dip-slip rate is obtained in another TOPAS profile along the CFZ. These are larger slip-rates than the ones obtained with MCS profiles since the Early Quaternary (0,04 mm/a) suggesting either an increase of the slip rate through the Late Quaternary or a change in the kinematics of the fault with an increase in dip-slip component.

SCS Sparker profiles clearly image the structures on the shelf and nearshore and will help to link onshore and offshore results and to better constrain the paleoseismic parameters for the entire CFZ.

IV. ACKNOWLEDGEMENTS

This study has been funded by Spanish national projects IMPULS (REN 2003-05996/MAR), EVENT (CGL2006-12861-C02-02), and MCYT acciones complementarias "Streamer" (CTM2004-21203-E), "EVENT-Shelf" (CTM2008-03346-E/MAR) wand “Sparker” (CTM2008-03208-E/MAR). We specially thank the captain, crew, technical staff and scientist involved on the marine cruises onboard the R/V Hesperides and R/V García del Cid for their assistance throughout data acquisition and further discussions.

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VERY HIGH-RESOLUTION SEISMO-ACOUSTICS IN THE STUDY OF SEAGRASSES. THE CASE OF POSIDONIA OCEANICA (MEDITERRANEAN SEA)

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Abstract - Posidonia oceanica is a coastal Mediterranean seagrass which accumulates in its subsurface large quantities of organic material derived from its roots, rhizomes and leaf sheaths embedded in sandy sediments. These organic deposits accumulate over thousands of years forming the matte, whose high content in organic carbon plays a major role in the global ocean carbon cycle. In this study, very high resolution seismo-acoustic methods were applied to image the subsurface features of a P. oceanica seagrass meadow at Portlligat (Cadaqués, Girona, Spain), in the NW Mediterranean Sea. Our findings yield fresh insights into the settling of the P. oceanica meadow in the study area, and define with unprecedented detail the potential volume occupied by the matte.

Keywords – Non linear seismo-acoustics, seagrasses, Holocene, Mediterranean Sea

I. INTRODUCTION

Posidonia oceanica, a widespread Mediterranean seagrass, accumulates in its subsurface large quantities of organic material, named matte. The matte is mainly composed of detritus of the seagrass, derived from their leaves and organs, embedded in the surrounding sediments [1].

The organic fraction of the matte is preserved over thousands of years forming structures several meters thick [2]. This preservation results from the highly anoxic conditions in the matte and from the refractory nature of the detritus [2]. The high content in organic carbon of these deposits plays a relevant role in the global ocean carbon cycle. Although the distribution of P. oceanica has been widely assessed using acoustic methodologies, informations on its internal structure obtained with seismic methods are still very rare. In this study, very high resolution non-linear seismo-acoustic methods were applied to image the subsurface features of a P. oceanica seagrass meadow in the NW Mediterranean Sea (Catalonia, NE Spain). The main advantage of the non-linear parametric echosounders lies in their capability to generate low frequencies producing narrow beams with small footprints [3]. This differs substantially from the linear seismic systems, which require long pulses and large transducers to generate focused low frequencies [4].

II. RESULTS AND DISCUSSION

The parametric echosounder “Innomar SES 2000 compact” was used to acquire 75 seismo-acoustic records. The echosounder was characterized by a primary frequency of 100 kHz and secondary frequency ranging from 5 to 12 kHz. Pulse Repetition Rate was up to 30/sec and the beamwidth of ±1.8°. P. oceanica meadow covers up to 60.000 m2 of the Portlligat Bay. It mainly occurs in mounds, generating irregular seabed topography, with leaves measuring from 20 to up to 60 cm long (Figure 2a). Although the seismo-acoustic method proved to be reliable in imaging P. oceanica meadows at Portlligat, this instrumentation suffered from difficulties in associating the internal structure of the matte with a specific seismic facies. The gradation between plant detritus and sediments along the vertical structure of the matte (Figure 3b) scarcely provided high-enough contrasts of impedance to generate neat seismic reflectors. Its heterogeneous composition is a very high dispersive medium for acoustic energy, resulting in a marked decrease in the signal to noise (S/N) ratio. Despite these limitations, in many records it was possible to detect a strong reflector, from 2 to 6 m depth, that was interpreted as the initial substratum where the seagrass established for first time. A 3D bathymetric model of this substratum allowed us to reconstruct the palaeo-environment of the area prior to the settling of P. oceanica, which corresponded to a shallow coastal setting protected from the open sea. A core drilled in the meadow revealed the presence of a 6 m thick dense matte composed of medium to coarse sandy sediments mixed with plant debris and bioclasts. Radiocarbon datings revealed a constant accretion rate of the meadow of about 1.1 m/kyr. Very high-resolution marine geophysical techniques allowed us to accurately define the volume occupied by P. oceanica matte, which in the study area reaches up to almost 220,000 ± 17,400 m3 (Fig.1).

III. CONCLUSIONS

The application of nonlinear seismo-acoustic technologies proved to be a powerful non-destructive method for highlighting the settling of coastal seagrasses in the Mediterranean Sea. Moreover, the new technological advances allowed in estimating the potential carbon retention of the P. oceanica meadows and better understand its relevance in the ocean carbon cycle.

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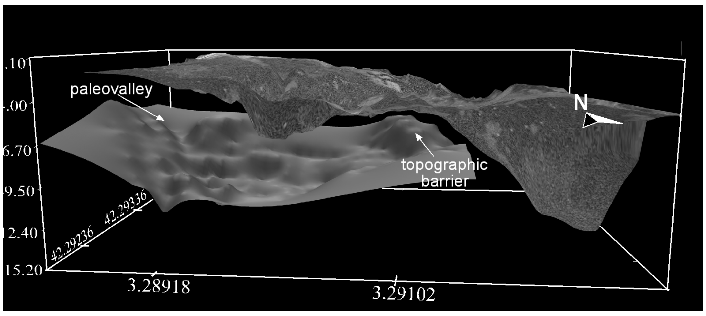

Fig.1: 3D view of the paleotopography of the matte substratum (lower gray layer) and of the actual seafloor in Portlligat Bay. Depth in meters.

OCEAN MONITORING USING GNSS-R TECHNIQUES AND MICROWAVE RADIOMETRY: THE PAU INSTRUMENT CONCEPT

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Keywords- microwave radiometry, GNSS-R, L-band, ocean, salinity, sea state, satellite payload

Lack of frequent and global observations from space is currently a limiting factor in many Earth Observation (EO) missions. For example, the Indian Ocean tsunami on 26 December 2004 was detected by radar altimeters but, since tsunami signals are quite weak in open ocean and the satellite must fly over it simultaneously, the probability of detection is very low [http://earth.esa.int/brat/html/appli/geodesy/tsunami_en.html]. Future missions have to provide better spatial and temporal coverage to allow the study of mesoscale variations and other phenomena. Two potential techniques that today have been proposed are [http://earth.esa.int/brat/html/alti/future/welcome_en.html]:

1) the use of satellite constellations, and
2) the use of Global Navigation Satellite Signals (GNSS) as signals of opportunity (no transmitter required).

GNSS-R can also be used to perform the sea state correction required in sea surface salinity retrievals by means of L-band microwave radiometry (TB). At present, two space-borne missions are currently planned to be launched in the near future with this purpose:

1) ESA's SMOS mission, using a Y-shaped synthetic aperture radiometer, launch date July 16th, 2009, and
2) NASA-CONAE AQUARIUS/SAC-D mission, using a tree beam push-broom radiometer.

In the SMOS mission, the multi-angle observation capabilities allow to simultaneously retrieve not only the surface salinity, but also the surface temperature and an "effective" wind speed that minimizes these errors. In AQUARIUS an L-band scatterometer measuring the radar backscatter (σ_0) will be used to perform the necessary sea state corrections. However, none of these approaches are fully satisfactory, since the effective wind speed captures some sea surface roughness effects, at the expense of introducing another variable to be retrieved, and on the other hand the plots (T_B-σ_0) present a large scattering.
In 2003, the PAU project was proposed to the European Science Foundation to test the feasibility of the use of GNSS signals of opportunity reflected over the sea surface to make sea state measurements and perform the correction of the L-band brightness temperature [http://www.esf.org/activities/euryi/awards/2004.html]. The concept is simple: when the electromagnetic wave is scattered over the sea surface, the scattered signal comes from the specular reflection point, determined by the shortest distance between the transmitting GPS satellite and the receiver, but when the sea is roughed, the scattered signals come from a wider region that enlarges with increasing sea state, in a similar manner as the Sun reflecting over the sea. We have proposed to measure the so-called Doppler-Delay Maps (DDMs) to provide a measurement of the width of the area over which the GNSS signals are scattered and infer form it the geophysical variables without need of any intermediate model, either numerical to compute the scattering or for the sea surface spectrum.
Under the EURYI-2004 grant a number of PAU prototypes have been developed (real and synthetic aperture versions of it, with just one receiver for ground tests and a lighter version for R/C aircraft operations). During May-June 2008 one of them was deployed in the North-West coast of the Gran Canaria island ([http://www.grancanariavirtual.com/miradorelbalcon.php]) and gathered for the first time ever L-band radiometric and GNSS-R data, together with oceanographic data (sea surface temperature + sea surface directional spectrum buoys). The field experiment will be repeated during the same period of time in 2009 with an improved version of the instrument. Now, we start understanding the relationship between the sea state and the GNSSR observables (DDMs) and the changes in the brightness temperature, but still there is a long way until meaningful physical quantities that can be successfully extracted from satellite data to be used by the oceanographic communities.
The limited GNSS-R data gathered by the UK-DMC satellite and publicly available shows the potential of this technique, and supported the proposal of a PAU secondary payload in SeoSat/INGENIO (Spanish Earth Observation Satellite). This proposal went through phase A, but did not succeed to enter into phase B due to the accommodation issues with the primary payload raised after a configuration change. Simplified, lighter and less power consuming payloads are currently under study to be ready for future launches of opportunity.
This paper will present:
•The Physics of the L-band radiometric and GNSS reflectometric observations over the ocean,
•The ground-based measurements and their interpretation, and
•The proposed satellite payloads to gather these type observations and how they can help future SMOS follow-on missions.

POTENTIAL USE OF MICROWAVE SATELLITE MEASUREMENTS TO RECONSTRUCT THE THREE-DIMENSIONAL DYNAMICS OF THE OCEANIC UPPER LAYERS

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Keywords – Ocean Dynamics, Surface Quasi-Geostrophy, Sea Surface Height, Sea Surface Temeprature, Microwave Remote Sensing

We examine the emerging potential offered by satellite microwave measurements to derive the three-dimensional dynamics of the upper ocean. The proposed approach exploits the properties of a theoretical framework based on Surface Quasi-Geostrophic (SQG) equations. Within this framework, Sea Surface Heights (SSH) and Sea Surface Temperatures (SST) are closely related. This provides a way to combine SSH and SST measurements and allows to recover surface currents from a single SST image. On the other side, this framework allows to reconstruct subsurface fields, such as horizontal velocities and density anomaly, in the upper 500m of the ocean from SSH and/or SST measurements. Furthermore, within this framework vertical velocities can also be diagnosed from a single SST and/or SSH snapshot. To demonstrate the feasibility of this approach, first, we have explored the ability to reconstruct the three-dimensional dynamics of the oceanic upper layers using numerical simulation. Then, these results have been applied to existing altimetric measurements and microwave SST data from AMSR-E instrument. Our results confirm the validity of this framework and unveil some limitations in the existing microwave measurements that should be improved in future missions.

DYNAMIC EFFECT OF QUASI-GEOSTROPHIC TURBULENCE ON OCEAN SURFACE AS DERIVED FROM SATELLITE IMAGERY

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Keywords - Satellite imagery, signal processing, pattern recognition, ocean surface velocity, Microcanonical Multifractal Formalism

In recent years, the application of new methodologies issued from the study of turbulent flows to the study of oceans has led to the design of novel tools for the description of the dynamics on ocean surface layer from satellite data [Turiel et al., 2005; Isern-Fontanet et al., 2007; Turiel et al., 2008a,2008b]. All the associated techniques are included within the so-called Microcanonical Multifractal Formalism (MMF) [Turiel et al., 2008a], which is a theoretical framework which group together diverse experimental facts (scale-invariance, intermittency) associated to the generation of chaotic, turbulent structures and allows to obtain a geometrical characterization of them. When MMF is exported to the context of satellite imagery of the ocean surface, we gain access to new dynamic information such as instantaneous streamlines [Turiel, 2008b], horizontal diffusivity and efficient flow characterization in terms of vortices [Nieves & Turiel, 2008]. Additionally, MMF can be applied to specific processing tasks such as pattern recognition, data compression, data fusion and data interpolation, with very good performance. In this paper, we will briefly review the applications of MMF to advanced image processing of ocean images, and discuss on future applications.

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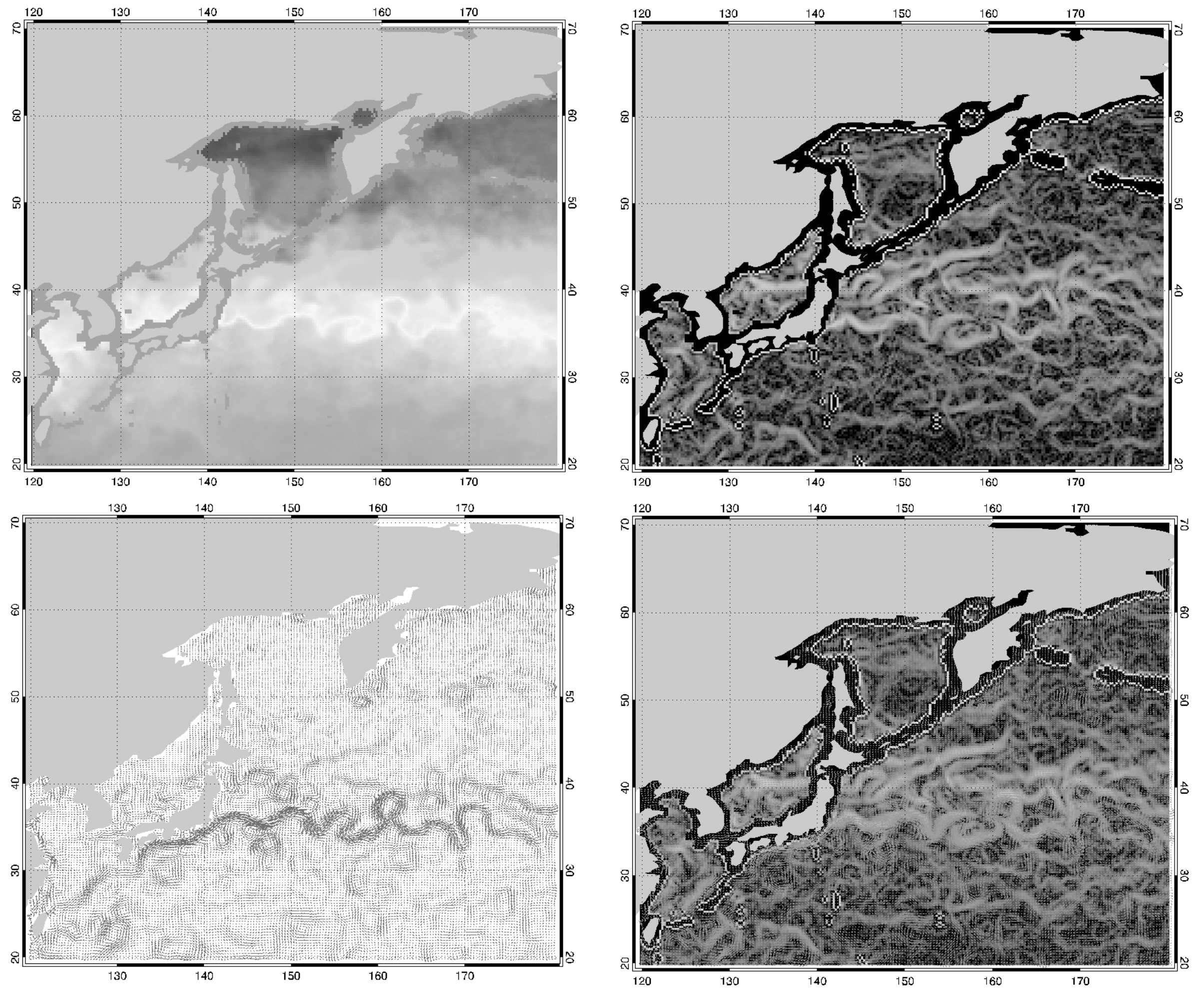

Fig.1: (from left to right and from top to bottom): Microwave SST map over the Kuroshio area in February 1st, 2003; associated singularity map; geostrophic velocities derived from the interpolation of four satellite altimeter traces; overimposition of the geostrophic velocities on the singularity maps. As it can be observed, singularities closely resemble the geostrophic streamlines; however, SST images are much less expensive to obtain and more synoptic.

SEA-ICE REMOTE SENSING WITH GNSS REFLECTIONS

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GNSS-R is a remote sensing technique that first appeared in 1993 (PARIS concept). The availability of the GPS, GLONASS and future GALILEO constellations of navigation satellites motivated this approach, which is based on the analysis of reflected L-band GNSS signals (bistatic radar). Despite being initially conceived for sea surface altimetry, this technique has many other potential applications, such as ocean wind speed, soil moisture changes, sea surface state determination, and sea ice detection and classification.
IEEC, jointly with GFZ and DMI, has carried on ESA's experimental campaign GPS-SI during the last polar winter. From October 2008 until May 2009, a set of GNSS reflected signals have been gathered at Godhavn (Qeqertarsuaq), Greenland. To do so, the GPS Open Loop Differential Real-Time Receiver (GOLD-RTR) have been employed. Placed on top of a cliff (fixed position) with around 700 m of altitude, the instrument has monitored the formation/evolution/melting of the Sea-Ice at the area during a continuous period of 7 months.
The GOLD-RTR was designed, developed and tested at the IEEC with the aim of collecting the GNSS signals reflected off the Earth's surface. Three different radio front-ends generate the complex cross-correlation function (waveform) in real-time. Input 1 is fed by an up-looking antenna for reference signal (direct), and either one or two other antennas (down-looking for reflected signals, either polarization) fed inputs 2 and 3. Ten configurable correlation channels running in parallel give an output of ten waveforms every millisecond. They can be tuned with ancillary Doppler and delay offsets. The length of these complex waveforms is 64 lags, with a delay resolution of 15 meters. To reduce the storage size, non-coherent integration is allowed (up to 1 second). The GOLD-RTR has been widely used since 2005, and nowadays it has been replicated (3 GOLD-RTR available).
During the campaign, non-coherent integrated data (1 second) have been stored, allowing measurements of total reflected GPS power, which relates to the surface emissivity at L-band; and study of the surface roughness by means of the shape of the reflected waveform. Complex waveforms at 1 msec coherent integration have also been gathered, both with Left- and Right-Hand Circular Polarization (LHCP and RHCP). These permit to look into phase and polarimetric observables, either to relate them with changes in the ice freeboard level (accurate altimetry with phase-delay), or changes in its complex permittivity (POlarimetric Phase Interferometry). A combination of GPS-based estimates of parameters such as roughness and permittivity could help classifying the sea ice type. Due to storage size limitations, coherent waveforms were restricted to a few hours per day, whereas non-coherent data have been continuously stored, summing up to 1.4 TB.

The campaign, its analysis strategies, processing algorithms and results will be presented.

17 YEARS OF EUROPEAN ALTIMETRIC MISSIONS AND THEIR CALIBRATION

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ESA has a long history on altimetric missions: from the European Remote Sensing Satellite (ERS-1), launched in 1991, with EnviSat launched in 2002, to the future missions of CryoSat-2 and Sentinel-3.
Different calibrations have been performed over these years to these altimeters, driven by the current scientific needs. The ERS-1 altimeter range was absolutely calibrated over the Venice tower (Francis, 1993). The ERS-2 altimeter was cross-calibrated against ERS-1 and TOPEX/Poseidon altimeters (Benveniste et al. 1997). The EnviSat RA-2 was calibrated in absolute terms for both: its range over the Mediterranean sea with a regional calibration (Roca et al. 2002) and, for the first time in altimetry, its backcatter using an ESA transponder (Roca et al. 2002).
CryoSat mission will determine fluctuations in the mass of the Earth's land and the marine ice fields. The primary scientific objectives for the CryoSat mission (Wingham et al. 2004) are to improve the accuracy of measurements of ice sheet elevation and sea-ice thickness and thus enhance understanding of cryospheric dynamics. Over sea-ice this is to be achieved by the use of a radar altimeter with synthetic aperture forming capability to improve the along track resolution. In addition, over ice-sheet margins the direction (along and across track) of the leading edge of an echo is retrieved through the use of a second receiving antenna recording chain allowing interferometric capability. This new design of an altimeter also implies that new calibrations shall be performed.
Its primary payload is a radar altimeter (SIRAL) that will operate in different modes optimised depending on the kind of surface: Low resolution mode (LRM), SAR mode (SAR) and SAR inteferometric mode (SARin).
A transponder can be seen by a radar as a point target. Transponders are commonly used to calibrate absolute range from conventional altimeter waveforms. As a uniquely defined terrestrial reflection surface, a transponder is deployed within the footprint of the radar altimeter. The waveforms corresponding to the transponder distinguish themselves from the other waveforms resulting from natural targets in power and shape. One transponder will be available for the CryoSat project, that will be deployed in the ESA Svalbard station.
We will be using the ESA CryoSat transponder to calibrate SIRAL's absolute range, datation, angle of arrival and sigma-0. In these calibrations, we will retrieve the biases in two ways: using the stack beams, before multi-looked (calibration stack data) and using the single multi-looked echo (L1b data).
During CryoSat Commissioning phase, these data will be retrieved during several passes over the transponder. The developed algorithms are currently being tested with simulated data from the CRYMPS simulator, generated by overflying a transponder point target in different geometrical and instrumental configurations. We will show the method, its performance, and the results obtained with these simulated data.

PREPARING LEVELS 3 AND 4 FOR THE SMOS MISSION

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The Soil Moisture and Ocean Salinity mission (SMOS) from the European Space agency, scheduled for launch in 2009, will initiate the era of satellite salinity observations. Because of the numerous geophysical contamination sources and the instrument complexity, the salinity products will have a low signal-to-noise ratio at Level 2. Averaging data in space and time is expected to allow a reduction of the observational error down to mission requirements (0.1 psu) at Level 3 (global maps with regular distribution). Geostatistical methods such as Optimal Interpolation are being implemented at Level 3 to operate this noise reduction. The methodologies require auxiliary information about SSS statistics that, under Gaussian assumption, consist in the mean field and the covariance of the departures from it. The present study is a contribution to the definition of the best estimates for mean field and covariances to be used in the near-future SMOS Level 3 products. At Level 4, the spatial-temporal structure of the salinity errors is investigated in a numerical ocean model to prepare for the assimilation of this new stream of observations.

This work is part of the effort conducted at the SMOS Barcelona Expert Centre (http://www.smos-bec.icm.csic.es) aiming at contributing to the ground segment of the SMOS mission.

POST - PROCESSING METHODS FOR OCEAN MONITORING FROM SAR IMAGERY

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Abstract – A number of experiments all over the world have proven that satellite borne SAR images constitute a valuable tool to monitor oceanic environment, preventing it from overexploitation or pollution matters and it can also help to evaluate the full implications of natural or man made hazards. In fact, thanks to their capability to cover large areas, in all weather conditions, during the day as well as during the night, spaceborne Synthetic Aperture Radar (SAR) techniques constitute an extremely promising alternative to traditional surveillance methods. Nevertheless, in order to assure further usability of SAR images, specific data mining tools are still to be developed to provide an efficient automatic interpretation of SAR data. In the last years, our group has been studying, analyzing and validating several dedicated methods for different marine applications: namely, ship detection, extraction of the coastline and detection and rough classification of pollutants in the sea surface.

Keywords – SAR, Wavelet Transform, ship detection, oil spill detection, coastline extraction

I. INTRODUCTION

Synthetic Aperture Radar (SAR) technology has proven to be useful in numerous civilian applications. Nevertheless, in the last years the progress in technological aspects is faster than the evolution of processing and post-processing techniques for the exploitation of SAR data. In fact, SAR images are often analyzed manually even if an operational and intensive exploitation of SAR images is not viable with completely supervised means. Automatic techniques able to produce rapid, reproducible and reliable results are to be provided instead. These techniques should be designed to work with no operator intervention and they should avoid specific tuning to a particular image. These requirements are especially difficult to satisfy with SAR imagery through automatic tools with no high level knowledge.

II. MULTISCALE FRAMEWORK FOR MARINE APPLICATIONS IN SAR DATA

In the last two years, our group has studied, analyzed and validated several dedicated and automatic processing methods for different marine applications in SAR imagery: namely, ship detection [1], extraction and monitoring of temporal evolution of the coastline [2] and detection and rough classification of pollutants on the sea surface [2]. All of these methods rely in a multiscale time (or space) - frequency framework which it has been shown to be well suited for this purpose. In fact, the use of time - frequency tools allow the evaluation of statistical parameters of the imaged scene, while preserving spatial information. Furthermore, the time – frequency trade off can be adjusted thanks to the multiscale capability of this method, providing a sense of context, extremely helpful to understand the observed scene, with no a priori information about it.

The main originality of the methods designed is that they propose the analysis of the image directly in the wavelet transformed domain, which leads to several advantages. More specifically, on the one hand, ship detection and coastline extraction are based on a combination of wavelet coefficients. On the other hand, detection of oil spills is carried out by estimating the Lipschitz exponent by means of the wavelet transform.

Even if usually treated separately, the oceanic applications concerned (vessel monitoring, coastline extraction and spill detection) are very closely related to each other. For example, any algorithm for automatic ship detection requires a previous land mask step which is usually performed with maps available from other sources. This is a problematic and time consuming operation which could be rendered easier by applying a method for automatic coastline extraction sufficiently robust. Moreover, the constitutive peakiness of SAR images can be reduced with a slight evolution of the technique used for ship detection and this increases substantially the performance of the algorithms used for coastline extraction or for the analysis of textures involved in oil spill detection. Besides, the discrimination of large elongated patterns can drastically reduce false alarms when the objective is to perform ship detection. It can also be used to locate oil spills in the sea surface. Additionally, the automatic detection of oil slicks aims at revealing responsibilities and it is then deeply associated to ship detection. Hence, previous examples suggest that the most efficient exploitation of oceanic SAR images implies a simultaneous use for different but complementary applications.

The objective of this presentation is to separately describe the algorithms specifically designed for marine applications with SAR data and to suggest the benefits of using a global tool incorporating these algorithms, enhancing both global and individual results whereas saving computing cost.

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SMOS: ESA'S WATER MISSION

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ESA's Water Mission, otherwise known as the Soil Moisture and Ocean Salinity Mission (SMOS) was selected as the second Earth Explorer opportunity mission to be implemented and is expected for launch in July 2009. SMOS single payload, an interferometric microwave radiometer, shall provide global observations of soil moisture and ocean salinity to improve our understanding of the Earth's hydrological cycle.

One of the highest priorities in Earth science and environmental policy issues confronting society today is to understand the potential consequences resulting from modification of the Earth's water cycle due to climate change. The influence of increases in atmospheric greenhouse gases and aerosols on atmospheric water vapour concentrations, clouds, precipitation patterns and water availability must be understood in order to predict the consequences for water availability for consumption and agriculture.

In a warmer climate, increased evaporation may well accelerate the hydrologic cycle, resulting in changes in the patterns of evaporation over the ocean and land and an increase in the amount of moisture circulating through the atmosphere. Many uncertainties remain, however, as illustrated by the inconsistent results given by current numerical weather and climate prediction models regarding the future distribution of precipitation.

It is evident that insufficient data are available today to help improve our scientific knowledge and understanding of the processes influencing the water cycle. Thus, ESA, the French Space Agency (CNES) and Spanish Centre for Development of Industrial Technology CDTI have teamed up to address this key scientific challenge by delivering a fundamentally new satellite tool to realise these new global datasets. The resulting regular, consistent measurement data will be used to improve our understanding of the way in which both the time-varying distribution of soil moisture and ocean salinity regulate the water cycle of our Blue Planet..

ISSUES IN THE BALANCING OF THE SMOS OCEAN SALINITY RETRIEVAL COST FUNCTION

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The Soil Moisture and Ocean Salinity (SMOS) mission will be launched in late 2009 to providesynoptic sea surface salinity (SSS) measurements with good temporal resolution [1]. To obtain a proper estimation of the SSS fields derived from the multi-angular brightness temperatures (TB) measured by the Microwave Interferometric Radiometer by Aperture Synthesis (MIRAS) sensor, a comprehensive inversion procedure has been defined [2]. Nevertheless, several salinity retrieval issues remain critical, among them: 1) Scene-dependent bias in the simulated TBs, 2) Lband forward geophysical model function definition, 3) Auxiliary data collocation and uncertainties, 4) Constraints in the cost function (inversion), especially in salinity term. These issues will have to be properly addressed in order to meet the proposed accuracy requirement of the mission: a demanding 0.1 psu (practical salinity units) after averaging in a 30-day and 2ºx2º spatio-temporal boxes.

The salinity retrieval cost function minimizes the difference between the multi-angular measured SMOS TBs (yet simulated, so far) and the modeled TBs, weighted by the corresponding radiometric noise of the measurements. Furthermore, due to the fact that the minimization problem is both non-linear and ill-posed, background reference terms are needed to nudge the solution and ensuring convergence at the same time [3]. Constraining terms in SSS, sea surface temperature (SST) and wind speed are considered with their respective uncertainties. Moreover, whether SSS constraints have to be included or not as part of the retrieval procedure is still a matter of debate. On one hand, neglecting background reference information on SSS might prevent from retrieving salinity with the prescribed accuracy or at least within reasonable error. Conversely, including constraints in SSS, relying for instance on the climatology, may force the retrieved value to be too close to the reference prior values, thus producing spurious retrievals.

In [4] it has been studied the impact of the different auxiliary salinity uncertainties in the accuracy of the retrieval. It has been shown that using physically-consistent salinity field uncertainties of the order of less than 0.5 psu the SSS term turns out to be too constraining. A half-way solution could be envisaged by using empirical weights which could smooth the overall influence of the SSS term still using the auxiliary fields with their corresponding physically-sounded uncertainties. This operation should be performed for the SST and wind speed term as well.

Simulated data using the SMOS End-to-end Processor Simulator (SEPS), in its full-mode, including the measured antenna patterns for each antenna and all the instrument errors, are used in this study. The salinity retrieval process and the SSS maps (for each satellite overpass) are performed with UPC SMOS-Level 2 Processor Simulator (SMOS-L2PS). The relative weight for each of the terms included in the cost function (observational and background terms) is assessed in different cost function configurations. Regularization factors are introduced to ensure that SMOS information content is fully exploited.

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ASCAT SCATTEROMETER WIND DATA PROCESSING

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Keywords – Microwave remote sensing, ASCAT Scatterometer, Sea Surface Winds, Non-linear Inversion,Quality Control, Spatial filtering.

The Metop-A satellite was launched on 19 October 2006 and carries the Advanced Scatterometer (ASCAT). The instrument is a real aperture, C band, vertically polarized radar with three fan beam antennas pointing to the left hand side of the sub-satellite track and three fan beam antennas pointing to the right hand side. Scatterometers are known to provide accurate mesoscale (25-50 km resolution) sea surface wind field information used in a wide variety of applications, including Numerical Weather Prediction (NWP) data assimilation, nowcasting, and climate studies. The radar antenna geometry, the measurement noise, as well as non-linearities in the relationship between the backscatter measurements and the wind vector complicate the wind retrieval process. In addition, scatterometers are sensitive to geophysical phenomena other than wind, such as confused sea state, rain, land & ice contamination of the radar footprint. These phenomena can distort the wind signal, leading to poor quality retrieved winds. As such, elimination of poor quality data is a prerequisite for the successful use of scatterometer winds.

An overview of the ASCAT scatterometer wind retrieval processing will be presented at the meeting. The presentation will focus on state-of-the-art quality control, inversion and noise filtering techniques. Also a view on future scatterometer systems and emerging (ocean) applications will be briefly discussed.

HF RADAR MONITORING INITIATIVE IN BARCELONA COASTLINE: CURRENTS AND WAVE MEASUREMENTS

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The coastline of Catalunya constitutes a valuable and vulnerable natural resource that requires an integrated and coordinated sustainable management effort. Several natural and human induced problems come together such as:
- High value coastal region having natural preservation as one of the its main assets associated to clean beaches and sports navigation
- Heavy populated area with strict water quality management and floating debris collecting requirements
- Sedimentation and erosion associated to coastal structures and harbours
- Climate change and environmental protection related studies

Coastal sustainable management has both an operational and a strategic function within the region. There is a long list of institutions and organisations that ensure that these environmental responsibilities are met in Catalunya, among then we can cite the following:
- Puertos del Estado, the Spanish Harbours Authority
- Autoritat Portuària de Barcelona, The Barcelona Harbour Authority
- Clavegueram de Barcelona (CLABSA),
- L'Agència Catalana de l'Aigua (ACA) , Catalan Water Agency,
- El Servei Meteorològic de Catalunya, Catalan
- Direcció General de Ports, Aeroports i Costes, The General Directorate of Harbours, Airports and Coasts of Catalunya,

All of these institutions recognized the great value (and the necessity) that real time 2D surface currents information would have for their coastal management activity. As a consequence, all of them agreed to start a joint initiative to install a radar HF monitoring network based on SeaSonde technology that shall highlight benefits that can be provided to their institutions and to society in general. This step has also been understood by the Catalan planning authorities as part of a more general strategic plan to deploy region- wide ocean observing networks for a more sustainable environment management of the coastal ocean.
The SeaSonde radar HF (High Frequency), based on the measurement of the Doppler shift of the electromagnetic wave scattered by the surface ocean roughness, was chosen for the initiative along the Barcelona waterfront because of its distinctive features its compactness and an impressive operational track record. The small equipment and energy consumption footprints are keys for the environmental integration, especially in valuable spots along the coastline.
The initiative consisted onf twoa Standard HF SeaSonde radars operating at a frequency centred at 25 MHz. One radial station was located at the east dock in Barcelona Harbour, the second radial station in the Masnou recreation Harbour. They were operating continuously for almost six months in year 2008: from July/August to December. Each of the radial stations has an average range of around 35 Km; The radial current data has a spatial resolution of about 1 km and are obtained every hour, moreover, wave parameter (significant waveheight, direction and period), are obtained every half an hour on a real time basis. The combination of the radial vectors from each of the two sites give a 2D representation of the total hourly surface currents on the area over a spatial grid of 3Km horizontal resolution. An example of the surface currents maps obtained are shown in Fig 1.
A more complete description of the installation, system performance and an indication of the quality of the observations will be presented here, together with a qualitative comparison of the radar HF wave data against wave buoy measurements as well as a validation and comparison of surface currents against other source of measurement.

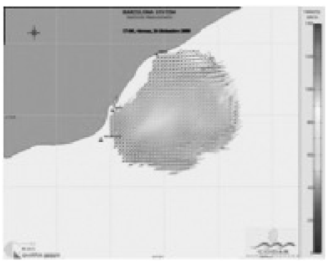

Fig 1 .2D surface vector currents

Fig 2. Detail of Antenna in Masnou Harbour

EUMETCAST RECEIVING STATION INTEGRATION WITHIN THE SATELLITE IMAGE DATABASE INTERFACE (SAIDIN) SYSTEM

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Abstract – Within the tasks devoted to operational oceanography, Coastal Ocean Observatory at Institut de Ciències del Mar (CSIC) has acquired an European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) Broadcast System for Environmental Data (EUMETCast reception system) to replace a satellite direct broadcast system that receives data via High Resolution Picture Transmission (HRPT). EUMETCast system can receive data based on standard Digital Video Broadcasting (DVB) technology using commercial telecommunication geostationary satellites with regular off-the-shelf satellite TV equipment and a PC and has great advantages over a satellite direct broadcast system. A pilot project has started to manage and integrate satellite data acquired through EUMETSAT's Advanced Retransmission Service (EARS)-AVHRR data stream with Satellite Image Database INterface (SAIDIN), a tool developed 4 years ago to access, visualize and distribute satellite data.

Keywords – EUMETCast, SST, AVHRR,EUMETSAT

I. INTRODUCTION

EUMETCast is a multi-service dissemination system based on standard Digital Video Broadcast (DVB) technology operated by EUMETSAT. It uses commercial telecommunication geostationary satellites to multicast files (data and products mainly satellite based) to a wide user community. EUMETCast is a contribution to GEONETCast and IGDDS (World Meteorological Organization Integrated Global Data Dissemination Service) and provides data for Global Earth Observation System of Systems (GEOSS) and Global Monitoring for the Environment and Security (GMES).

Before this new dissemination system was operational, satellites provides meteorological and oceanographic data only to user community that have one very expensive and complex ground receiving station via direct broadcast (HRPT station). Nowadays, EUMETCast data are sent on via commercial telecommunication satellites to individual users. Users of the service can take advantage of off-the-shelf, commercially available, and inexpensive equipment. This results in the possibility to use relatively low cost reception stations. In addition, time delay of global services and spatial coverage of local HRPT system is improved because EARS is composed of a network of existing HRPT systems. This network of stations acquire, process and forwards the generated meteorological products (e.g. the NOAA satellite HRPT telemetry data) to central office. EUMETSAT collects the products and disseminates them to the users via a commercial satellite broadcast service. It's expected that in the near future, most of the users of direct readout reception systems will migrate to EUMETCast.

About transmission technology, EUMETCast uses the DVB-S MPEG2 stream for encapsulating IP frames (IP over DVB). At this IP layer, IP Multicast techniques are used for distributing the file based content. For this purpose, TELLICAST (an IP multicast software from Newtec (formerly Tellitec)) is used. The primary transmission via Eutelsat's Eurobird 9 satellite can be received by most end users in Europe and is relayed via Eutelsat's Atlantic Bird 3 (Europe and Africa) and SES New Skies' NSS-806 (covers both Americas). The technology used makes it possible for end users to receive the data with regular off-the-shelf satellite TV equipment and a PC.

II. DATA ACQUISITION SYSTEM

The system is composed of a receiving subsystem, a computer subsystem of control and data archiving, and a processing and publishing subsystem. The receiving subsystem consists of a 1.0-meter-diameter antenna with V/H Low Noise Block (LNB) and a Dell Precision T3400 CPU 2Gb RAM and 750 Gb disk with GNU/Linux Fedora 8 and DVB Skystar2 card of Technisat. Data and products are encrypted by the EUMETCast uplink and could be decrypted by the EUMETCast Client Software that must be installed on the reception station. Those data controlled in accordance with EUMETSAT Data Policy are only accessible by users who have been given the necessary decryption keys for the EUMETSAT service/s they have been licensed to receive. To access these services in addition to the decryption keys users will need to operate a station equipped with a EUMETCast Key Unit (EKU).The EKU decryption device is connected, via USB, to the reception station. The decryption device is used by the EUMETCast Client Software to decrypt the data key of the next transmission. EUMETSAT manages the distribution of the decryption devices to registered users. In addition, EUMETSAT distributes an optional software EFTS-Agents software that provides secure and reliable transfer of files from a source host to a number of target hosts.

During 2001 an HRPT receiving station was acquired and a near-real time system was developed, allowing users to acquire data, process them to obtain temperature maps of the Western Mediterranean at its maximum resolution (nadir) of 1.1 kilometers and publish them to the Web in approximately one hour. Additionally, a bzipped netCDF file with AVHRR channels, latitude, longitude, land mask and multichannel sea surface temperature (MCSST) variables is created and added to a Thematic Realtime Environmental Distributed Data Services (THREDDS) catalog [1]. The processing layer executes routines of radiometric, geometric and atmospheric corrections automatically with scripts that use SeaSpace Corp.'s (Poway, California) TeraScan® software [2]. The current routines for atmospheric correction are not sufficient, and sometimes under specific atmospheric conditions (like low clouds in a very dry atmosphere, sand advections or mists) do not output a product with therequired quality. Therefore, it is recommended that users reprocess this data manually. After these corrections, maps of temperature are produced using McClain split-window equations [3] and made available for the scientific community on the Web. During the initial processing, quicklooks and metadata subproducts are also generated, providing complementary information useful for gauging the quality of temperature maps and allowing users to detect processing errors.

III. MIGRATION TO THE NEW ACQUISITION SYSTEM

The network of EUMETSAT stations acquire data as station segments of three-minute duration from the satellite as it passes over the station locations. These segments are sent to the EUMETSAT computers located at organisations site. These computers then create user segments of one-minute duration. For each segment a message is sent reporting the availability of the segment and its completeness and quality to the central 'decision maker' computer at EUMETSAT. The decision maker will wait a short time to receive messages about available segments at the various remote computers and identify if there are any duplicate segments for the same time slot (duplicates arise due to station coverage overlaps). Finally, a decision is made as to which station has the best segment and this decision is sent to the particular remote computer instructing it to send the segment to the EUMETCast uplink server and on to users. This means that overlaps between stations are removed and end users should get a continuous set of 'best quality' segments for the regional pass.

One part of the migration has consisted of to writing some python scripts to concatenate the segments to construct a regional pass that can be considered equivalent to a pass of a HRPT station. These scripts allow to pass the satellite ID and the time range as arguments and log all the actions done.

The other part of the migration involves adapting the C-shell scripts done using Terascan software.

IV. CONCLUSSIONS

The SAIDIN interface is under continuous development to provide more functionality. Recently been updated with an EUMETCast receiving station, which can receive data based on standard digital video broadcast technology using commercial telecommunication geostationary satellites. This allows a low cost and very simple system (compared with a HRPT) to obtain similar data with only a slight delay of 30 minutes. It is intended to provide improved near-real time quality control using independent information, such as that supplied by an environmental array of buoys.

Additional improvements include migrating the Web site to a content management system to facilitate Web updating and decoupling the applet application using Web site supplementary information. New implementations will allow users to better integrate SAIDIN into the THREDDS catalog server as a viewer and increase SAIDIN's capabilities as a light geographic information system, allowing users to overlay data from several sources and to implement new products, such as ocean surface velocity fields derived from SST maps. From a technical point of view, SAIDIN will provide flexible file name conventions, image formats and database server dependency. Next things to do is to migrate physical system to a virtual one to have a more robust service in case of crash.

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APLICATION OF REMOTE SENGING TECHNIQUES TO THE STUDY OF INTERNAL WAVES IN THE STRAIT OF GIBRALTAR

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Abstract. The generation and propagation of internal waves is one of the most interesting oceanographic processes in the Strait of Gibraltar. In this paper, radar (ASAR) and ocean colour images (MODIS y MERIS) have been used in order to characterize this phenomenon. The processing of instantaneous colour images has allowed the analysis of the relationship between physical processes of the internal waves and the biological implications. During internal waves generation, MODIS and MERIS images show a chlorophyll maximum structures in the coastal areas of Camarinal Sill. When these waves are located in Alborán Sea, the colour images illustrate the presence of chlorophyll maximum associated to the waves front. The results seem to indicate that a suction of coastal water take place during the internal waves generation and this rich chlorophyll water entry in Alborán Sea travelling joint to the internal waves.

Keywords internal waves, Gibraltar Strait, ASAR images, Ocean Colour images.

I. INTRODUCTION

The high amplitude and short period internal waves are generated at the western side of Camarinal Sill during maximum tidal outflow (toward Atlantic Ocean) when the flows reach 1 m s-1 (Vázquez et al., 2008). These remain there until the flow weakens. And then, the internal waves propagate towards the Mediterranean Sea. The internal waves produce a sea surface signal of roughness bands, named boiling water, (Bruno et al., 2002) which are detected from ASAR (Advanced Synthetic Aperture Radar) images.

The mixing processes associated to the internal waves are able to produce a recirculation of the Mediterranean Water nutrients towards Alborán Sea and, consequently, to increase the phytoplankton populations inside de Atlantic Jet (Macías et al., 2008). The main objective of this work is to characterize the waves processes and its biological implications in the study area using instantaneous radar and ocean colour images.

II. MATERIAL Y METHODS

In order to achieve the objective of this study, three tools have been used:

- Instantaneous ASAR and ocean colour images (MODIS and MERIS) to characterize the generation and propagation of the internal waves processes in the Strait of Gibraltar.
- Tidal velocity prediction in Camarinal Sill to identify the state of the internal waves.
- CTD data obtained from GIBRALTAR 08 Cruise on board of R/V Sarmiento de Gamboa to confirm the remote sensing information.

III. RESULTS

Generation

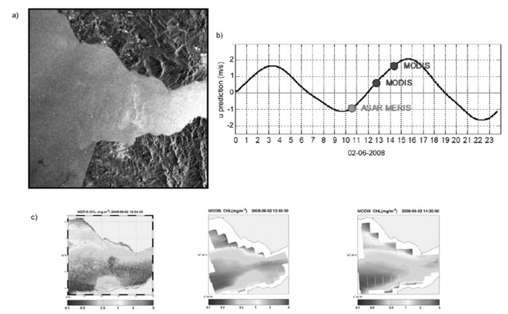
In the ASAR image of 2nd of June of 2008 (Fig. 1a) the roughness features confirm the generation of the internal waves in the Strait of Gibraltar. The tidal velocity prediction (Fig. 1b) shows that this image was captured during maximum outflow with a current intensity greater than 1 m s-1, when hydraulics conditions are favourable for the generation. On other hand, in MERIS and MODIS images (Fig. 1c), it can be seen an increase of surface chlorophyll in coastal area of Camarinal Sill. This chlorophyll maximum structure travels eastward according to the propagation of the internal waves toward Alborán Sea.

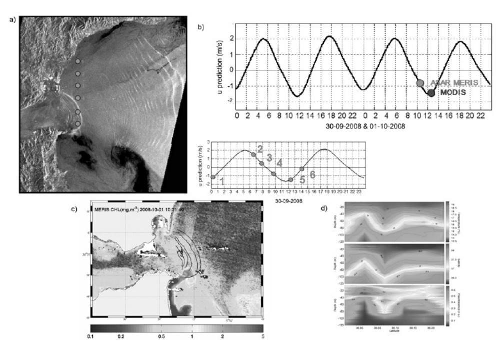
Propagation

In the ASAR image corresponding to 1st of October of 2008 (Fig. 2a) can be detected waves train propagating in Alborán Sea. The tidal velocity prediction in Camarinal Sill (Fig. 2b) confirms that the internal waves have been approximately one cycle late in coming to Alborán Sea from its generation in Camarinal Sill. In MERIS image (Fig. 2c), high chlorophyll values associated to waves train extracted of SAR image can be seen. In the CTD transect carried out 30 of September of 2008, a waves train in Alborán Sea was recorded. The isothermals and isohalines rise, joint to an increase of chlorophyll values (as colour images show) characterize the arrival of the internal waves in station 5 (Fig. 2d).

IV. CONCLUSSIONS

The combined analysis of images and in situ data reveal advection of North and South coastal water to the centre channel of the Gibraltar Strait and its entrance to Alborán Sea. This coastal water with higher chlorophyll concentration is incorporated to the Mediterranean Sea associated to the arrival of the internal waves train to this area.





THE DIAGONAL OF THE TT TRANSFORM: COMPUTATION AND MEANING

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Abstract - The TT-transform stands for time-time transform and has been derived as an inverse Fourier transform of the time-frequency S-transform. So far, it has been proposed that the diagonal of the TT-transform can be used for signal characterisation. We show here an alternative and simplified derivation of the TT-transform which enables a better understanding of this transform.

Keywords - TT-transform, S-transform, time-frequency localisation, time-time analysis

I. INTRODUCTION

In disciplines such as music or geophysics, signals are non stationary. The need for processing such signals has led to the appearance of several types of time varying frequency filters, such as the short time Fourier transform [1], wavelets [2], and more recently the S-transform (ST) [3]. These transforms introduce redundancy passing from a 1D time signal to a 2D time-frequency (or time-scale) signal. In 2003, [4] introduced a new transform based on the ST and called it the TT-transform (TT). It includes redundancy in time passing from a 1D time signal to a 2D time-time signal. Until now, this transform has seen little application [5] and in general, interest has mainly been focused on the diagonal part. The aim of this correspondence is to show an simpler way of computing the diagonal of the TT and to give a clear interpretation of it.

In the next section, the S- and TT-transforms will be reviewed. Section 3 will demonstrate a simplified way to compute the latter. Section 4 will show examples and the last section will conclude this paper.

II. THE S- AND TT-TRANSFORMS

The ST of u(t) is

$$S(\tau.f) = \int u(t)w(t - \tau, f)e^{-2i\pi ft}dt$$

$\omega(t,f)$ being a 1-mean window, generally a Gaussian with a variance of 1/f .

The TT, [4], is the inverse Fourier transform(FT) w.r.t. f of S(τf) :

$$TT(\tau,t) = \int S(\tau,f)e^{2i\pi ft}dt$$

Both transforms are easily invertible.

III. COMPUTING THE DIAGONAL OF THE TT-TRANSFORM

In the applications using the TT, only its diagonal part has been used. We will hence concentrate on this part. For details on the rest of the transform, see [5]. We have shown, [5], that

$$T(t,t) = F^{-1}\{U(f)G(f)\}$$

where F^{-1} is the inverse FT, U(*f*) the FT of *u*(*t*) and $G(f) = -k\pi^2|f|$, k being a constant. This is an important result as, by using this formula, not only can we completely forget about the use of the ST and thus simplify the computation of the TT but we can also much more easily understand its behaviour. Indeed, we see that the diagonal terms of the TT are just a frequency filtered version of the original signal, putting more emphasis on high frequencies.

IV. EXAMPLE OF APPLICATION

The example, Fig. 1, top, is a sum of sines. The bottom plot show the diagonal terms of its TT.

On its TT, Fig. 2, it is seen how most of the information is centred on the diagonal part.

On Fig. 3, the FFT of the diagonal of the TT as well as the FFT of the original signal is shown. The first one has been normalised to facilitate the comparison. Here, we can clearly see how the TT emphasises high frequencies at the cost of low frequencies.

V. CONCLUSION

In this presentation, we show that computing the diagonal elements of the TT-transform of a signal is equivalent to frequency filtering it; the equivalent filter gives more emphasis to high frequencies with respect to low ones. As well as allowing a clear interpretation of the meaning of the diagonal of the TTtransform, this work thus gives a much simpler and more direct way to compute it.

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[5] C. Simon, M. Schimmel and JJ. Dañobeitia, "On the TT-Transform and Its Diagonal Elements", IEEE Trans. Signal Processing, vol. 56, no. 11, pp. 5709-5713, 2008. Fig. 1. Original signal and the diagonal of its TT

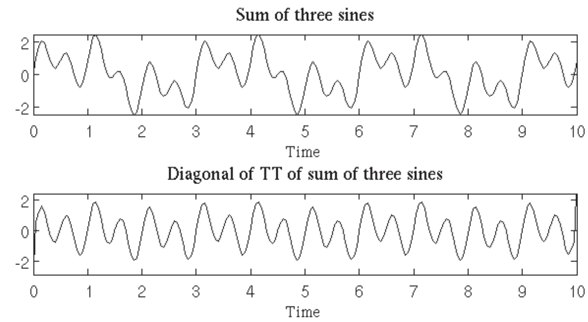

Fig. 1. Original signal and the diagonal of its TT

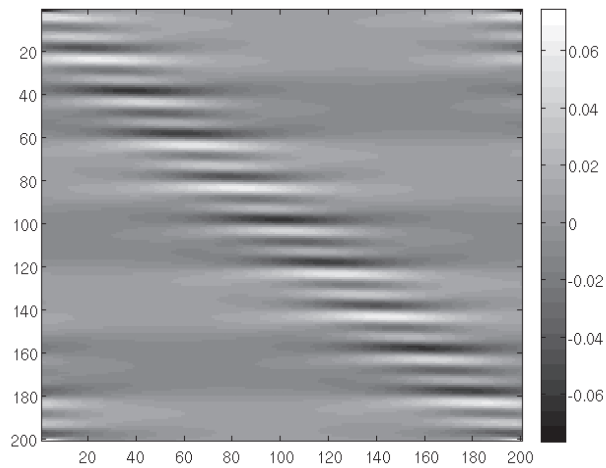

Fig.2. TT of the signal

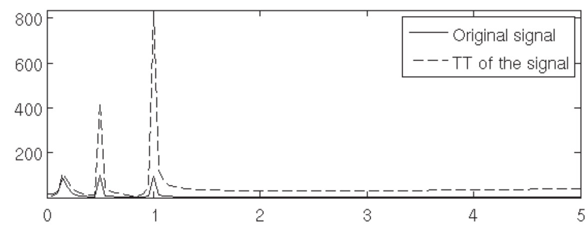

Fig.3. FFT of the signal and of the diagonal of its TT

PRINCIPAL COMPONENT ANALYSIS TO COMPRESS ACQUIRED DATA OFFSHORE

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Abstract - Telecommunications offshore have connectivity in virtually all parts of the globe via satellite, with increasing bandwidth and lower cost, but still far from levels that are onshore. The principal component analysis (PCA) is a statistical technique that has found application in fields such as biometrics or compression of images, being a common tool for finding patterns in multidimensional data sets. The hypothesis for this work was that it was possible to use the theory of PCA to compress, with sufficient accuracy, the large amount of data that are collected on board to a vessel and then sent by satellite in a more economical or rapid way than the traditional one. The material used were 44 samples of 182 different signals, collected from 19 different equipment on board to "Castillo de Villalba" Liquid Natural Gas carrier vessel. With these data, the PCA algorithm was applied using a computer program developed by the authors, generating new data packets to send by satellite. Different strategies were used in order to ensure that the coefficient of correlation r between original and reconstructed data onshore were equal or greater than 0.95. The results showed that it was possible to save 46.9% in the number of data sent via satellite, in the case of grouping all the 182 signs, with a mean r = 0.95 ± 0.08. This strategy is appropriate for onshore vessel equipment telediagnostic and maintenance decision making, with telecommunication cost or time savings.

Keywords - 1. Ship, 2. Telecommunication, 3. Satellite, 4. Compression, 5. Non-exact.

I. INTRODUCCIÓN

Communications at sea are in the process of evolution. The coverage by the satellite is virtually the entire globe for major technologies used today, either Iridium, Inmarsat or very small aperture terminals (VSAT). Moreover, where more progress is being made is in the bandwidth, increasing it, as well as the dwindling cost of communications and hardware equipment necessary. This paper presents a data non-exact compression method by applying principal components analysis (PCA) for monitoring the condition of equipment on board which allows lower cost of communication or reduce the occupation time of the bandwidth for a given amount of data sampled.

In order to reduce offshore satellite communication fees, there are two ways to compact information: exact and non-exact computer data compression. Exact compression algorithms usually exploit statistical redundancy to represent the sender's data more concisely without error.

Another compression technique, called non-exact data compression or perceptual coding, is possible if some loss of fidelity is acceptable. Generally, a non-exact data compression will be guided by research on how people perceive the data in question. Non-exact data compression provides a way to obtain the best fidelity for a given amount of compression. In some cases, transparent (unnoticeable) compression is desired; in other cases, fidelity is sacrificed to reduce the amount of data as much as possible.

Principal Component analysis (PCA) is a statistical technique with application in fields such as face recognition and image compression, and is a common technique for finding patterns in data of high dimension.

The other main advantage of PCA is that once you have found these patterns in the data, is possible compress it, by reducing the number of dimensions, without much loss of information.

For this work, the departure hypothesis was based in the possibility to use PCA theory to manage great quantity of data collected onboard by vessel control system, to compress and send it through satellite.

II. OBJECTIVES

1.To develop a computer program to perform PCA compress and uncompress algorithm with collected date onboard.

2.To find the best strategy to compress data using PCA.

III. MATERIALS AND METHODS

The data used were collected on board a ship for transporting liquefied natural gas LNG (Castillo de Villalba) through its integrated automation system (IAS, Norcontrol, Norway). This device generates a spreadsheet file every 12 hours, which represents the condition of 182 different signals of the 19 major subsystems of the vessel: Main Turbine, Boiler Common, Boiler No. 1 Boiler No 2, Turbo Generator No 1, Turbo Generator No 2, Diesel Generator, Boiler Water Readings, Feed Cond. System, Evaporators, Water Tanks, Fuel Oil, Marine Diesel Oil, Gas Oil, Sludge and Bilge, Others, LD Compressors and Fridges-Air Conditioning.

Two computer programs were developed by the authors (Labview 8.2, National Instrument, Austin TX). One of them performs PCA and generated the packets to send by satellite offshore. The second program uncompressed data onshore. All results were displayed graphically and saved in file format compatible with spreadsheet programs. Figure 1 shows the block diagram of the transmission method.

The designed computer application chosen in sequence the eigenvectors from highest to lowest eigenvalue and calculated the mean correlation coefficient r of all the variables from the matrix with the real data [Data]mxn and the received matrix [ReceivedData] mxn. When r was greater or equal than a given threshold, the data package to send was prepared. In the case of this work, the threshold chosen was r ≥ 0.95. The figure 2 shows the front panel of the that program.

IV. RESULTS

TABLE 1

OBTAINED TRANSMISION RESULTS SENDING ALL COLLECTED ONBOARD VARIABLES TOGETHER

	Number of Signalsv	Number of principal components used	Coefficient correlation	Number of original data	Number of sent data	File space saved
All equipments together	182	18	0.95±0.08	8008	4250	46.9%

V. CONCLUSION

The software developed for transmission using PCA significantly reduces the amount of data sent via satellite, reducing time and cost of communication in case of transmission of all signals together. Alternatively, PCA technique may increase the number of samples sent for a defined time and cost.

For some subsystems of the ship, it is advantageous the transmission of their signals separately, bringing savings of 81.4% in the amount of data to send with very high mean correlation coefficient (r = 0.97 ± 0.08). For other subsystems, due a low correlation between variables, the PCA is not advantageous with regard to sending the raw data. The software should detect these situations and use the less cost way.

PCA compression strategy is appropriate for making onshore maintenance decisions about onboard equipment with a strong correlation between sampled signals as propulsion subsystem, generation plant, etc, reducing communication cost.

VI. ACKNOWLEDGMENTS

Our sincere thanks to the Castillo de Villalba ship crew and especially to D. Pablo Vegas, for his invaluable help.

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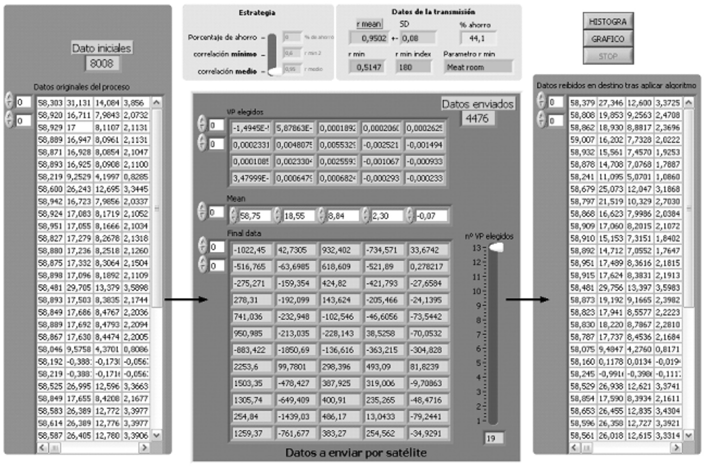

Figure. 1. Front panel of the designed computer application. In the left side are the real data collected onboard. In the center are the three packets sent by satellite. In the right side it is shown received data.

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TABLE 2
OBTAINED TRANSMISION RESULTS SENDING EACH VESSEL SUBSYSTEM INDEPENDENTLY

		Number of Signals	Num of principal components used	Coefficient correlation	Number of original data	Number of sent data	File space saved
1	**Main Turbine**	34	6	0.95±0.11	1496	502	66.4%
2	**Boiler Common A**	4	4	1±0	176	196	-11.4%
3	**Boiler Common B**	3	2	1±0	132	97	26.5%
4	**Boiler nº1**	12	6	0.96±0.09	528	348	34.1%
5	**Boiler nº2**	12	7	0.95±0.11	528	404	23.5%
6	**Turbo Generator No 1**	12	2	0.97±0.04	528	124	76.5%
7	**Turbo Generator No 2**	12	3	0.99±0.02	528	180	65.9%
8	**Diesel Generator**	17	2	0.97±0.08	748	139	81.4%
9	**Boiler Water Readings**	4	4	1±0	176	196	-11.4%
10	**Feed Cond. System**	12	7	0.95±0.12	528	404	23.5%
11	**Evaporators**	2	2	1±0	88	94	-6.8%
12	**Water Tanks**	7	5	0.98±0.03	308	262	14.9%
13	**Fuel Oil**	18	9	0.95±0.08	792	576	27.3%
14	**Marine Diesel Oil**	3	3	1±0	132	144	-9.1%
15	**Gas Oil**	4	3	0.96±0.08	176	148	15.9%
16	**Bilge and Sludges**	2	2	1±0	88	94	-6.8%
17	**Others**	3	2	1±0.01	132	97	26.5%
18	**LD Compressors**	17	5	0.96±0.09	748	322	57.0%
19	**Fridges - Air Conditioning**	4	4	1±0	176	196	-11.6%
	Total	**182**			**8008**	**4523**	**43.5%**

IMPROVE RELIABILITY USING HOTELLING T^2 TECHNIQUE IN A LIQUEFIED NATURAL GAS PLANT

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Abstract - A method for improve the reliability in a gas liquefied plant using Hotelling T2 is showed in this paper. The stationery work in this manufacture facilities during a few moths in a year involve a heavy duty service of gas diesel engines and ammonia gas plant for processing the methane gas and extract the condensate fluid of it. Then, a predictive maintenance plan is necessary to prevent a possible malfunction or shut down of the plant and avoid an operational cost increased. We are just sampling the signals from the plant when its working in optimal condition and then we will compare the next incoming data from the machinery versus the previous historical data set. An statistical process control algorithm Hotelling T2 based for monitoring the condition of gas engines and ammonia gas plant will be implemented.

Keywords - Gas Plant Process Control, Historical Data Set, Hotelling T2 method ,Predictive Maintenance.

I. INTRODUCTION

An in-control set of process data is a necessity in a multivariate control procedures. In this case a collection of 26 variables from the liquefied gas plant was recorded in order to establishment a predictive maintenance plan . The temperatures from natural gas spark engine motor, multiplier gear box and ammonia refrigeration gas plant pressures and temperatures was sampled 4 times each 1 hour.

Such a data set, often labeled historical, baseline, or reference, provides the basis for establishing the initial control limits and estimating any unknown parameters. However, the construction of a multivariate HDS is complicated and involves problem areas that not occur in a univariate situation (such as isolated diesel engine or general purpose machinery).

We development of the HDS is referred to as a Phase I operation. We are using it as a baseline to determine if new observations conform to its structure is termed a Phase II operation. The parameters estimates are used to construct a preliminary control procedures whose major porpoise is to purge the original data set of any observations that do not conform to the structure of the HDS. The nonconforming or atypical observations are label outliers. After the outliers are removed from the preliminary data set, new estimates of the parameters are obtained and the purging process is repeated . This is done as many times as necessary to obtain a homogeneous data set as defined by the control procedure. After all outliers are removed, the remaining data is referred to as the HDS.

II. MATERIAL AND METHODS

The variables analyzed were the follow: the 12 cylinder exhaust gas temperatures (left side and right side) from a spark gas engine, the six temperatures of multiplier gear-box lube oil; fit it between the engine and gas compressor and pressures a temperatures from the ammonia refrigeration plant. The rpm of the natural gas compressor was monitored also. It was taken 100 samples of them All devices are at the REPSOL GAS & OIL CO. facilities in Bermeo-Bizkaia-Spain and they are used for management the liquefied natural gas from the deep hole which it is stored to process plant for cleaning and condensating.

Firstly, we constructed the HDS using the guidelines showed in figure 1.

A correlation analysis and control X-bar, R Chart were used for detecting both correlations and outliers. HDS for the first 6 variables and 20 samples is showed in Table 1.

Considering to be this process a continuous steady-state process where the observation vector are independent and the parameters of the underlying normal distribution are unknown and must be estimated. We assume the process is being monitored by observing a array of 32 new samples of liquefied gas plant parameters $X' = (x_1, x_2, ...x_p)$,on variables at each time point. The T^2 Hotelling´s value associated with X is given by: $T^2 = (X-\overline{X})' \times S' \times (X-\overline{X})$ where the common estimates X and S are obtained from the HDS. Here, the T^2 statistic follows the F distribution. For a α=0,05 given , the UCL is computed as:

$$UCL = \left(\frac{p \times (n+1)(n-1)}{n(n-p)} \right)_{F(\alpha,p,n-p)}$$

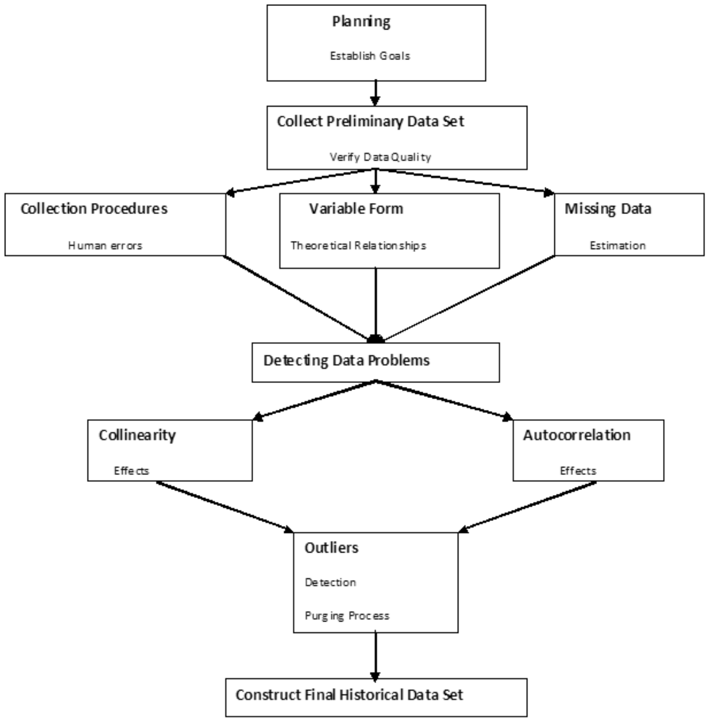

Fig. 1

Pos	TI-1964	TI-1966	TI-1968	TI-1970	TI-1972	TI-1974
0	ºC	ºC	ºC	ºC	ºC	ºC
1	559,22	552,6	541,76	528,34	514,39	485,86
2	557,26	552,8	541,76	527,96	514,39	485,48
3	559,98	554,56	541,55	528,54	514,78	487,41
4	560,95	554,15	542,31	529,51	514,98	489,35
5	559,6	553,77	541,55	528,75	514,78	485,86
6	557,46	553,01	541,35	527,58	513,63	484,31
7	557,08	552,8	541,17	527,58	514,39	488,38
8	558,25	553,39	540,59	528,16	514,6	484,69
9	556,11	554,56	541,17	528,75	514,6	486,45
10	557,84	553,59	541,76	527,58	514,6	488,38
11	559,39	553,39	542,31	528,54	514,78	487,21
12	554,94	553,59	541,17	528,54	514,98	486,06
13	553,01	552,42	541,35	528,34	514,39	481,96
14	557,46	553,39	541,76	527,96	515,19	485,65
15	553,97	552,8	541,93	528,54	514,6	487,21
16	559,22	553,39	543,11	528,93	514,78	485,48
17	559,8	554,15	541,93	528,34	512,08	487,21
18	557,84	553,39	542,52	528,54	512,08	484,31
19	559,39	553,59	542,31	527,58	513,43	487,41
20	559,98	553,59	543,11	528,93	515,95	488,58

Table 1

where n is the size of the HDS and $F(\alpha;p,n-p)$ is the α quantile of $F(\alpha;p,n-p)$.

III. CONCLUSION

Signal interpretation requires a procedure for isolating the contribution of each variable and/or a particular group of variables. As with univariate control, out of control situations can be attributed to individual variables being outside their allowable operational range

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A SOFTWARE FOR TIME SERIES ANALYSIS OF NORTEK INSTRUMENTS: TSA_NORTEK_V1

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Abstract - The software TSA_NORTEK_V1 has been created to carry out the processing of current meter data from NORTEK INSTRUMENTS: AWAC, AQUAPRO and AQUADOPP. The software offers a default data processing (spectral analysis, harmonic analysis, calculation of residual series) and an optional processing (axes rotation, choice of depth for the analysis, processing of vertical velocity component and filtering of time series). In addition, TSA_NORTEK_V1 produces harmonic constituents files to be used with the tidal prediction software TIDEX.

Keywords - software, processing data, time series analysis, AWAC, AQUAPRO, AQUADOPP.

I. INTRODUCTION

TSA_NORTEK_V1 software has been created by the Physical Oceanography Group of University of Cádiz in collaboration with the Instituto Hidrográfico de la Marina and INNOVA S.A. to carry out the processing of current meter data from NORTEK INSTRUMENTS: AWAC, AQUAPRO and AQUADOPP. TSA_NORTEK_V1 is written in Matlab language but it has been compiled to works independently of that.

The program begins asking some questions. First one, you should indicate which instrument data to process are from. Data can be derived from three different instruments: AQUADOPP (current meter), AQUAPRO o AWAC (current profilers). Later, you should indicate the mooring position and the header file name, to open and extract the more relevant information about the mooring and instrument configuration. This part of the program is common to any analysis you want to do, nevertheless, from here, the processing of AQUADOPP data varies slightly from the AQUAPRO and AWAC ones.

II. RUNNING TSA_NORTEK_V1 TO AQUAPRO AND AWAC DATA

The processing of AQUAPRO and AWAC data has the same features (both are current profilers) and, therefore, the software runs similarly in both cases. Once the header file is opened, the program shows the more important information related to the mooring and instrument configuration: mooring position, sample period, sample interval, cell size, blanking distance, mean mooring depth and cell depths. AQUAPRO and AWAC data are available along the whole water column at different depths and you can choose the desired depths for the data analysis. As an aid, the program displays two graphics. First one, illustrating the pressure (sea level) and velocity time series of the five surface cells.

The second one shows the time averaged current velocity profiles for the chosen period. Once the depths for the analysis are selected, the software carries out an optional and a default data processing

Optional data processing:

•Axes rotation to project the velocity data on the predominant direction.

•If several depths were chosen, you can decide between the data analysis for each depth or for the averaged depths.

•In many cases the value of the vertical velocity is not necessary for the study and then the analysis of this velocity component is optional.

•If you want, it is possible to obtain a filtered series of velocity and sea level data.

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Default data processing:

•Spectral analysis of original and/or residual series.

•Harmonic analysis of time series.

•Velocity and sea level tidal prediction for the mooring dates and computation of residual series.

•Creation of harmonic constituent files for tidal prediction software TIDEX.

The results from data analysis are saved in a set of files:

•A data processing information file.

•Harmonic analysis results for each depth (or averaged depths), each velocity component and sea level.

•Harmonic analysis results for each depth (or averaged depths), each velocity component and sea level compatible with TIDEX software.

•Residual series for each velocity component and sea level.

•Filtered data for each velocity component and sea level (only if filtered data option is chosen).

•Spectral analysis graphics for original and/or residual velocity and sea level data.

III. RUNNING TSA_NORTEK_V1 TO AQUADOPP DATA.

The recorded data by AQUADOPP, on the contrary that these obtained by current profilers (AQUAPRO or AWAC) are taken in only one depth, were instrument is placed. Therefore, the software varies slightly. The principal differences are three:

•Mooring information and depth choice. As there are not time series in different depths, it is not necessary to choose the desired depth to analyse.

•Sea level series analysis. Due to the fact that the instrument is moored at a certain depth suffering the displacement of the mooring line these measurements are frequently noisy an its analysis is not worthwhile.

•Output files. The number of result files is lesser by the cited reasons: Sea level analysis is not carried out and only one depth is processed.

NEW METHODOLOGICAL APPROACH TO ESTIMATE THE TURBULENT KINETIC ENERGY DISSIPATION RATE (ε)

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Abstract - The length scale and the spatio-temporal variation of turbulence intensity has relevant implications on phytoplankton dynamics. Thus, it is important to estimate the relevant parameters that characterize the turbulence in the water column, such as epsilon (kinetic energy dissipation rates). One of the main objectives in this work is the characterization of the physical dynamics at scales relevant to the biology. Here we show different approaches to estimate the epsilon in the Alfacs Bay (Ebre Delta), where recurrent harmful algal bloom events occur. First, we applied the solid boundary layer theory wind velocities obtained by a nearby meteorological station. Secondly, the gradient temperature microstructure method, based on the Batchelor spectrum adjustment was applied on temperature data obtained by a Self-Contained Autonomous MicroProfiler (SCAMP). These two approaches have methodological restrictions, i.e. isotropic turbulent or the process applied to do the Batchelor spectrum fitting.
A new method to characterize the turbulence is proposed. The velocity fields measured by a deployed high resolution 2 MHz acoustic Doppler current profiler were processed using the Reynolds decomposition to obtain an empirical parameter which provides us the information about the turbulent kinetic energy in the water column.

Keywords – Turbulent kinetic energy dissipation rate, Signal Processing, ADCP, new method to estimate turbulence

I. INTRODUCTION

Hydrodynamics plays a primary role in aquatic ecosystems. Understanding of any physical and biological interactions requires obtaining the characterization of the environmental changes derived from the transport mechanisms and the response of organisms to these changes. Interest in the interaction of small-scale processes is reflected in the increasing number of review papers [1] [2].
This paper presents two different methods used in the literature to estimate the turbulent kinetic energy dissipation rate. A new method to compute an empirical parameter similar to ε value from velocity profiles obtained from ADCP is presented.

II. METHODOLOGICAL APROACHES

The first method was developed by MacKenzie and Leggett [3].
This method uses the wind and the depth as inputs to compute the ε value. These input characteristics and the consideration of the exponentially decreasing energy, limit the potential of this method to characterize all water column. The results of this method are only valid from surface to the picnocline.
Next expression (1) represents the formula to compute epsilon.
Where ρa is the density of air (1.2Kg m-3), ρw is the density of seawater, CD is

$$\varepsilon = \left[\frac{\rho a}{\rho w} C_D\right]^{3/2} * \left[\frac{Wind^3}{0.4\,depth}\right]$$

coefficient of drag between the water surface and the wind and 0.4 represents the von Karmann's constant.

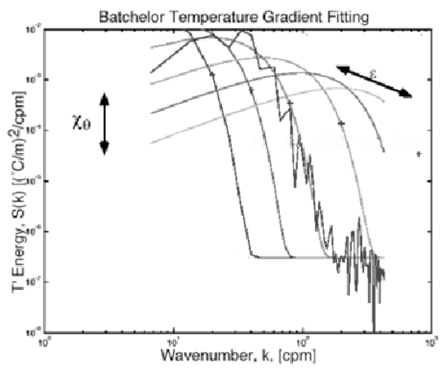

Fig.1 Batchelor temperature gradient fitting process to obtain the turbulent kinetic energy dissipation rate.

Second method apply the algorithm developed by Ruddick [4] to obtain the epsilon by fitting the theoretical Batchlelor spectrum [5] to the measured spectrum of temperature gradient, as is shown in figure 1.
This method presents restrictions in the fitting process and jittering effects on spatial sampling.
Wrong adjustments during the fitting process are difficult to identify and to reject, as we can see in figure 2.

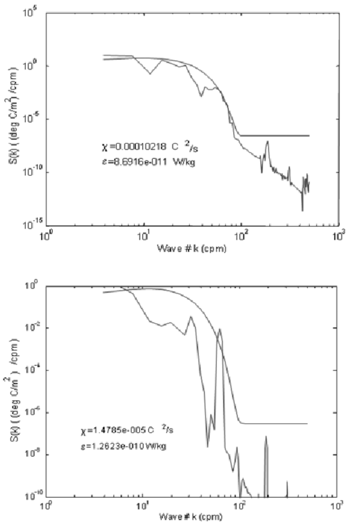

Fig. 2 Batchelor temperature gradient fitting process to obtain epsilon. i.e: (a) represent well adjusted spectrum – (b) wrong adjuste.It is difficult to identify the error to reject the epsilon value.

III. NEW METHOD

An empirical parameter computed from ADCP data is obtained from the new method to establish a relation between turbulence and kinetic energy in the water column.
Using Reynolds decomposition [6] we can obtain Kinetic energy of the mean and turbulent velocity components.
Where u represents the instantaneous velocity, U the mean component and u´ the turbulent velocity.
Power Spectrum density from kinetic energy gives us the information about energy at different frequencies. The kinetic energy spectrum integration indicates the energy concentration in a frequency range.

IV. SUMMARY

The ε estimation is important in the study of turbulence, but it requires many restrictions and difficult calculations. We aimed to find a more convenient, easy and empirical parameter to obtain similar information than epsilon. Our suggested parameter can be obtained in base of the Power Spectrum Density from the kinetic energy.

V. ACKNOWLEDGES

The project TURECOTOX (CTM2006-13884-C02-00/MAR) is funded from the Spanish Ministry of Education and Science.

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TIME-SCALE SLOWNESS ADAPTIVE FILTERS

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Keyword – slowness filters, wavelet transform, frequency-wavenumber filter, Radon transform.

I. INTRODUCTION

In seismic record-section signals are recognised through their lateral coherence. In the present of more than one signal it is possible to distinguish the signals which characterise a set of wavefronts that interfere with each other. One of the characteristics of any wave field is the similarity of the waveforms along the wavefront. This high lateral coherence can be used to separate the waves of interest in function of their slowness (inverse of velocity) in order to analyse them with higher precision.

In geophysics, most of the slowness filters work in the frequency-wavenumber (f-k) or the Radon domains [1]. The f-k domain allows to easily filter signals in a constant range of slownesses through the record section but, as it is based on a 2-D Fourier transform, its space resolution is null. The Radon domain is suitable for signals whose wavefront have a known trajectory that varies smoothly with the distance.

II. FILTER DESCRIPTION

With the aim of solving the limitations of the f-k and Radon based filters, we propose the slowness adaptive filters in the time-scale domain. These filters can adapt automatically to variations of the slowness along the wavefronts. In addition, the greater flexibility that this domain provides gives us a higher degree of freedom to design these filters: for example, the slowness resolution can be adjusted optimally at each frequency or, in contrast, can be constant to build filters that do not distort the waveform of the processed seismic signals. Furthermore, it is also possible to adjust these filters to make a great variety of filters in the f-k or Radon domains.

To carry out a slowness adaptive time-scale filter, in the first place, we decompose each trace of the seismic section in slowness in the time-scale domain and we measure the coherence degree of the decomposed section. The slowness decomposition is performed combining the windowed Radon transform with the analytic wavelet transform [2], and the coherence is measured using the phase stack coherence estimators because they are amplitude unbiased and avoid the zero-crossing problems [3]. These coherence measures are used to locate the coherent signals in time, scale, slowness and distance. With this information and the specifications of the filter to design, we can determine the gain of the filter at each slowness component in order to preserve the signals of interest and attenuate the other ones. And finally, we build the filtered seismic section in the time domain using the inverse wavelet transform.

III. RESULTS

In the following we apply the slowness filter to the seismic section shown in Fig. 1 to detect coherent signals with slowness between ±0.2 s/km. The data are recorded by an OBS set in the Cantabric Sea (Project Marconi). In this test, we have decompose each trace of this section in time, scale and slowness using a Morlet wavelet transform and a Hamming window of 15 traces (120 m) long in the windowed Radon transform. As we can notice in Fig. 2, the filter automatically detects the maximum coherent signals in the time-scale domain, and builds the filtered section preserving these signals while attenuating the noise and interferences.

IV. CONCLUSIONS

The time-scale slowness adaptive filters are a powerful tool that enables an easy separation of the seismic waves in function of their slownesses in an adaptive way, with a good degree of control of the slowness resolution across the time-scale domain. As interferences are seen in the time-scale and slowness domain, it is possible to isolate them whereas it was not the case in classical f-k or Radon domains. The filters attenuate the incoherent noise which permits to reveal small-amplitude coherent signals otherwise buried in the noise.

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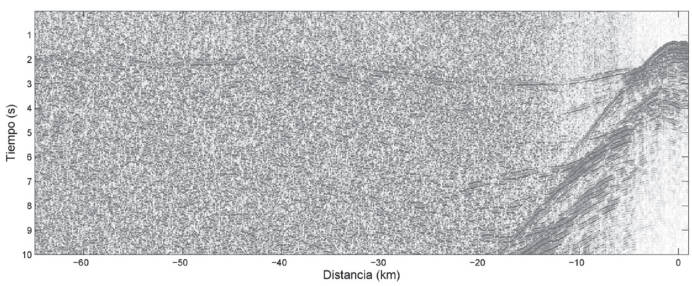

Fig. 1. Original record section.

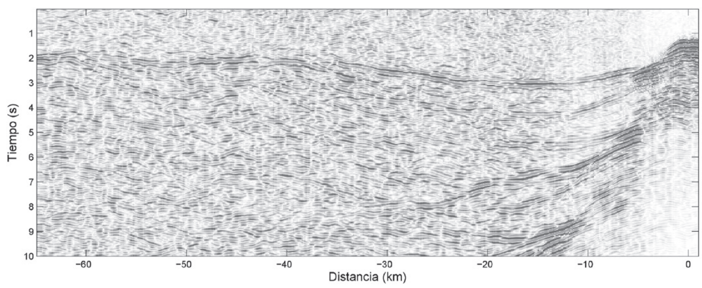

Fig. 2. Filtered record section.

INCOHERENT VERSUS COHERENT MATCHED MODE PROCESSING FOR SHALLOW WATER SOURCE LOCALISATION USING A SINGLE HYDROPHONE

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Abstract - The aim of this paper is to propose a method of source localization using a single hydrophone in shallow water. To perform this localization, modes are first filtered in the time-frequency plane and then used in two different Matched Mode Processors: Incoherent and Coherent broadband processors. Results on simulated data are presented.

Keywords - source localization ,shallow wate, modal filtering, Matched Mode Processing.

I. INTRODUCTION

Source localisation using a single hydrophone is a challenging task. A few methods have been proposed [1,2] but either they are sensitive to the environment knowledge or not adapted to Ultra Low Frequency sources (1-100 Hz) in shallow water environment. In this paper we propose two Matched Mode Processing methods based on modal filtering in the time-frequency plane to localize an Ultra Low Frequency source in depth and range using a single hydrophone.

II. MODAL FILTERING AND MATCHED MODE PROCESSING

A) Modal Propagation:

Considering a Ultra Low Frequency source (1-100 Hz) in a shallow water environment allows the use of normal mode theory to model the propagation. In this case, for a broadband source S located at (R_s, Z_s) in a classical Pekeris waveguide (made of two isovelocity layers), the received acoustic field on the hydrophone $M(0, Z_h)$ is expressed, in the frequency domain, by:

$$Y_{real}(R_s, Z_s, \nu, Z_h) = \sum_{m=1}^{M} X_{real}(R_s, Z_s, \nu, Z_h, m)$$

where is the mode m recorded at frequency *V* on the hydrophone.

B) Modal Filtering:

The first step of the method consists in filtering the modes X_{real} that will be used in the Matched Mode Processing. This step is done using a time-frequency representation (t-f) adapted to guided propagation in underwater acoustics [3]. We must note that the t-f transform can be used to filter modes only if the length time of the source is short compared to the differences between mode time arrivals.

C) Matched Mode Processing:

Once modes have been filtered, they are used in the processors. We adapt works from Matched Field Processing to Matched Mode Processing using a single hydrophone: a signal recorded on a hydrophone is replaced by a mode.

Incoherent Matched Mode Processing: We first build the data vectors and the replica vectors (which are column vectors), at each frequency, in the following way:

$$\underline{X_{real}}(R_s, Z_s, \nu) = \left[X_{real}(R_s, Z_s, \nu, Z_h, m_1)....X_{real}(R_s, Z_s, \nu, Z_h, m_M)\right]^T$$

$$\underline{P_{simu}}(r, z, \nu) = \left[P_{simu}(r, z, \nu, Z_h, m_1)....P_{simu}(r, z, \nu, Z_h, m_M)\right]^T$$

where r and z denotes the possible locations of the source and T is the transpose operator. Then, the classical Bartlett processor is built:

$$B_{Incoherent}(r, z, \nu) = \frac{\underline{P_{simu}}^H(r, z, \nu)\underline{X_{real}}(R_s, Z_s, \nu)\underline{X_{real}}^H(R_s, Z_s, \nu)\underline{P_{simu}}(r, z, \nu)}{\left\|\underline{P_{simu}}(r, z, \nu)\right\|^2\left\|\underline{X_{real}}(R_s, Z_s, \nu)\right\|^2}$$

where H is the conjugate transpose operator. Localization is then performed by maximizing the following function :

$$B_{Incoherent}(r, z, \nu) = \frac{\underline{P_{simu}}^H(r, z, \nu)\underline{X_{real}}(R_s, Z_s, \nu)\underline{X_{real}}^H(R_s, Z_s, \nu)\underline{P_{simu}}(r, z, \nu)}{\left\|\underline{P_{simu}}(r, z, \nu)\right\|^2\left\|\underline{X_{real}}(R_s, Z_s, \nu)\right\|^2}$$

Coherent Matched Mode Processin : The aim of this processor is to process frequencies coherently [4]. To do so, as proposed in [5], a normalised super-vector is built for the real data and for each simulation. As an example, for the real data, the column super-vector (SV) is:

$$\underline{X_{SV\ real}}(R_s, Z_s) = \left[\underline{X_{real}}(R_s, Z_s, \nu_1)^T....\underline{X_{real}}(R_s, Z_s, \nu_F)^T\right]^T$$

Then to avoid problems due to the source phase, the data are scaled at each frequency so that they have zero phase on the most energetic mode (this scalling will be indicated using the subscript PC for Phase Compensated) and unit length. Then, the correlator is built:

$$B_{Coherent}(r, z, \nu) = \underline{P_{SV\ PC\ simu}}^H(r, z, \nu)\underline{X_{SV\ PC\ real}}(R_s, Z_s, \nu)\underline{X_{SV\ PC\ real}}^H(R_s, Z_s, \nu)\underline{P_{SV\ PC\ simu}}(r, z, \nu)$$

The source location is finally estimated by maximising the previous correlator.

III. APPLICATION ON SIMULATED DATA

We simulate a Pekeris waveguide of 130 m depth with a water velocity of 1520 m/s and and bottom velocity of 1875 m/s. The source is an unknown impulsive source (frequency band: 1-70 Hz) located à Zs=40 m and Rs=5000 m. We use the 7 first modes to perform the localization.

To estimate the processor performances, we define two criteria : the width of the main lobe of the ambiguïty surface (at 75%) and the ratio between the main ML and secondary SL lobes (defined by 10 log10 (ML/SL) and equal to infinity in the best case and to 0 in the worst). Ambiguïty planes for Incoherent and Coherent processors are presented on figure 1 and criteria are summarised in Table 1. We can see that in both cases the localization is achieved but that localization using Coherent MMP is more accurate (smaller width, higher ratio ML-SL).

Method	Ratio ML-SL	Vertical width	Horizontal width
Incoherent MMP	1.42 dB	16 m	140 m
Coherent MMP	1.86 dB	15 m	120m

Table 1. Ratio ML-SL and lobe width for the Incoherent and Coherent MMP

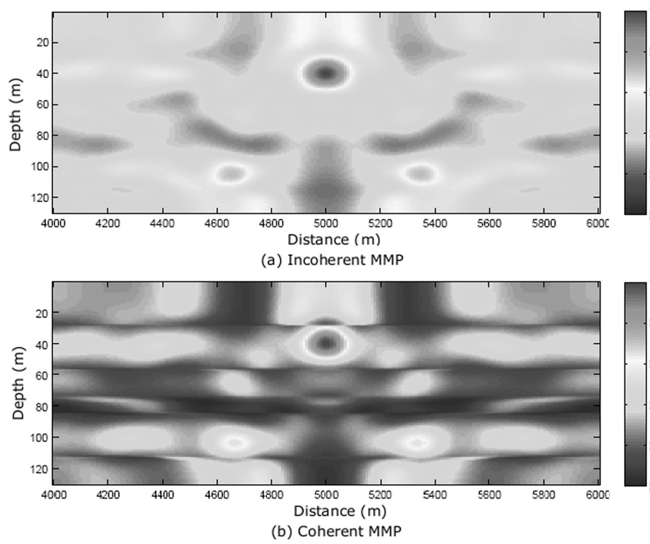

Fig. 1. Ambiguity planes for source localisation using Incoherent (a) and coherent (b) Matched Mode Processing

IV. CONCLUSIONS

We propose two Matched Mode Processors to localise sources in shallow water environments using a single hydrophone. We show that the Coherent Processor allows a more accurate localisation as well as a reduction of the side lodes. This processor has now to be studied in detail and applied to real data to prove its efficiency.

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NORMALITY TESTS ANALYSIS OF RADIOMETRIC SIGNALS FOR RADIO FREQUENCY INTERFERENCE DETECTION

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Radio-frequency interference (RFI) present in microwave radiometry measurements leads to erroneous radiometric results. RFI sources include spurious signals and harmonics from lower frequency bands, spread-spectrum signals overlapping the "protected" band of operation, or out-of-band emissions not properly rejected by the pre-detection filters due to its finite rejection. RFI sources' density increases in populated areas, as shown in [1].

RFI addition to the radiometric signal modifies the detected power and the estimated antenna temperature from which the geophysical parameters will be retrieved. In recent years, techniques to detect the presence of RFI in radiometric measurements have been developed. They include time- and/or frequency domain analyses [2], or statistical analysis of the received signal which, in the absence of RFI, must be a zero-mean Gaussian process. The statistical analysis of the received signal includes the calculation of the Kurtosis parameter to compare it with the Kurtosis of a Gaussian signal [3], and the Shapiro-Wilk normality test to the received signal [4]. Nevertheless, statistical analysis of the received signal could be more extensive, as in statistical literature several normality tests have been developed.

The motivation of this paper is the study of a set of normality tests applied to the received signal as the radiometric signal presents a Gaussian nature; observing the best normality test for different RFI components. A description of the normality tests and the RFI detection results for different kinds of RFI are presented.

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AN EVALUATION OF SOIL MOISTURE DOWNSCALING TECHNIQUES USING L-BAND AIRBORNE OBSERVATIONS

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The European Space Agency (ESA) will launch the Soil Moisture and Ocean Salinity (SMOS) mission in late 2009. This mission is aimed at monitoring, globally, surface soil moisture and sea surface salinity from radiometric L-band observations [1]. Soil moisture is a critical state variable of the terrestrial water cycle and the factor that links the global water, energy and carbon cycles. Currently there are not observing systems that monitor this key variable, being SMOS an unprecedented initiative to provide global soil moisture mapping. SMOS observations are expected to be highly accurate but, due to technological limitations, their spatial resolution is limited to 40-km. This resolution is adequate for many global applications but restricts the uses of the data in regional studies, where a resolution of 1-10 km is needed [2].

Specific disaggregation techniques using simulated SMOS brightness temperatures from the SMOS End-to-end Performance Simulator (SEPS) have been explored to address the possibility of improving the spatial resolution of future SMOS observations: In [3], deconvolution techniques using improved Wiener, Constrained Least Squares and wavelet filters that may include different levels of brightness temperature information in the simulator were presented. With these techniques, the product spatial resolution and radiometric sensitivity was improved in a 49% over soil pixels and in a 30% over sea pixels. However, despite the improvements, results are still far for the 1-10 km goal. Within the preparatory activities for the SMOS cal/val at the REMEDHUS soil moisture station network [4], a high resolution brightness temperature generator and a dedicated Level 2 Soil Moisture processor have been conveniently added to SEPS. Thereby downscaling techniques for improving the spatial resolution of SMOS soil moisture estimates using REMEDHUS high resolution in-situ ground measurements of soil temperature, vegetation canopy, and NDVI data could be developed.

Several field experimental campaigns using the UPC Airborne RadIometer at L-band (ARIEL) have been conducted [5].

By using ARIEL airborne observations, this paper is devoted to evaluate and adjust soil moisture downscaling techniques The authors would like to thank J. Mart´ınez, N. S´anchez, C. P´erez, and G. Baroncini from the Centro Hispano-luso de Investigaciones Agrarias (CIALE), University of Salamanca, for providing the REMEDHUS ground truth data. The work presented on this paper was supported by the projects MIDAS 4 ESP2005-06823-C05-02, MIDAS-5 ESP2007-65667-C04-02 and AYA2008-05906-C02-01, and by the FPU grant AP2005-4912 of the Spanish Ministry of Science and Education. The SMOS-BEC is a joint initiative of CSIC and UPC mainly funded by the Spanish Ministry of Science and Education through the National Program on Space.

using real data, prior to their application to SMOS. Flights at different heights were performed over the Ebro River Mouth and over the REMEDHUS area with the ARIEL radiometer and L-band observations over these areas at different spatial resolutions were obtained: the deconvolution technique of [3] will be applied to brightness temperature data over the Ebro River Mouth, using an improved filter with a land-sea mask; pixel disaggregation techniques using high resolution in-situ auxiliary data will be tested using the brightness temperature data over REMEDHUS. An overview of the downscaling techniques developed and preliminary results of their application to airborne field experimental data will be presented at the conference.

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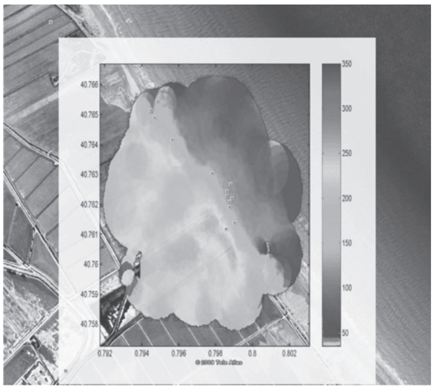

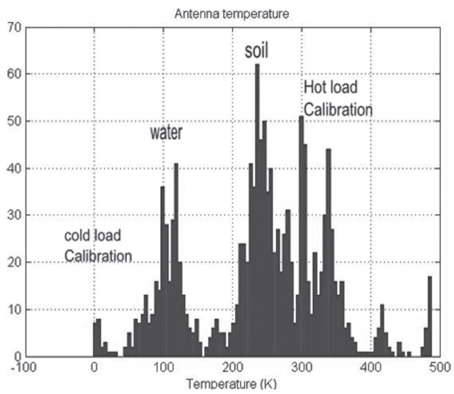

COLOUR CALIBRATION FOR QUANTITATIVE BIOLOGICAL ANALYSIS: A NOVEL AUTOMATED MULTIVARIATE APPROACH

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Abstract - This work proposed a novel approach to practical use of digital photography for biological purposes.

Keywords - Image color calibration, image analysis, color checker, multivariate analysis.

I. INTRODUCTION

In biology, as well as in agriculture, colour images are acquired and analysed for several different purposes e.g. studying the animal beahviour [1] [2], distinguishing among animal related groups [3] [4] and plant science [5]. The illuminant and therefore the light source present when acquiring an image is crucial in determining the quality of obtained images. Different light sources present different emission spectra dominated by diverse wavelengths that affect those reflected by the object under analysis. Thus, following Planck law, light sources can be classified on the base of their colour temperature. Therefore, the calibration of acquired pictures is compulsory in order to discriminate samples or recognise colour patterns.

In digital photography, with printing aims, a number of software are available for colour flow management from the acquisition to the print. Conversely, there are no practical standard methods of illumination and colour calibration to make pictures easily comparable for scientific purposes. In addition, the camera settings and its sensor's response to light, play a crucial role. Although some problems may occur when digital photography for objective colour quantification and pattern recognition is used inappropriately, the benefits it provides are several. Examples of advantages are: flexibility, low cost, accessibility, and the amount of information provided. Therefore this study aims to minimize the effects of illuminants and camera settings introducing a novel approach to colour image calibration based on automated multivariate analysis. This allows practical colour quantification in biological systems analysis.

II. MATERIALS AND METHODS

To diminish the colour variance among calibrated pictures the following camera characteristics and settings have to be adopted as previously reported [6]. The camera (Nikon Coolpix P600) provided high resolution (13.5 real MP) TIFF 8bit image (from RAW format) with good macro features and optical 4x NIKKOR lens. Manual white balance control, exposure and metering methods, were enabled. ISO sensibility was set to 100 to avoid noise appearance. The GretaMachbeth ColorChecker 24 colour-patch was used as reference standard while the relative software, ProfileMaker Pro 5.0 (PROM), was adopted as conventional calibration system.

MATLAB 7.1 R14 was used to perform the image calibration based on: i. second order polynomial interpolation (POLY2); ii. PLS (Partial Least Square) calibration. RGB declared values of the ColorCheker (24 patch) were used as y-block. The x-block was represented by the mean RGB value of the same 24 patch. Eight different light conditions were used to acquire pictures: 200 watt Tungsten bulbs; weakened Tungsten; flash; weakened flash; internal shadow; internal shadow slightly underexposed; external shadow; and finally, full sun (midday). These could represent unknown conditions of light colour temperature, thus the operativity of digital image acquisition.

The ColorCheker was displaced next to different biological samples on a black cardboard. For each condition, three consecutive images were acquired and the same 5 uniform Region Of Interest (ROI) belonging to biological objects (Fig. 2-A) were consequently extracted from each image. To quantify the efficiency of the different calibration systems (PLS, POLY2 and PROM) with respect to the original images (NONE) mean intra- and inter-euclidean distances were calculated. Intra-distances represent differences among mean ROI values of the same illumination condition (triple). Inter-distances represent differences among mean ROI values of different illumination condition.

The colour calibration based on the PLS model was then applied to 3 biological case studies, for which pictures were taken in non-standardized light conditions. In these case studies 2 kind of colour checker were used: GretaMachbeth ColorChecker 24 patch, IFRAO standard scale 7 patch. 1st case: colour pattern of the squat lobster Munida tenuimana (Crustacea: Decapoda) caught at different depths of Mediterranean continental margins (400-1500 m). 2nd case: dorsal colour pattern of Salamandra salamandra (Amphibia: Urodela) a quite widespread European species having several subspecies recognisable on this parameter. 3rd case: Anguilla anguilla (Teleostea: Anguillidae) lateral body colouration to observe contrast between dorsal and ventral skins along the lateral line as an evidence of the developmental transition between yellow and silver eel stage. One image per case study was calibrated.

III. RESULTS AND DISCUSSION

Table 1 shows as intra-distances among pictures taken in sequence at the same illuminant conditions are always lower then the inter-ones. Both the new approaches proposed (PLS and POLY2) allow achieving a better calibration with respect to the conventional software (PROM). The distances are lower were the colouration of the sample are more homogeneous (ROI1= Leave; ROI2=dark background).

Figure 1 presents the original and the PLS calibrated images of the three biological case studies.

Finally, the process was fast and comparable to other available methods, with potentially hundreds of images taken in a day, quickly calibrated with a custom platform such as MATLAB environment. Detailed and complex measurements of traits associated with colour can be undertaken rapidly, with measurements and calculations that would normally be painstakingly undertaken by hand, including morphometric measurements and shapes analysis, such as Fourier analysis [7].

ACKNOWLEDGEMENTS

This work was funded by the project High-Vision (DM 19177/7303/08) from the Italian Ministry of Agricultural, Food and Forestry Politics.

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	Mean Intra-Distance				Mean Inter-Distance			
	NONE	PLS	POLY2	PROM	NONE	PLS	POLY2	PROM
ROI 1	2.7	1.2	1.1	2.2	24.5	6.6	4.6	17.3
ROI 2	11.0	8.3	8.3	9.9	38.6	14.8	15.0	28.7
ROI 3	11.3	6.6	6.7	8.8	43.1	14.9	15.1	27.4
ROI 4	11.9	8.5	8.0	9.2	40.9	20.4	19.2	23.9
ROI 5	7.6	3.8	3.4	6.5	25.4	8.9	7.4	19.7

Tab. 1. Mean intra- inter-Euclidean distances among RGB mean ROI values; the scale reported is 0-255.

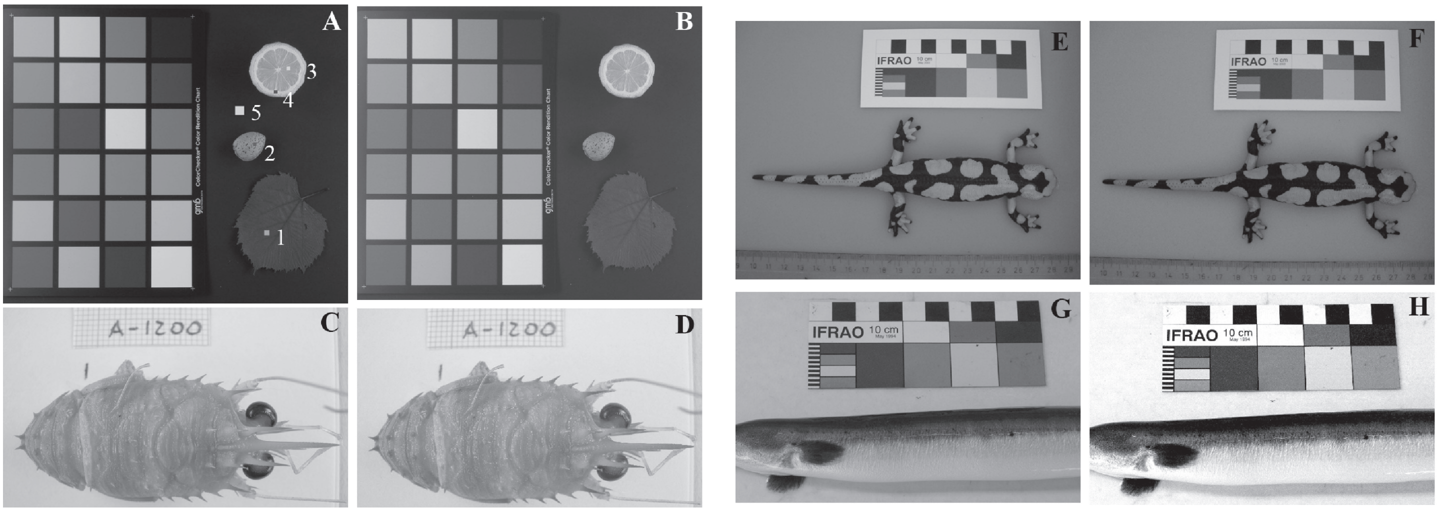

Fig. 1. A. Original image used to build the models (coloured squares represents the object ROIs reported in Table 1: 1. red ROI on a leave, 2. blue ROI on an almond, 3. green ROI on the lemon segment, 4. brown ROI on the lemon flavedo, 5. pale gray ROI on the dark background). B. Original image used to build the models after PLS calibration. C. Original image of Munida tenuimana. D. PLS calibrated image of Munida tenuimana. E. Original image of Salamandra salamandra. F. PLS calibrated image of Salamandra salamandra. G. Original image of Anguilla anguilla. H. PLS calibrated image of Anguilla anguilla.

OTOLITH GROWTH ALLOMETRY MEASUREMENTS IN THE EUROPEAN EEL

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Keywords – European eel, Otolith, Wavelet transform, Elliptic Fourier analysis, PLS

I. INTRODUCTION

The analysis of otolith morphology represents an efficient tool for the discrimination of fish stocks, populations, and species when genetic data are not available for comparison [1]. The saccular otolith (sagitta) is characterized by a high morphological diversification that not only reflect genetic variability, but also environmental changes. Endogenous and exogenous factors determine both otoliths overall shape and growth patterns [2]. So they are good phenotypic markers that may be more applicable for studying short-term, environmentally induced variation; perhaps more applicable for fisheries management, as opposed to genetic variation and endangered species management [3].

No studies for European eel (Anguilla anguilla Linnaeus, 1748) focus on the relationship between otoliths growth patterns and morphology. A. anguilla is a catadromouse species that constitute a single, randomly mating population [4] and animals live in all types of European and North African freshwater habitats. Changes during the growth in the otolith shape are analyzed in relation to juvenile-adult transitions (i.e. from the entry of individuals in inland waters systems up to the following reproductive migration).

In this study we evaluated if the relation between otolith growth and shape is allometric. We targeted on shape variability of the sagittae otolith during growth in a Mediterranean population. In order to do so, we compared two morphological analytic approaches: wavelet transform (WL) and Elliptic Fourier analysis (EFA).

II. MATERIALS AND METHODS

The sampling site was the Caprolace lagoon, situated within the Circeo National Park, (central Italy; 12°58'14.02; 41°21'7.08). 400 sedentary and downstream migrant animals were collected during 2007 with fyke nets. Fishes were sacrificed to extract the otholits from the cranium. A subsample of 150 right sagittae was selected for the shape analysis representing all total length size classes of eels sampled. Otoliths were photographed and measured with an approximation of 0.01mm. Image processing for automatic extraction of otholits outline was performed by the image analysis software Age&Shape (Ifaimon); 512 points equidistant to each other were chosen on the otholit contour, starting from the rostrum as input signal for the calculation of wavelets. Level 7 of wavelet transform was selected given the sensibility of the analysis for that coefficient in the resolution of the entire otolith shape.

Elliptic Fourier analysis (EFA) consists in decomposing a curve into a sum of harmonically related ellipses [5]. The correct number of harmonics was calculated using the method proposed by Crampton [6]. The Fourier series was truncated for k equals to 15, the level at which the average cumulative power is 99.99% of the average total power. According to Rohlf & Archie [7], the elliptic Fourier coefficients were normalized to be invariant of size, location, rotation, and starting position (which was always approximately the tip of the umbo). Cartesian Coordinates were considered. The wavelet transform (WL) compares the signal to a finite length analysing the function called wavelet in a set of increasing scales that are obtained by dilating the wavelet. Choosing the appropriate wavelet shape and setting, a scaling parameter allows the wavelet transform to detect singularities of different sizes in the analysed signal. The successive convolution of the radius with the wavelet and blurring filters produces a complete representation (discrete wavelet transform). Using this wavelet, the fast changing points of an otolith shape appear as large values of the wavelet transform [8].

Partial Least Square analysis (PLS, [9]) was used to regress otoliths predicted lengths, obtained from both EFA and wavelets approaches, against the observed sizes of each otolith in order to investigate the occurrence of allometry in this relationship. PLS allow constructing predictive models when the factors are many and highly collinear. The X-block (EFA or WL coefficients) values were pre-processed by an autoscaling. Each model was validated using a full-cross validation ('Venetian blind' algorithm). The sample was randomly subdivided in two groups: a calibration set (75% individuals), used to develop the calibration model, and a prediction set made by the other 25% individuals that were used to test the model. The PLS analysis provides, the percentage of correct classification and the loadings of each species on each latent vector (LV)

In order to observe a particular trend of growth trajectory in eel otholits a clustering procedure based on k-means was used to obtain the best number of k-clusters [10].

III. RESULTS AND DISCUSSION

Two PLS models have been obtained from both datasets, the first is based on EFA coefficients and the second on wavelets at level 7. Test results in the EFA case show a percentage of correct classification of 97% while the second analy-

sis performed with WL obtained 83.7% of correct classification. RMSAC and RMSECV are lower in the EFA model.
Length values predicted by PLS models were regressed on observed otolith length for both EFA and WL7 shape descriptions. PLS model generated values much efficiently related with measured lengths. In both cases a significant high correlation was found (puncorr.<0.01); EFA model showed an R2=0.98, while WL7 for R2=0.88.
K-means validation test reported that otolith growth of Caprolace eels, calculated between the otolith size and shape, is allometric and the trend of variation is continuous and not "step-shaped".

IV. CONCLUSIONS

From the methodological point of view Elliptic Fourier method applied to European eels otolith shape analysis has obtained better performances using the Partial Least Square regression between observed vs. predicted otolith length. Further studies are needed to verify and implement these results applying lower wavelet coefficients in order to be able to describe outlines at a higher resolution.
Many studies described a good linear correlation between fish length and the caudal otolith radius [11] which reflect its whole size. Our results confirm this evidence for eel population of Caprolace lagoon. Animals otolith growth showed an allometric and continuous trend. Therefore in this case it seems not possible to identify different typologies of otolith shape as a tool for indirect ageing as suggested by Doering e Ludwig (1990)[12].

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POTENTIAL APPLICATIONS OF AUTOMATED VIDEO-IMAGE ANALYSIS IN THE PELAGIC AND DEMERSAL ENVIRONMENT INCLUDING THE DEEP-SEA

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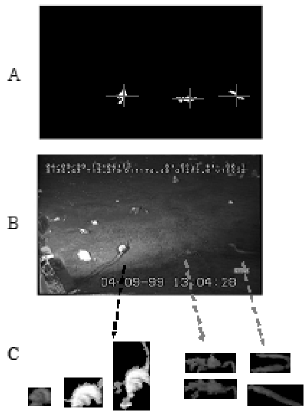
Keywords - Automated Video-Image Analysis, Activity Rhythms, Deep-Sea, OBSEA, Sagami Bay

I. INTRODUCTION

The identification of species, the estimation of their biomasses and associated behavioural rhythms is acquiring increasing importance for fishery management and biodiversity estimation in deep-water continental margin areas and the deep-sea [1].
In the past two decades, the number of submarine video-stations has progressively along with socio-economic interest ocean exploration. In this context, expandable Submarine Stations at different depths such as JAMSTEC's Real-Time Deep-Sea Floor Permanent Observatory of Sagami Bay (1100 m) and SARTI-UPC's western Mediterranean OBSEA (20 m) were installed to measure several submarine parameters, including videos [2].
Accordingly, we have elaborated a novel morphometry-based protocol for automated video-image analysis of data from the JAMSTEC and UPC-SARTI cameras. Our approach accomplishes species identification with Fourier Descriptors and Standard K-Nearest Neighbours analyses on their outlines, and performs animal movement tracking (by frame subtraction), both in the demersal and in the pelagic realm.

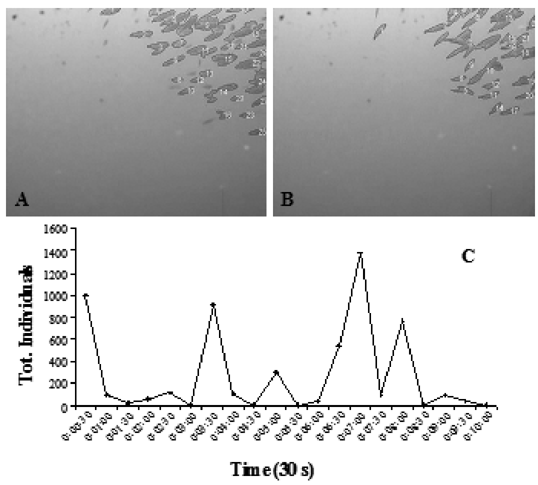
II. MATERIALS AND METHODS

For Sagami Bay we analysed one week of footage (09-04-2009 to 16-04-1999), from the infrared 3CCD video-camera.
For OBSEA, ten minutes of footage were obtained at midday (23-06-2009), from the OceanCam OPT-06 video camera.
Video-image analysis for both cameras followed the same procedure: A) selection of the frame to be analyzed; B) definition of a region of interest; C) identification of displacing objects in consecutive frames by Area thresholding (within the circle (which circle?)); D) grey-level scale thresholding; E) display of original greyscale image with object identified in overlay representation for comparison Figure 1 illustrates the identification of unknown biological objects by a trained operator in Sagami footage. Object selection (Figure 1A); class attribution (Figure 1B); the saving of newly classified objects as single images for their later individual processing by Fourier Descriptors analysis (Figure 1C).



(left) Fig. 1. The object selection by Expert Supervision

(below) Fig. 2. Automated counting of fishes in the OBSEA footage. Two consecutive frames at 30 s distance (A, B) are reported as well as a time series of individuals per unit of time as an example of biomass counting applications



III. RESULTS AND DISCUSSION

Sagami bay footage.

Three displacing species were identified as the most recurrent: Zoarcid fishes (eelpouts), red crabs (Paralomis multispina), and snails (Buccinum soyomaruae) Double-plot actograms referring to the number of observed moving eelpouts, crabs, and snails are presented in Figure 3. Complex rhythmic patterns appeared with varying strengths in the corresponding time series, being especially(?) marked in fishes (Figure 3A). As revealed by the program analysis (Figure 3B), eelpout rhythmic behaviour presented a periodicity of 1049 minutes (equal to 17.5 hours), fitting inertial currents frequency.

OBSEA footage.

The automated protocol efficiently detected a variable number of fish specimens over consecutive frames. These data can be efficiently represented as a time series (Fig. 2C).

IV. CONCLUSIONS

The understanding of ecosystem dynamics in the sea is to date still constrained by datasets This situation is rapidly changing as systems that provide high-quality long-duration datasets are deployed. The analysis presented in our work can be potentially performed on diverse video sources form very different depth environments, where permanent stations are acquiring (or may acquire in the future) footage of very long duration spanning months or years.

V. ACKNOWLEDGEMENTS

We would like to thank Dr. T. O´Reilly (MBARI, CA) for his valuable help during the preparation of this work. This work was funded by the project High-Vision (DM 19177/7303/08) from the Italian Ministry of Agricultural, Food and Forestry Politics

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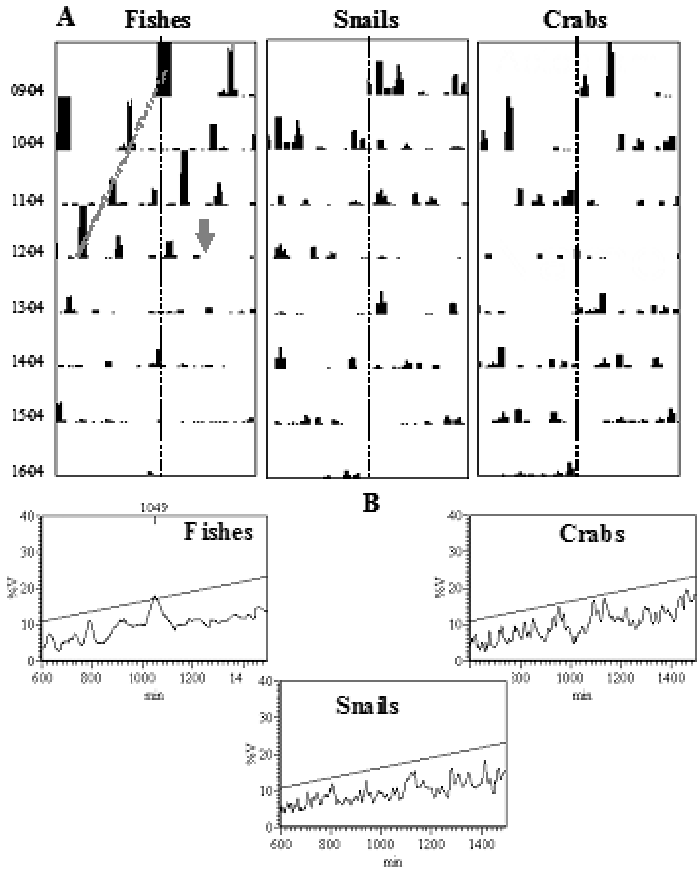

Fig. 3. Double-plot actograms (A; vertical dashed line is the 24-h based limit) and outputs of periodogram analysis (B).

APPLICATION OF GEOMETRIC-MORPHOMETRIC, HYPERSPECTRAL IMAGING AND MOLECULAR MARKERS TO THE STUDY OF DEPTH-DRIVEN DIFFERENCES IN POPULATIONS OF DECAPODS (CRUSTACEA)

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Keywords - Image colour calibration, image analysis, color checker, multivariate analysis, mtDNA sequencing.

I. INTRODUCTION

The levels of environmental light experienced by animals during their phases of behavioural activity determine the type of experienced interspecific interactions [1]. The form and colour of an organism constrains its use of ecosystem resources. At the same time, resource accessibility contributes to the construction of its form. That process occurs via evolution through the confrontation of individuals with important ecological tasks such as feeding, mating, displacement, and predatory evasion [2].

The squat lobster, Munida tenuimana, is an ecologically key crustacean decapod of the Mediterranean slope [3]. Autoecological traits in relation to behaviour and population distributions are poorly understood. A curious depth-related variation in size has been reported [4]; smaller individuals are located at 900 m, while larger individuals occur both above (400-600 m) and below (1000-1500 m)

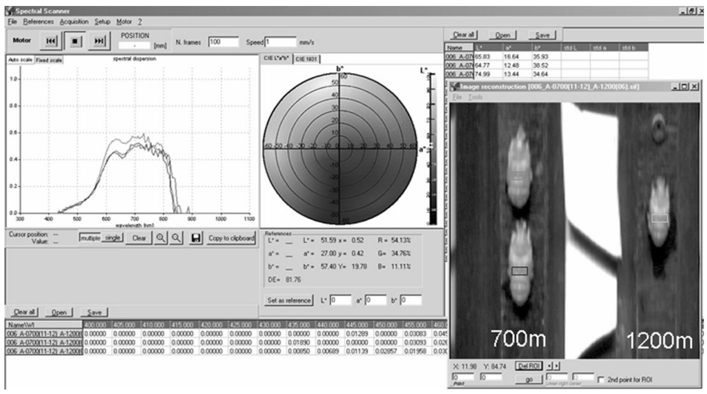

Fig. 1: Software output of the spectral and colour analysis via hyperspectral imaging of the ROI in Munida.

that depth. Curiously, 900-1000 m depth corresponds to the lower border of the twilight zone in the Mediterranean Sea [5].
In this work, we propose the use of geometric morphometry and hyperspectral imaging applications to ask whether distribution of sizes above and below the twilight zone is significantly associated to variation in a suite of selected morphological characters and-or colour pattern. We also coupled the morphological surveys with the analysis of sequence variation in a fragment of the mitochondrial DNA (mtDNA) region encoding for the subunit I of NADH dehydrogenase gene (ND1) to test for any potential bathymetric subdivision in the population structuring.

II. MATERIALS AND METHODS

During the PROMETEO field surveys onboard of the R/V "García del Cid" trawl sampling was carried out at different depths. Sample sizes (N) varied with local population abundances and were the following: >700 m, N=62; 900-1050 m, N=11; 1200 m, N=24; 1350 m, N=72; 1500 m, N=60.
All animals were photographed with a Nikon Coolpix P600 providing high resolution (13.5 real MP) TIFF 8bit image (from RAW format). Manual white balance control, exposure and metering methods, were enabled. ISO sensibility was set to 100 to avoid noise appearance. The GretaMachbeth ColorChecker 24 patch was used as reference standard. MATLAB 7.1 R14 was used to perform an image calibration based on PLS (Partial Least Square) supervised multivariate modelling [6].
Future studies (results not yet available) will focus on:
-Shape analysis through geometric morphometric survey on 35 carapace landmarks
-Colour pattern warping on photographs
Colorimetric and spectral data were acquired through an optical system able to capture the image over a wide wavelength range (i.e. 400-975 nm) and returning data with 5 nm step, following the CIE L*a*b* colorimetric standards and spectral values. The spectral system was made with 4 components: a sample transportation plate (Spectral Scanner DV, Padova, Italy); a collimated illumination device (Fiber-lite) made by a 150 W halogen lamp (the light source); one illumination opening in optical fibre of 200 mm long and 2 mm width, using the standard illumination-optical device geometry β45/0 in relation to the transportation plate (i.e. bearing the sample) and presenting a minimum light divergence; an imaging spectrograph (ImSpec V10-Specim Ltd., Oulu, Finland) coupled with a standard C-mount zoom lens and a Teli CCD monochrome camera.
Hyperspectral imaging characterization [7] of colorimetric and spectral data on a Region Of Interest (ROI) of animals from different depth groups was carried out by selecting a posterior part of the carapace. Animals were grouped with Partial Least Squares Discriminant Analysis (PLSDA; [8]) (Fig.1). Prior PLSDA analysis, the dataset was pre-processed with the 'mean centre' algorithm and divided into 75% to build the model (calibrated and validated) and 25% for the independent test set.
A 315 base pair (bp) fragment of the mtDNA ND1 gene was PCR amplified and sequenced in a subset of 96 individuals (400m N=5; 700m N=17; 900m N=6; 1050m N=6; 1200m N=19; 1350m N=19; 1500m N=20). Finally, four individuals from a far away location (Gulf of Alicante) were sequenced to test for levels of genetic variation at increasing geographical scale. SAMOVA [9] was used to test for population structuring without any a priori grouping of samples.

III. RESULTS AND DISCUSSION

Hyperspectral imaging results on colorimetric and spectral data are reported in Tab. 1 It is possible to observe that, with respect to the probability of random assignment of an individual into a depth unit (20%), the percentage of correct classification of the independent test set, was very high for Spectral data (83.64%) and for Colour data (62.45%).
Moreover the colour data (expressed in the CIE L*a*b* values) showed significant differences between <900 m / 900-1050 m / and >1100 m, meanwhile the three depth units 1200/1350/1500 m appeared as non-significantly different.
MtDNA data revealed eight unique haplotypes largely shared across sampled locations. Overall level of genetic divergence was low (FST= -0.05; P n.s.) suggesting extensive gene flow. However, SAMOVA showed that the most likely population structure was that with samples grouped according to the depth of origin (FCT = 0.152; $P < 0.05$).
In this study, we showed how the combination of novel and diverse technological tools could be efficiently used to approach problems such as behaviour and structuring of populations subjected to decreasing levels of environmental light.

IV. CONCLUSIONS

The problem of colouration in marine invertebrates has been mostly studied in pelagic species leaving this field poorly explored for demersal species [10]. The successful application of hyperspectral imaging techniques to the study of emitted colouration and spot patterning in decapods will contribute to the understanding of constrains to their population distributions in continental margins in relation to light availability. The joint analysis of selectively neutral molecular markers will help in understanding the relative importance of population stochastic processes (i.e. larvae dispersal) over local adaptive phenomena.

V. ACKNOWLEDGEMENTS

This work was funded by the project PROMETEO (CICYT; CTM 2007-66316-C02-02/MAR) and by the project High-Vision (DM 19177/7303/08) from the Italian Ministry of Agricultural, Food and Forestry Politics.

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	Colour	*Spectra*
N	232	232
n° LV	2	16
% Cumulated Variance X-block	91.81	99.98
Mean Specificity (%)	62.26	90.64
Mean Sensitivity (%)	76.26	93.32
Mean RMSEC	0.41	0.33
Random Probability (%)	20	20
Mean % Corr. Class. Model	49.42	87.28
Mean % Corr. Class. Test	62.45	83.64

(left) Tab. 2: Characteristics and principal results of the PLSDA models performed on Colour and Spectra amplings carried out at 5 depths (Y.block). N is the number of samples. n° LV is the number of latent vectors for each model. Random Probability (%) is the probability of random assignment of an individual into a depth unit.

OPERATIONAL OBSERVATORY OF THE CATALAN SEA (OOCS)

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Abstract – The Operational Observatory of the Catalan Sea (OOCS) recently created by the Operational Oceanography Group at CEAB-CSIC is presented. The OOCS aims at performing observations of the marine environment in the Catalan Sea and beyond, assessing, modelling and forecasting the hydrodynamic and biogeochemical processes of the region. Some of the biogeochemical variables available in the models and forecast are phytoplankton, zooplankton and nutrients. Although OOCS is expected to be fully operational in 2011, some of its services are already available to the public through a dedicated webpage http://www.ceab.csic.es/~simob/.

Keywords – Operational observatory, oceanographic buoy, numerical modelling, ocean forecast, NW Mediterranean Sea.

I. INTRODUCTION

Observation and modelling of biological, physical and geochemical properties of the ocean are essential to assess present and past of the ecosystem functioning, and to predict upcoming changes in environmental patterns. At present, the observing systems at global, regional and local scales, such as environmental satellites and moored and drifting buoys, provide information for short and long term monitoring of the ocean. In the Catalan coast, a number of buoys, meteorological stations and tide gauges provide information to public and contribute, together with numerical models, to atmosphere and surface ocean forecasts. Existing services provide little information on the sea conditions below the surface. Furthermore, no instruments measuring biological and geochemical properties of water are available and therefore no forecasts of those environmental variables are provided.
The Operational Observatory of the Catalan Sea (OOCS), http://www.ceab.csic.es/~simob/, a component of project OAMMS funded by the Spanish Ministry of Science and Innovation, started operations in January 2009. The OOCS is maintained by the Group on Operational Oceanography at CEAB-CSIC, taking advantage of the facilities available at the CEAB. The OOCS aims at performing observations of the marine environment in the Catalan Sea and beyond and also assessing, modelling and forecasting the hydrodynamic and biogeochemical processes of the. Biogeochemical variables available in the models are phytoplankton, zooplankton, detritus, nitrate, ortophosphate and silicate. The observatory is expected to be fully operational in 2011. Much of the work that should integrate the observatory is already done in the framework of research project MERIS-ENVISAT CAL/VAL.

II. COMPONENTS

The following components constitute the basis of the Observatory:

2.1 Multiparametric Oceanographic Buoy

The buoy system is being outfitted at CEAB's facilities. It is composed by a dough-nut-type float with an emerging structure containing a full set of meteorological sensors, the central data-logging facility and the real-time communications system. In addition, the buoy has underwater instruments measuring, at various depths, oceanographic and ecological magnitudes, including currents (ADCP), temperature, salinity, dissolved oxygen, fluorescence, turbidity, and photosynthetically active radiation. Data are collected continuously and averaged over 30 minute periods before they are transmitted to the base in the CEAB.
Pre-deployment on a shallow, near shore mooring site, is expected to take place in July 2009 and final deployment is planned for September 2009. The buoy system was operated in a pilot study for three months back in 2005 with relatively satisfactory results.

2.2 Complementary Sampling and Infrastructure Maintenance

Fortnightly CTD/Niskin casts started in March 2009 on board the CEAB's vessel DOLORES. An autonomous rosette water sampler with twelve 5 L Niskin bottles and a SeaBird 19+ CTD with fluorescence, PAR and turbidity sensors will be used. Six-monthly visits from the R/V GARCIA DEL CID will be performed at the mooring site and at a grid covering parts of the Catalan Sea. On-deck inspection and maintenance of the instrumentation on the buoy will be carried out.

2.3 Real-time Modelling and Forecast

Two models developed by Group members are available: 1DV [1] and 3D coupled hydrodynamic-biogeochemical [2, 3] models for NW Mediterranean Sea. They are both being adjusted to assimilate data obtained from the OOCS observing system as well as from remote sensing. Forcings from the European Centre for Medium-Range Weather Forecasts are being used to produce real time operational forecasts. At present, 7-days forecast of the biogeochemical and oceanographic conditions are provided and available to public (see http://www.oceans.cat/forecast/June 2009/).

2.4 Historical Data

Oceanographic cruises carried out by the team in the last four decades in the study area providing historical information of hydrographic and biogeochemical conditions will soon be accessible on-line. Relevant features on these conditions can be found in several doctoral theses i.e.[4, 5]. Data are under quality control processing at NOAA.
Development and implementation of a Quality Control Program for all the components of the Observatory are part of the project activities.

III. OUTREACH

The Observatory, through its web page, will disseminate results and data sets but will also advertise the willingness of the scientists in the CEAB to lecture in colleges, high schools and other communities which might be interested in knowing firsthand the experiences of the day-to-day work. Once the system will be consolidated it is expected to become an Operational Observatory providing services for local and regional meteorological and marine climate change projections.

The OOCS is currently a part of the consortium MOON: Mediterranean Operational Oceanography Network. The future of the OOCS, after the end of the project OAMMS in 2011, will depend upon the support provided by the CSIC, the Ministry and/or any other potential source of funding. The Observatory aims at becoming a service for the scientific community and general public.

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COASTAL AND MARINE LANDSCAPE ECOLOGY BASED ON MARINE GEOSPATIAL DATA INFRASTRUCTURE FOR ANALYSIS OF MARINE RESOURCES AND FISHING EFFORT

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Keywords - marine geospatial data infrastructure, landscape ecology, Emergy and Exergy, Fishing impact

I. INTRODUCTION

Researchers, resource managers and policy makers deal with a plethora of data for the coastal and maritime space. They know that the coastal zone and continental shelf are difficult areas to manage due to the 3-dimension of space (and data), the overlapping of offshore, near-shore, shoreline and inshore physical geography, hydrography-bathymetry, as different type and quality of data, as well as jurisdictional and organizational overlaps. The needs of governance of coast and continental shelf resources, the management of high economic value of activities, and to the social value of coastal zones for quality of life, are drivers for planning and management of the socio-economic framework (Longhorn 2004). These complex physical and institutional relationships require that a Coastal - continental Shelf Spatial Data Infrastructure (CSSDI) or marine geospatial data infrastructure (MGDI). MGDI be developed in close cooperation with the more generic SDI initiatives of countries, and partially exists in the form of the numerous data collection, formatting, data exchange and some data policy standards and guidelines set by UNESCO's Intergovernmental Oceanographic Commission (IOC) via its Committee on International Oceanographic Data and Information Exchange (IODE) (Longhorn 2002). This data set permits a GIS classification system based on seascapes. This methods grew out of an approach advanced by Day and Roff (2000) that is based on definition and classification of physical habitat types. With this approach it is possible use some indices (e.g. emergy, and exergy) representing the distribution of biomass, abundance, and the dynamics inside of dynamical ecosystem. We applied this method in study a benthic ecosystem of continental margins, considering fluxes of energy and biomass among species of the pelagic and the benthic realms that are preyed by Nephrops Norvegicus populations.

II. MATERIALS AND METHODS

The study area is the continental shelf and slope of the south-western margin of Gulf of Lyon (Catalan Sea). The measure were made in at 100-110 m depth off the Ebro River delta (latitude and longitude ranges: 40° 39′ N, 1° 13′ E; 40° 38′ N, 1° 11′ E) and 400-430 m depth off Tarragona (41° 1′ N, 1° 37′ E; 40° 55′ N, 1° 31′ E). Consecutive trawl were carried out at 1-h interval during 4 days in october 1999 and June 2000. All species were sorted and individual were counted. In the approach presented here, physical nektobenthic habitat types were characterized based on a suite of relatively enduring and recurrent characteristics that are themselves known to influence the distribution of species and biological communities (Roff et al., 2003). The data set of the need MGDI included characteristics of the seawater, composition of the seafloor, and depth. This data set, represent an ecosystem but also a trophic spectra, which represents the distribution of biomass, abundance, or catch by trophic level, and may be used as indicators of the trophic structure and functioning of aquatic ecosystems in a fisheries context (Gascuel et al, 2005). Methodology of trawling and light intensity measurements were already detailed by Aguzzi et al. (2003). Marine environment can be chiefly represented as a three-dimensional space. Roff & Taylor (2002) indicated that the different strata of the water column and seabed are equivalent to patches when these present recurrent oceanographic features in selected habitat parameters such as the water temperature, depth/light, stratification/mixing regimes, substrate types and exposure/slope. They denominated these habitat types as the fundamental units of marine seascapes. Accordingly, the seascape ecology uses recurrent oceanographic features to discriminate different types of marine habitats (Roff & Taylor 2000). According to the three-dimensional character of marine ecosystems, seascapes are more dynamic, intermittent and with a more fuzzy geography in comparison to landscapes (Longhurst, 2007). The combination of all these physical factors results in a horizontal gradient of change in habitat conditions from deep-sea to the coastal lines: along that gradient seascape patches change in form, dimension and components, the size of different habitats decreases while their diversity increases (Grimm et al. 2003). Because seascapes are fluids and spatially heterogeneous entities, their structure, function and dynamics are scale-dependent. In fact, moving across marine ecological processes, abiotic and biotic interactions have families of scales (i.e. eddies, fronts, internal waves), which exhibit emerging properties, but also relations among resources and population (Farina 2006). A possibility of modelling and quantify parameters, within a biophysical approach, is possible trough the integration of landscape ecology and ecological indicators as emergy and exergy (Marotta et al. 2007; 2008).

III. RESULTS

The analysis shows that Nephrops at 400 m need an energetic input from other species or from detritus (Marotta et al. 2008). Important results are the evidence of turnover of patches and this need an approach very strong within marine geospatial data infrastructure. The community (Nephrops and its food items) eco-exergy is ≈. 2.0-2.3*107 J/day and emergy ≈.3.4*108 sej/day. Considering and adequate data set, a general model of data integration in seascape is discussed. Considering the seascape and the community, Nephrops norvegicus and others species (Munida iris, Alpheus glaber, and Liocarcinus depurator) are correlated in rhythmicity (as resulting from corresponding catch patterns). The integration among data and indicators appears to be a promising way of analysing and modelling marine ecosystem dynamic at the diel and seasonal base in relation to local trawl fishery.

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AUTOMATED VIDEO-IMAGE ANALYSIS FOR THE ANALYSIS OF THE BEHAVIOUR OF DEEP-WATER LOBSTERS (NEPHROPS NORVEGICUS)

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Abstract - In this study, we show the results of applying automated data processing to a set of videos previously used to manually monitor the period and the phase of activity rhythms of the deep-water Norway lobster Nephrops norvegicus. Resulting data are consistent with published findings on Nephrpos norvegicus activity rhythms both in the laboratory and the field.

Keywords – Video-Image Analysis, Automation, Signal Processing, Behaviour, Laboratory Applications.

I. INTRODUCTION

Video-image analysis can be used to disclose the period and the phase of activity rhythms in relation to the day-night cycle in laboratory controlled conditions [2]. In fact, the expression of rhythmic behaviour can be considered as the phenotype of biological clocks regulation (reviewed by [3]). Biological clocks drive the internal biology of organisms and the overt change in activity rate strictly depends and hence coincides, with their mode of functioning. In this sense, neuroethology studies behaviour to understand the neuronal regulation and video-image analysis can be a very efficient tool [4].

The traditional method of turning data into knowledge relies on the manual analysis and interpretation [5], [6]. For long-term monitoring applications, this form of proceeding is inefficient and expensive. When data volumes grow dramatically manual analyses become completely impractical in many domains. Hence, analysis requires automation [7]. The video-image analysis of footages depicting the behavioural pattern of species in relation to time is to date of growing interest for neuroethology and biomedicine [1] but not yet fully exploited for the large augmnt of frames it produces (from several-days experiments). In this study, we show the results of applying automated data processing to a set of videos previously used to manually monitor the period and the phase of activity rhythms of the deep-water Norway lobster Nephrops norvegicus, a species of elevated commercial fishery value. These data consist on video images taken from above of clusters of tanks, where each specimen remains isolated from the others.

II. METHOD 1: MOTION QUANTIFICATION BASED ON BACKGROUND SUBTRACTION

The method exposed focuses on how to isolate objects from the rest of the image. Because of its simplicity and because camera locations are fixed in many contexts, background subtraction (i.e. differencing) is the simplest approach to quantify motion. In order to do it, we first must configure a model for the background. Once configured, that model is compared against the current image and then the known background parts are subtracted away. The objects left after subtraction are converted into a binarized image, with background in black and foreground in white. The subtraction of two consecutive binarized images corresponds to the amount of motion of the foreground object, the animal (Fig. 1, upper diagram).

III. METHOD 2: MOTION QUANTIFICATION BASED ON BACKGROUND SUBTRACTION AND CONTOUR FINDING

This method is similar to the previous one but in addition, the binarized image is preprocessed, in order to find the position of the greatest foreground object (which should correspond to animals) by using contour finding techniques and the computation of its summary characteristics. The difference between the centre of the objects of two consecutive frames corresponds to the amount of motion of the object of interest (Fig 1, lower diagram).

IV. RESULTS

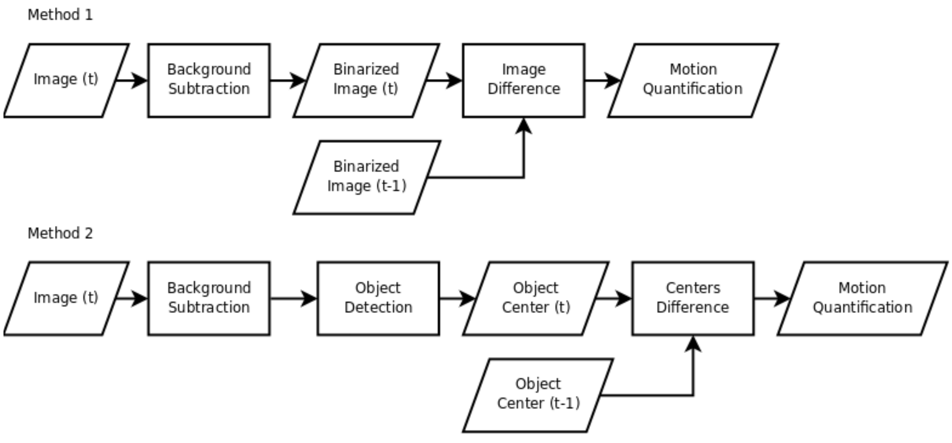
The main issues of the proposed methodologies are allocated on the phase of background modelling. In contrast to other motion detection applications such as surveillance cameras, the background has a great variability in time. Intrinsic phenomena from aquatic installations, produced by moving water (e.g., bubbles), and illumination (e.g., reflexes in superficial waves) increase the difficulty for automated systems to distinguish background from foreground objects.
sampling for a given individual. In order to qualitatively appreciate the activity periods, the automated data has been processed and smoothed to a sampling rate of 30 minutes (the raw data has a sample per frame, with a frame per 41 seconds). Figure 2 (next page) is the cross-correlation of the original manual sampling with itself, and the two methods against the original. Cross-correlation is a measure of similarity of two waveforms, therefore can be used to validate the methodologies and extract additional conclusions (e.g., the periodicity of the autocorrelation is an indicator of the periodicity of the original signal).

V. DISCUSSION

Present data are consistent with published findings on Nephrpos norvegicus activity rhythms both in the laboratory and the field (reviewed by [4]). The specie show diel peaks of locomotion phased at night-time. The observation that automated video image analysis reporpose behavioural pattern similar to what observed by [2]) indicates the viability of the used automated protocol.

The implementation of automated protocols for the processing of large augment of video information is to date a challenging topic for the exploration of the sea. Automated object tracking and object classification developed in the laboratory represent important steps to investigate poorly accessible environments.

Fig. 1: Work flow of the two methods.



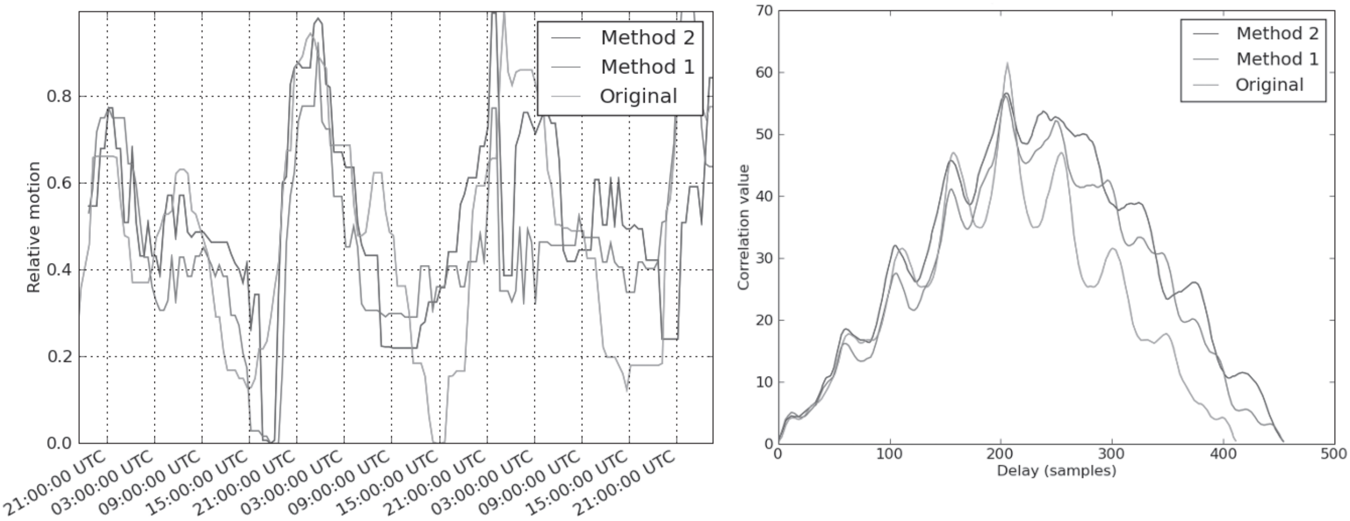


Fig. 2: (left) Monitored activity for a single specimen, with the manual samplign and the automated methods. (right) Cross-correlation of the manual (original) method with itself, and the manual method versus the automated methods.

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FISH TELEMETRY AND POSITIONING FROM AN AUTONOMOUS UNDERWATER VEHICLE (AUV)

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Abstract - We explored telemetry of transmitter tagged fishes from an autonomous underwater vehicle with a hydrophone/ datalogger processing code-division-multiple-access acoustic signals. Geolocation estimates used synthetic aperture and relative sound strength mapping. Signal reception patterns from tagged Atlantic sturgeon were similar to that of moored reference tags but those from tagged winter flounder were reduced in range due to burying behavior.

Keywords-AUV; telemetry; sturgeon; flounder; synthetic aperture; habitat mapping

I. INTRODUCTION

Autonomous underwater vehicles (AUVs) are attractive as a complement or alternative to surface vessels for mobile telemetry of marine macrofauna. Robots, in general, excel at deep or tedious missions such as tracking fish in continental shelf waters. AUVs in particular can simultaneously and continuously sample hydrography and benthic sidescan data for habitat delineation at depths relevant to the animals under study. Freedom from a cable allows signal reception and processing at depth, below interfering thermoclines, without line-associated signal attenuation or vehicle pitch. However, AUV users are challenged by a lack of real-time data for en-route decision making and potential conflicts in choosing paths for best sampling of different variables. We explored the signal reception patterns of an AUV telemetering moored reference transmitters and two species of fish to develop bounds of expectation useful for mission planning and data interpretation.

II. METHODS

The Remote Environmental Measuring Units (REMUS-100, Hydroid Inc.) is an autonomous, propeller-driven AUV. The 36 kg (1.6 m length by 0.19 m diameter) vehicle hosts a conductivity/temperature/depth sensor (CTD, Yellow Springs Instruments), a rapid response oxygen optode (Aanderaa Data Instruments), port and starboard sidescan sonar (Marine Sonic Technology, Ltd.) and upward and downward looking acoustic current Doppler profilers (ADCPs, Teledyne RD Instruments) [1].

REMUS follows a user programmed path. Navigation may apply dead-reckoning, transponder-based trialateration, calibrated by global positioning satellite (GPS) fixes. Ballast is static. Depth and trim is achieved dynamically by control surfaces. REMUS has an endurance of 14 h at 1.5 m/s velocity or approximately 9 h at 2 m/s. It may thus supply a near-synoptic view of mesoscale hydrography [2]. REMUS AUVs are deployed worldwide in various scientific and naval mis-

sions, including under ice.
A hydrophone/processor (WHS_3050, Lotek Wireless, Inc., St. Johns, Canada) was mounted coaxially with the vehicle in place of its nose cone. The package was minimally modified from its intended use as a moored wireless system by removing the battery case and drawing power from the AUV's guest port. Hydrophone and AUV clocks are synchronized before launch. The processor is capable of discerning 80,000 individual coded acoustic (76 kHz) tags using code-division multiple access (CDMA). CDMA is robust against interference from motorized platform noise, echo from ice or reef, or code collision from multiple tags. Therefore, it is not necessary to stagger or vary signal bursts rates within or among tags. Accurate and invariant signal burst timing is a requisite for synthetic aperture geolocation where the transmitter and receiver are not collocated as a transceiver [3, 4]. Signal burst intervals are programmable. Tags may carry and transmit data from optional temperature, pressure, and motion sensors. Detected signals are stored with a time stamp and a value of relative received strength (RSS) and married with location, depth, speed, heading, sound speed, salinity, temperature, depth, flow, oxygen concentration and percent saturation, suspended materials backscatter, and sidescan images in post processing. Nominal power requirements of the WHS represent only 0.5 % of the AUV's 1 kWh battery budget over a 9 hr mission. The channel does not overlap with the operating frequencies of optional long-base-line navigation transducers (20-30 kHz), sidescan (600 kHz), or ADCP (300 and 1200 kHz).
We compiled data on receiver-tag coupling from twelve missions following sinusoidal paths in riverine, estuarine, and coastal ocean environments. Stationary reference tags were deployed as controls in all included missions. Additionally, tagged Atlantic sturgeon (Acipenser oxyrinchus) and winter flounder (Pseudopleuronectes americanus) were at liberty in the study areas during three and two missions respectively.

III. RESULTS

The AUV-mounted hydrophone detected moored acoustic tags as well as those on fish at liberty. The distance and power with which tags were detected varied with environment and fish behavior. In the Hudson River, the AUV detected tags in excess of 2 km distant. Thus, signals from individual tags were detected during multiple path legs (AUV headings), allowing for creation of synthetic arrays that could calculate position estimates. However, location was determined with greater precision for stationary tags than sturgeon there, because the large fish (~2 m length) could move significant distances during array creation. Winter flounder were detected from smaller distances than reference tags and fewer times per pass. However, power was as high for these tags as for reference tags. This is consistent with flounder being buried, during which sound is occluded to the side by sediment more than overhead. In this situation, the tags were less often detected during at least two adjacent path segments (new headings) and appropriate synthetic arrays could not be constructed for all individuals. RSS mapping was useful for estimating flounder position along a single vector and location estimates from RSS maps always compared favorably with synthetic aperture solutions.
Reference tags were detected at all bearings relative to the AUV's heading. Bearing had no effect on RSS. However, tags were more frequently detected as the vehicle approached, rather than departed from reference tag locations. Hydrography and bathymetry data was collected during all missions. Sidescan echograms showed seventy nine additional (untagged) Atlantic sturgeon and numerous unidentified fishes, but winter flounder were not imaged [5].

IV. CONCLUSIONS

This demonstrates that an AUV can simultaneously telemeter tagged fish distribution and survey hydrographic and benthic habitat parameters. The use of AUVs to map individual fish movement relative to dynamic habitat features is especially promising for the continental shelf because of the expense and challenges of placing and maintaining instruments there on scales germane to mesoscale questions. The time-invariant coding structure made synthetic aperture possible and proved to be robust to noise and interference that could typify some niche applications for this tool. The success of this simple bolt on makes it worthwhile to explore more complex models, such as integrating of the hydrophone's circuitry with the AUV's. That would lower the system's mass and wetted area, allow different hydrophone orientations, and would facilitate direct communication and a single clock. This, in turn, would allow for reactive navigation (maneuvers cued by data events). Until then, paths must compromise between the detection range of the hydrophone for its transmitting tags, the spatial resolution being sought for fish positions, the suite of possible behaviors exhibited by the tagged fish in response to parameters under study, the resolution of the hydrographic features of interest, and the useful AUV battery life/mission length. Mission parameters must therefore include the size and shape of the search area, the path of the vehicle inside that area, including the spacing and shape of search line, the vehicle speed, and the vertical profile of the path. While these may seem to be a daunting list of requirements, they do not differ from those conducted by a manned surface vessel, and may be conducted in complement to such an operation.

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IDENTIFICATION OF PHYTOPLANKTON PIGMENT ASSEMBLAGES USING DERIVATIVE SPECTROSCOPY OF HYPERSPECTRAL REMOTE-SENSING REFLECTANCES

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Abstract – One of the major challenges of ocean color research is distinguishing phytoplankton groups from in situ, airborne and satellite measurements to better understand diversity of phytoplankton and some involved biochemical processes. In this framework, high spectral resolution measurements of the remote-sensing reflectance, hyperspectral Rrs(λ), can potentially yield more information about the presence of diverse phytoplankton groups than can be gleaned from traditional analyses of single band-ratios at discrete wavelengths (i.e. multispectral approaches). We introduce and discuss the feasibility of performing derivative spectroscopy and cluster analysis of hyperspectral Rrs(λ) to improve the automatic identification of phytoplankton populations in open ocean waters.

Keywords – Ocean bio-optics, derivative spectroscopy, cluster analysis.

I. INTRODUCTION

Marine scientists have had a long term-interest in characterizing the diversity of phytoplankton communities in the ocean and understanding how diversity changes on spatial and temporal scales relevant to environmental and climate changes. The goal of this research is to estimate the diversity of phytoplankton communities from measurements of ocean color and to do so, an hyperspectral approach is proposed. We introduce and discuss the feasibility of performing derivative spectroscopy of hyperspectral remote-sensing reflectances (Rrs(λ)) [1] to improve the identification of phytoplankton assemblages in open ocean waters. The full potential of hyperspectral optical information, as opposed to current multispectral measurements, in combination with development of algorithms for automatic assessment of phytoplankton composition is explored.

II. RESULTS AND DISCUSSION

The dataset analyzed corresponds to measured and modeled optical properties collected along a north-to-south transect in the eastern Atlantic Ocean during the German expedition ANT-XXIII/1 on R/V Polarstern. Stations were first classified into differing phytoplankton assemblages based upon the ratios of dominant accessory pigments to chlorophyll a, obtained through HPLC chromatography (Table 1). Next, numerical simulations with the Hydrolight radiative transfer model [2] were performed to estimate remote-sensing reflectances (Rrs(λ)) for each station. Differences in each station Rrs(λ) (Fig. 1a) were further examined using tools such as derivative spectroscopy and hierarchical cluster analysis, HCA (Fig. 1b).

Different phytoplankton assemblages, identified by HPLC pigment analysis, were automatically classified from cluster analysis of simulated hyperspectral remote-sensing reflectance data. Our analysis indicates that utilizing derivative spectra of hyperspectral remote-sensing reflectance provides better separation between classified stations and the maximum distance between the clusters of classified stations.

III. CONCLUSIONS

The preliminary results suggest that the application of derivative spectroscopy to hyperspectral Rrs(λ) provides an effective means to potentially characterize phytoplankton biodiversity in open ocean environments. Future work will be focused on exploring the potential of the proposed methodology within the framework of NASA Ocean Color Science projects [3].

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Dominant accessory pigments to Chlorophyll *a*		Station Label
Fucoxanthin, 19'-Hex-Fucoxanthin		A
Divinyl Chl a, Zeaxanthin	(DV Chl a > Zea)	B
Divinyl Chl a, Zeaxanthin	(DV Chl a ≈ Zea)	C1,C2,C3,C4
19'-Hex-Fucoxanthin, Zeaxanthin	(19'-Hex-Fuco > Zea)	D
19'-Hex-Fucoxanthin, Zeaxanthin	(19'-Hex-Fuco ≈ Zea)	E
19'-Hex-Fucoxanthin, Fucoxanthin	(19'-Hex-Fuco > Fuco)	F

Table 1. Classification of stations into different groups based on phytoplankton community composition, as indicated by the ratios of two dominant accessory pigments to chlorophyll a.

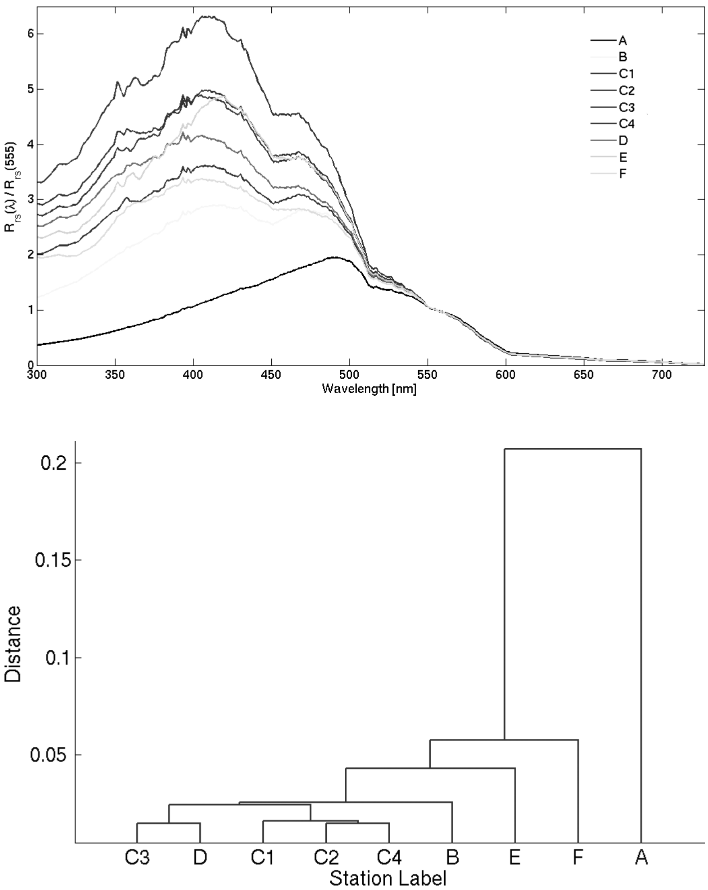

Figure 1. (a) Remote-sensing reflectance (Rrs(λ)) ratios computed for each group of stations (cf. Table 1). (b) Classification of stations based on hierarchical cluster analysis for second derivative of normalized hyperspectral Rrs(λ) spectra shown in Fig. 1(a).

POTENTIAL SUPPORT VECTOR MACHINES FOR PHYTOPLANKTON FLUORESCENCE SPECTRA CLASSIFICATION: COMPARISON WITH SELF-ORGANIZING MAPS

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Abstract – Evaluation of phytoplankton communities is an important task to characterize marine environments. Fluorescence spectroscopy is a powerful technique usually used for this goal. This study presents a comparison between two different techniques for fast phytoplankton discrimination: Self-Organizing Maps (SOM) and Potential Support Vector Machines (P-SVM), evaluating its capability to achieve phytoplankton classification from its fluorescence spectra.

Keywords – Self_Organizing Maps (SOM), Potential Support Vector Machines (P-SVM), hyperspectral, phytoplankton fluorescence.

I. INTRODUCTION

Fluorescence spectroscopy is a non-invasive technique able to measure water properties directly, and provide qualitative and quantitative information about phytoplankton. It has become in the last years a powerful tool to study phytoplankton communities' distribution. Several techniques use phytoplankton fluorescence spectroscopy to discriminate between different phytoplankton groups. Some of these techniques can achieve a high taxonomic discrimination but they are based on measurements that require excitation at different wavelengths. In [1] the possibility to use the information contained in emission fluorescence spectra to discriminate between several phytoplankton species was evaluated. In that case, Self-Organizing Maps was used and its performance was presented as a feasible technique to use in those studies, in which time acquisition is an important constraint, e.g. mobile platforms for high spatial resolution measurements. In this work, a comparison between fluorescence spectra classification based on Self-Organizing Maps (SOM) and Potential Support Machines (P-SVM) is presented. SOM is a type of unsupervised artificial neural network commonly used for clustering, pattern recognition, classification and visualization of high dimensional data. A brief description of SOM and previous results using it for classification of phytoplankton from emission fluorescence spectra can be found in [1]. P-SVM is herein briefly described and finally, the results of both classification techniques are presented and discussed.

Potential - Support Vector Machines

P-SVM [2] is a supervised learning method used for classification and regression. As well as standard Support Vector Machines, it is based on kernels. Kernel Methods approach the problem by mapping the data into a high dimensional feature space, where each coordinate corresponds to one feature of the data items, transforming the data into a set of points in a Euclidean space. In that space, a variety of methods can be used to find relations between the data.

II. DISCUSSION AND RESULTS

Five different cultures representing the major algae divisions were selected and grown under the same conditions. Excitation-Emission Matrices were acquired every day.

SOM method was used as a first approach to phytoplankton discrimination from excitation and emission fluorescence spectra [1]. Herein we present the results using P-SVM, and we compare the results using both techniques.

Two data sets were selected: excitation spectra at a 680nm emission wavelength, and emission spectra from samples excited at 470nm.

In the first case, using excitation spectra, training and test data sets were chosen doing repeated random sub-sampling validation, and the results of 10 different classifications were averaged. In order to evaluate the performance of both techniques, the confusion matrices from the classification step were obtained, and the index Kappa [1] was computed.

The averaged Kappa index resulted is 0.3636. SOM performed better in this case obtaining K=0.6629.

The next step was to try the same procedure but using emission fluorescence spectra instead of excitation spectra. Again, training and test data sets were chosen doing repeated random sub-sampling validation, and the results of 10 different classifications were averaged. The results in that case increase slightly, obtaining K=0.4839, while using SOM we obtained 0.6568.

As it happened utilizing SOM, these poor results could be due to the similarity of the emission fluorescence spectra among the different classes studied. In order to enhance the fluorescence spectra differences between the algae, a derivative analysis has been applied to the emission spectra. Derivative analysis has demonstrated to be a powerful tool to enhance differences [3], although it is high sensitive to noise. For this reason, the noise of the spectra has been also reduced using a wavelet denoising technique [4].

Once the data were pre-processed, P-SVM was used again to classify the different spectra into the correct class. The index Kappa obtained this time was 0.7141. In contrast to the results obtained with SOM (K=0.6992), the performance of P-SVM using pre-processed data are even better than those obtained with SOM.

III. CONCLUSIONS

The performance of P-SVM for fluorescence spectra classification was evaluated. For this purpose Excitation-Emission matrices from 5 different cultures were measured every day. Two different data sets were prepared for this study: one containing excitation spectra, while the second one contains emission spectra. The results were compared with those obtained with SOM.

The best performance was obtained with the P-SVM and using derivative analysis in order to enhance subtle differences between spectra (K=0.7141). If no pre-processing is used, the P-SVM results (0.4839) were worse than the results obtained with the SOM method (0.6568). Although the pre-processing step helps to achieve higher classification accuracy with both techniques, it also shows the kernel method as a feasible technique to achieve phytoplankton discrimination from its emission fluorescence spectra, reducing the acquisition time needed by other techniques.

ACKNOWLEDGMENTS

This research has been supported by the project ANERIS (PIF-015-1), funded by the Spanish National Research Council (CSIC).

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ANERIS: DEVELOPMENT OF AN INTELLIGENT OCEANOGRAPHIC PROBE WITH HIGH RESOLUTION AUTONOMOUS SAMPLING AND COLLECTING CAPABILITIES.

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Abstract – ANERIS is a multidisciplinary project focused on the design and development of a innovative sampling and collecting sonde. The probe design pretend to minimize actual sea water collecting devices limitations by providing autonomy and intelligence to the system.

Keywords – ANERIS, innovation, autonomous, hyperspectral, CMIMA-CSIC.

I. INTRODUCTION AND MOTIVATIONS

Sea water collecting devices have been evolving but they still have limitations. One of the main limitations is the uncertainty of collecting water samples at a desired depth because of the existing delay between decision and water sample collection. Other limitations stem from the movement produced by the oceanographic ships, platforms and wiring systems. Turbulence and mixing effects produced by oceanographic ships and collecting bottles itself, that break water column thin structure and disable water samples for low-scale studies, are also problems that have not been solved yet.

ANERIS, acronym of Analysis and development of an intelligent oceanographic probe with autonomous sampling and collecting capabilities, is a multidisciplinary project that started at the end of 2008. ANERIS project is focused on the design and development of a new sampling and collecting oceanographic sonde able to minimize limitations of current devices. As a multidisciplinary project, four research groups from the Spanish institution CSIC (Consejo Superior de Investigaciones Científicas) work in collaboration for this project. The covered areas are: Oceanographic Instrumentation (Marine Technology Unit, UTM), Marine Biology (Marine Sciences Institute, ICM), Automatic Control Systems (Industrial Automatics Institute, IAI) and Artificial Intelligence (Artificial Intelligence Investigation Institute, IIIA).

II. MAIN CHARACTERISTICS

ANERIS probe is designed pretending to minimize actual sea water collecting devices limitations by providing autonomy to the system. This instrument will incorporate an intelligence system to be able to adapt and modify its performance depending on the environment. It will be used as well to predict the points in the water column that are most significant, following a predefined biological criteria, where the water samples will be collected.

The sampling process will be made up of three stages (Fig. 1): environment exploration, sampling points estimation and water samples collection. During the first stage, when the profiling system will go down, it will collect environmental data from different types of sensors (temperature, pressure, conductivity, fluorescence and hyperspectral irradiances [1]), in order to characterize sea water column. Therefore, during the second stage, the system will process the stored data and decide some provisional interesting points where to collect. During the last stage, when the profiling system will go up, the intelligence system will take part. The sonde will be able to decide where to collect the water samples, taking into account the previous processing stages and the measurements acquired during the ascent.

One of the benefits of device's autonomy is that undesired effects produced by nearby ships and wires will not be present. The included hydraulic navigation system will stabilize the speed, avoiding the main part of turbulences and mixing not produced by natural causes.

Other important parts of the sonde are: (1) the sensors system, which is composed by environmental sensors and optical sensors, such as fluorescence sensors and high spectral resolution sensors (hyperspectral), (2) the new collecting system, which consist of a new type of sampling bottles. Each bottle will be constructed so as to collect water samples in a segmented manner. The spatial resolution of the sampling system will be improved, since the structure of the bottle will be segmented in different small compartments.

2.1 Sensors system

ANERIS optical system is intended to provide information related to water column composition. This type of sensors offer the possibility to better distinguish different groups of phytoplankton, which are characterized by an specific pigment composition and therefore by an specific optical signature. We are working specially with high spectral resolution miniaturized spectrometers (i.e. Ocean Optics USB4000, MP [2]), and fluorescence sensors. Its reduced dimension make them suitable to be integrated in underwater probes. This kind of sensors, like all the other included sensors, will be governed by a PC104 embedded PC, that will control all acquiring, processing and storing data processes.

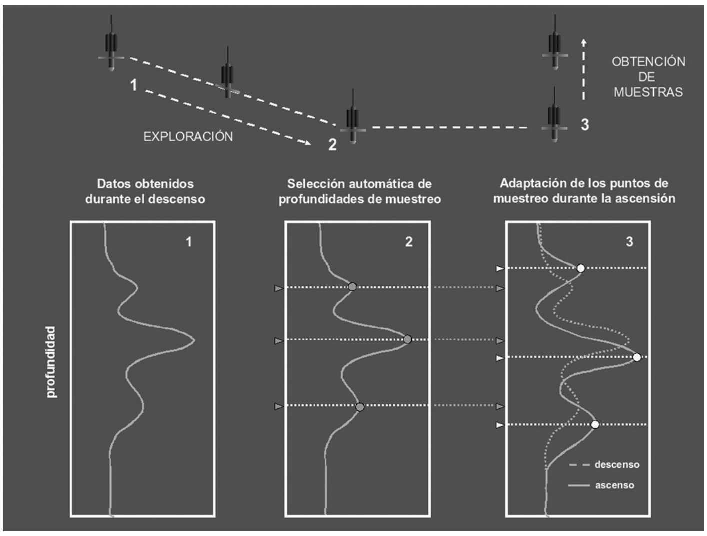

Fig. 1. Schema of the performance of the ANERIS probe.

Our goal with this system is to obtain a device able to acquire environmental data every few centimeters in the water column. We hope it will work fast enough to make possible a real time data acquisition during the ascent mode. Therefore, the intelligent module will be able to predict optimum collecting depths enough time in advance and compensate possible delays between detection and collection.

2.2. Collecting bottles system

Standard collecting procedures using Niskin bottles have the drawback that the whole water column obtained becomes mixed. The aim of the new collecting system is to obtain samples without modifying the conditions of the water column, by collecting high resolution samples.

Collecting bottles will consist in a system of segmented bottles. They will closed using the artificial intelligence system with an appropriate speed so as not to create artificial turbulence. Thereby the bottle will be sealed with a tightness system and in the land bottles will be emptied using a nozzle system.

System design will take into account ocean currents speed, turbulence created by the probe or the sealing and the integrity of materials used to avoid sample contamination.

III. CONCLUSIONS

ANERIS project has recent started and is just at the first stages of development. At present, UTM staff is working on the probe sensors and all its control elements (software and hardware). Anyway, we are working on processing techniques based on model-based simulated data to train and validate probe performance [3,4]. On the other hand, ICM staff is working on collecting bottles design, in order to study the best system for recollecting samples without mixing the water. Up to now there is not any instrument with high resolution sampling and collecting capabilities, even much less performed automatically based on the detection parameters. Therefore this will be a modern and useful tool for future oceanographic campaigns.

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ROBUST AND ACCURATE MONITORING OF GUADALQUIVIR ESTUARY WATERS: A HIGH-RESOLUTION AND LOW-MAINTENANCE SYSTEM FOR WATER QUALITY AND HYDRODYNAMICS.

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Abstract – Since January 2008, The Guadalquivir Estuary has been equipped with a large amount of instrumentation performing an intensive collection of meteorological, hydrodynamic, hydrological and water-quality parameters. An important effort has been made in setting up a telemetry network to register most of those variables in near real time. All this instrumentation generates more than 70000 data per day. The final purpose of this deployment, and the circulation model being developed in parallel, is to generate a powerful tool for the integral analysis and management of the Estuary.

Keywords – real-time telemetry, water-quality, hydrology, hydrodynamics, meteorology.

I. INTRODUCTION

The results described in this document have been obtained under the framework of a contract between Autoridad Portuaria de Sevilla (A.P.S.), the institution in charge of Sevilla harbour, and Consejo Superior de Investigaciones Científicas (C.S.I.C.).

The main objective of the research conducted, led by Instituto de Ciencias Marinas de Andalucía (I.C.M.A.N.), is to diagnose and forecast the consequences of human actions on the dynamics of the Guadalquivir River estuary. In order to reach that goal, it has raised the necessity of generating a comprehensive collection of hydrodynamic and hydrological data since this database is an essential tool to validate the model that explains the global behaviour of the estuary. With the aim at promptly fulfilling this task, the Department of Ecology and Coastal Management of I.C.M.A.N.–C.S.I.C. has carried out the deployment of a telemetry network able to perform intensive real-time data collection of hydrological, hydrodynamic and meteorological variables. Furthermore, some other oceanographic instrumentation has been moored in the area of study: a thermistor chain and Acoustic Doppler Current Profiler (A.D.C.P.) with a tide-wave module, a single-point current meter and six temperature-pressure sensors for tide-regime characterisation (fig. 1).

II. MOORED INSTRUMENTATION

Thermistor Chain and Seafloor CTD

The thermistor chain registers sea temperature at 16 depths every 1 minute. The spatial resolution of the chain is 1 meter. The top thermistor is equipped with a pressure sensor monitoring the verticality of the chain. Attached to the concrete block, a moored CTD (RBR) monitors salinity, temperature and sea level every 10 minutes. This chain is located in the continental shelf, nearby The Guadalquivir River mouth.

A.D.C.P and Wave Module

This A.D.C.P. (AWAC-AST) performs 20-cell current vertical profiles and sea-level measurements every 10 minutes. The spatial resolution of the profiles is 1 meter. The Wave Module sample frequency is 2 Hz, the integration period is 60 seconds and it registers wave information every 10 minutes. Wave measurement is carried out every hour.

Tide gauge network

This network consists of 7 tide gauges deployed at the locations shown in figure 2. They have been configured to take sea-level measurements every 10 minutes.

III. REAL-TIME TELEMETRY NETWORK

Previous to the deployment of this network, the Department of Ecology and Coastal Management of I.C.M.A.N. – C.S.I.C. has carried out the design and construction of two prototypes able to perform intensive real-time telemetry of hydrological (temperature, salinity, dissolved oxygen, turbidity and chlorophyll fluorescence) and hydrodynamic (water column velocity profiles) variables. The technology developed for those prototypes has been used to equip the navigation buoys of the estuary, transforming them into environmental monitoring stations [1]. Figure 2 shows a sketch of the telemetry network deployed at the Guadalquivir Estuary.

Meteorology

This station, installed at the mouth of the estuary, is operative since April 2008 and supplies the network with the following real-time data: wind module and direction, 2π solar radiation, air temperature, relative humidity and atmospheric pressure. All these variables are sampled at 1 Hz and the actual integration period is 10 minutes.

Hydrodynamics

The Water Dynamics (WD) nodes of the network have been installed at the locations shown in figure 2. Every node is equipped with an ADCP (Nortek Aquapro, 1 MHz) providing 21-cell 3-D velocity profiles of the water column every 15 minutes. The upper 6 cells are monitored in real time as well as some other quality parameters: instrument pitch, roll and head pressure.

Water Quality

The Water Quality (WQ) nodes of the network have been installed at the locations shown in figure 2. Every node is equipped with a CTD (Seabird SBE16plus with three external sensors: a SBE43, for dissolved oxygen, and two Turner Design Cyclops, for turbidity and fluorescence) and a 4-pump module able to provide 4-depth vertical profiles of temperature, salinity, dissolved oxygen, turbidity and chlorophyll fluorescence every 30 minutes.

IV. I.T. INFRASTRUCTURE

In order to remotely control the nodes and store all the data generated by them, a data management and control server has been set up (figure 2). This server is behind a firewall to prevent the loss of sensitive information and it periodically publishes the scientific information gathered by the network into an external FTP server. The data retrieved from the moorings at maintenance are also published into that FTP server.

All the instrumentation infrastructure (moorings and telemetry stations) set up for this project generates more than 70,000 data per day. More than 18,000 of them are processed by the telemetry network in near real time.

ACKNOWLEDGEMENTS
This Project is supported by Autoridad Portuaria de Sevilla (A.P.S., Sevilla, Spain) and by Consejería de Innovación, Ciencia y Empresa (Junta de Andalucía, Sevilla, Spain). Thanks are due to the A.P.S. technicians and Aguayo Ltd. divers. The authors would like to offer particular recognition to David Roque, Raúl García and Antonio Moreno (I.C.M.A.N.-C.S.I.C. technicians).

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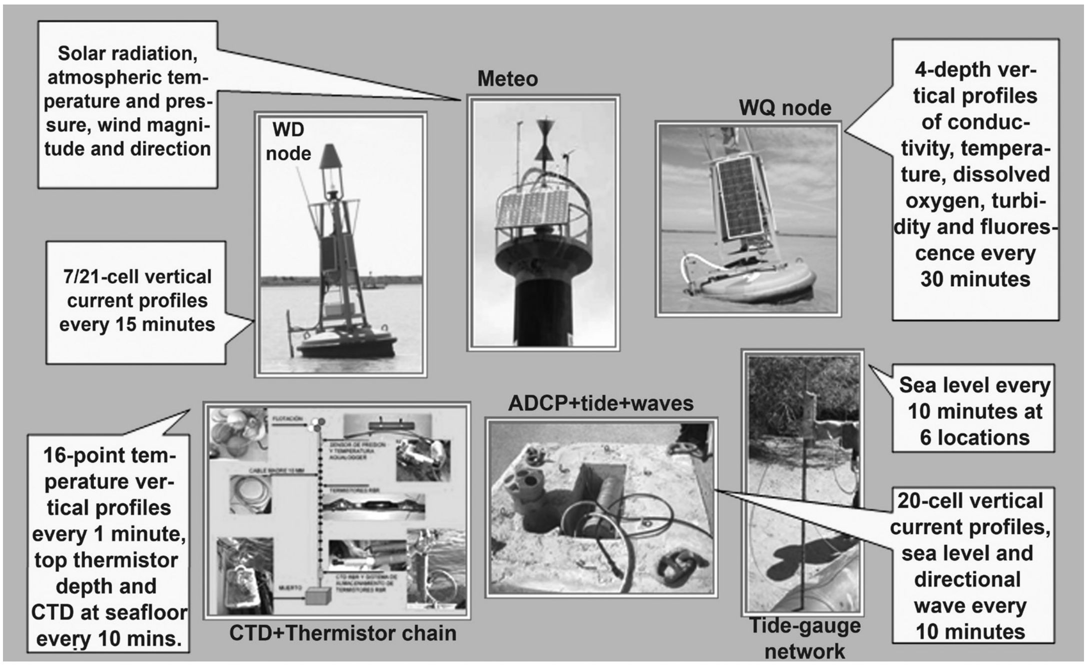

Fig. 1. Types of equipments deployed at Guadalquivir Estuary: variables and measurement rates.

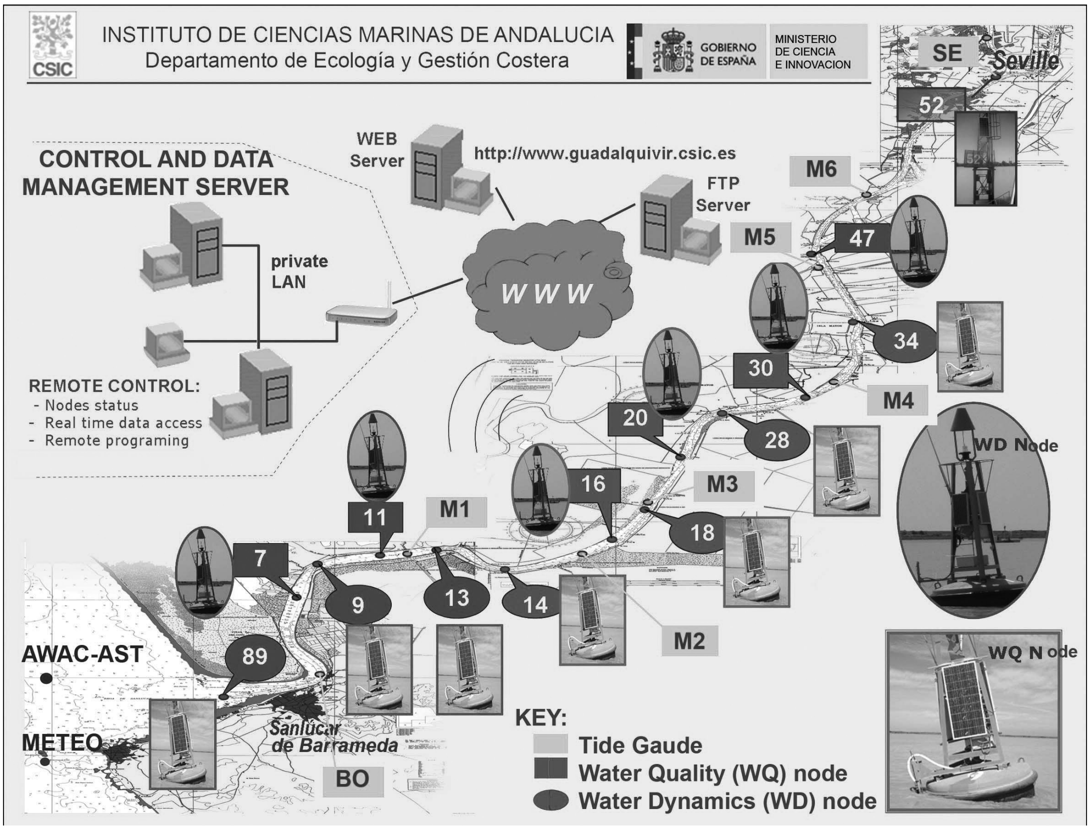

Fig. 2. Diagram of the whole technological infrastructure deployed at the Guadalquivir Estuary from January 2008.

A MULTILAYER SERVICE DATA ACQUISITION AND OPERATION SYSTEM FOR OCEANOGRAPHIC SHIPS AND INSTRUMENTATION NETWORKS

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Abstract - A new Data Acquisition and Operation System for Oceanographic ships and Instrumentation Networks has been developed by the Marine Technology Unit of the Spanish Research Vessels for their networked remote acquisition platforms. The new system built over LABVIR project background follows a Service Oriented Architecture to allow expandable access to acquired data in real time and to archived data. Several Data layers are implemented to allow data access from the more common tools and formats used in marine sciences.

I. INTRODUCTION

The Marine Technology Unit (UTM) from the Spanish Research Council (CSIC) manages different research platforms as "BO Hesperides", "BO Sarmiento de Gamboa", "BO García del Cid" and Antarctic Base "Juan Carlos I", where different type of data is acquired depending on the instrumentation used in each survey. Broadband communications systems via satellite installed on research platforms (ships and bases) provides a link from remote networks to the local area network of the UTM in Barcelona, obtaining a network of instrumentation on each platform that works as a generator node of data,being all of them managed from the headquarters of UTM.

There is a set of instruments that operate on a continuous and unattended mode, provide information of general interest for surveys, but they provide a valid reference for other specific sensors or information necessary to understand and process data from other equipment.

The objective is to ensure uniform treatment of information from these systems and their access (in real time or by consulting the historical record) by the maximum possible number of protocols and procedures. A new Oceanographic Data Acquisition and Exploitation System has been integrated on vessels managed by UTM, providing answers submitted to this goal. This system is applicable to any network of instrumentation where an integrated management of data and a wide range of procedures for data access is needed. It has been

It is designed following a Service Oriented Architecture (SOA) with a multilayer service schema in order to be easily expandable to new required data services.

It is fully operational and it has been implemented on top of the Java library and data model build in two technological research projects: The Virtual Distributed Lab for Oceanographic Data Processing and Monitoring (LABVIR) and the Interoperability in Environmental and Marine Sensor Networks (INTIMAS) both funded by the Spanish government [1].

II. SYSTEM DESCRIPTION

The basic mechanisms of transport and exchange of data between acquisition applications and interfaces, users or other external systems have been built using a model of overlapping layers (Figure 1). Basic interfaces, and instrumentation have been placed at the core of the system, and several layers of service of increasing complexity are superimposed until the mechanisms of communication with user applications. Layers of service cover data access in real time as well as access to stored or archived data sets.

2.1 Basic Data Transport Service Layer

The basic mechanism for information exchange from acquisition applications to the different layers of service is made using datagrams ASCII following the NMEA-183 standard using the User Datagram Protocol protocol (UDP) in broadcast mode. The inner ring of the service layer model for communication with instruments is formed upon this basic mechanism that has been used and tested successfully from several previous works [2].

For instruments that use UDP as thea native method of data transmission, this layer of service provides the proper normalization of telegrams that identifies the type of instrument and the platform (ship or base) that is issued. For those that use other input/output interfaces, an additional network interface is provided within this service.

The UDP protocol is not as reliable as TCP in the delivery of messages, but is faster, it also introduces low overhead of headers in the network and allows a design between client applications and servers without needing to establish permanent links or specific boot order when is used in broadcast mode.

2.2 Access to Historical Records Service Layers

In order to provide access to the historical records of the acquired data a three-layer service have been designed and developed.In each platform and in the central node of the whole system the historic records are feeded by real time acquisition applications while an additional copy is stored, every minute, in the central node by database synchronization procedures. This databases redundancy allows the detection of sporadic cuts in satellite links.

2.2.1 RAW and Processed Files Service Layer (FILE)

This layer provides data storage in ASCII files with the raw information, contained in the telegrams NMEA and ASCII files in CSV format [6], with a subset of data encoded within the telegrams specifying the name and units of the measured variables .

2.2.2 The ASCII files are generated daily. The name of each file is a code with information about the day, month and year of its creation..The extension of the name identifies the instrument that originates the data.Relational Database Service (SQL)

This layer provides data storage in tables in a relational database with geographic extensions, as POSTGRES with PostGIS. The acquisition date adjusted to the millisecond is formed as a primary key databases. The relationships between tables are not formally expressed as table relations, but are implemented inside the logic of the service at the application level.

2.2.3 Geographic Data Service (WFS and WMS)

It is built on the previous layer. This service offers georeferenced data in map and features using the standard WMS and WFS from Open Geospatial Consortium [3]. The requests to these two services are initiated by GIS clients using the HTTP protocol as a channel of communication with the servers WMS / WFS.

2.2.4 This is a service typically oriented to recover historical data but its design allows its operation in real time by defining an specific "service" for taking the last data arrived in the system.Data Export Service (EXP)

An exportation interface to different formats commonly used in marine and environmental sciences as SensorML [3], NetCDF [4] or openDAP [5] is built from the two previous layers.Real Time Data Access Service Layers

These layers are formed by all the service layers that provides access to data in the same moment of its acquisition, in different formats and network protocols, asynchronously or by request.

2.2.5 UDP Data Service

This service multiplex UDP messages received on an specific port to multiple ports in broadcast mode or directed to a particular IP address. This service is oriented to processes or applications such as real time data graphic displays or event handlers.

2.2.6 TCP Data Service

This service replicates the messages received on a specific UDP port to three TCP ports in three different formats: ASCII raw from the received NMEA, self describing XML with information of structure of corresponding data and Java object as a serialized object of data from the used LABVIR library.It is a service oriented to other processes or applications that need to overcome the inherent limitations in the use of UDP, such as the multi attendance to a determined port number in the same server, the reliability of the the data reception, and the overcoming security mechanisms on broadcast traffic related to Java applications.

This layer provides an interface to universal queries of on-line data, using a valid TCP client that is a tool from all the operating systems that support TCP/IP as "telnet".

2.2.7 TCP data service implements a mechanism to match the UDP telegram reception rate to its asynchronous service to TCP clients.WSS Data Service
This service offers real-time data provided by UDP telegrams and the stored data from databases in Service Oriented Access Protocol (SOAP) using a Web Service called Web SADO Server (WSS) that are published on a application server using WSDL [6] for its description.
The data access using WSS enables communication from the data acquisition system to any application, regardless of the programming language or platform used.
Part of WSS service is built on the SQL service layer becoming a layer from access to historic data layer, and part is built over the Basic Data Transport Service Layer in order to provide data access in Real Time.

2.2.8 KMZ Data Service
This service provides the values of the last acquired data in compressed KML files [3] whose content and structure is updated in real time and are served through HTTP protocol. In those files a time value is included in order to allow the automatically refreshment of data.

2.2.9 This is a service oriented to Google Earth clients, although some map servers and Geographical Information System clients can defined contents layers from those files.Data Management Agent Service (NMA)

3 This layer allows the asynchronous transmission of data using a TCP channel to a ZABBIX network management [7] server. Through this service, the functionality of the management system used to monitor the physical network devices is extended by introducing the quality of data management. Future work

In next future, new instruments will be added to the current integrated data network, specially those who have complex data formats or those whose have a high data streaming behaviour.
Data access will be improved by the creation of a new metadata service layer.
The system will be implemented in new platforms as cabled seaflooor observatories or remote weather stations located in Antarctica.

IV. ACKNOWLEDGEMENTS
This work is supported by the Spanish "Ministerio de Ciencia e Innovación" under contract CTM2008-04517

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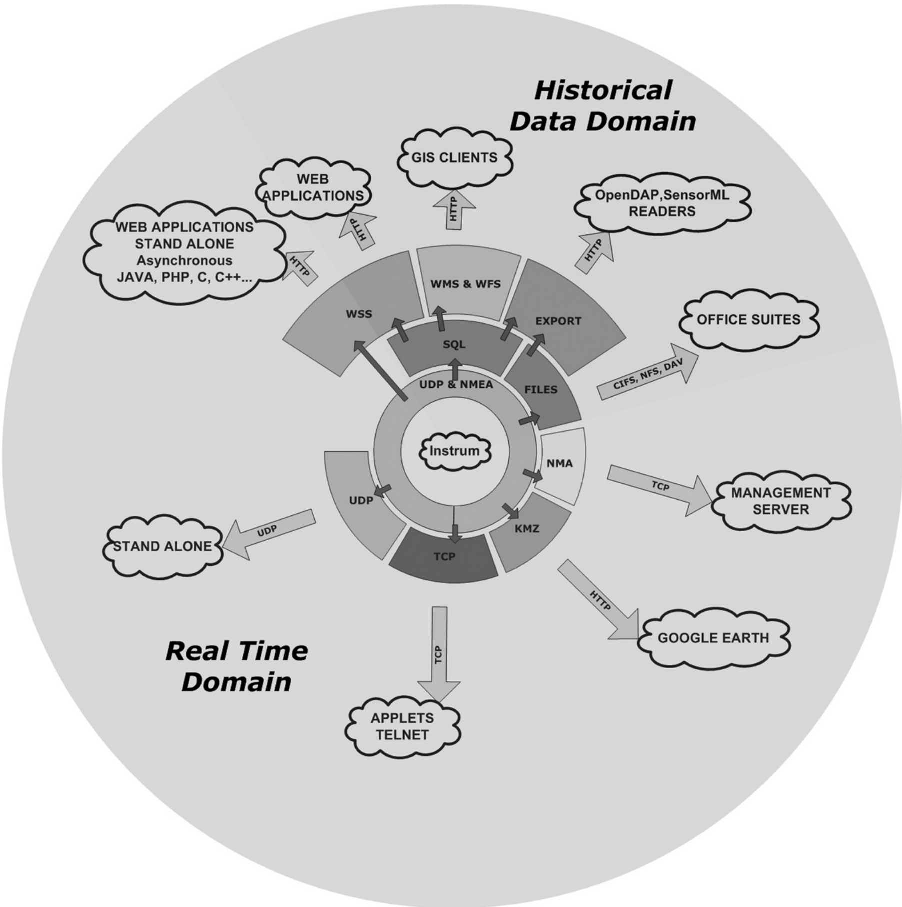

Figure 1: Data Service Layers, communication protocols used and data clients used in the Multilayer Service Data Acquisition and Operation System for Oceanographic ships and Instrumentation Networks. Real time and archive data domains are located at the background.

EVALUATION OF MBARI PUCK PROTOCOL FOR INTEROPERABLE OCEAN OBSERVATORIES

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Abstract - IEEE-1451[1] and OGC Sensor Web Enablement (OGC SWE)[2] define standard protocols to operate instruments, including methods to calibrate, configure, trigger data acquisition, and retrieve instrument data based on specified temporal and geospatial criteria. These standards also provide standard ways to describe instrument capabilities, properties, and data structures produced by the instrument. These standard operational protocols and descriptions enable observing systems to manage very diverse instruments as well as to acquire, process, and interpret their data in a uniform and automated manner. We refer to this property as "instrument interoperability". This paper describes integration and evaluation of MBARI PUCK protocol [3] within different observatories including OBSEA [4,5] in Spain, the ESONET test-bed in Germany, and the SmartBay observatory in Canada.

Keywords - MBARI PUCK Protocol, Instrument Interoperability, IEEE1451, OGC SWE

INTRODUCTION

To achieve instrument interoperability, the physical instrument must be reliably associated with software and information that conform to standard protocols and descriptions. In most cases today, the "firmware" that is physically embedded within the instrument does not conform to standards; instead standards-compliant external instrument "driver" software and metadata files residing on observatory host computers are logically associated with the physical instruments. Setting up the logical association is typically a manual process; technicians must install instrument driver software on the host, specify a host data port where the instrument is installed, and specify baud rates, configuration files, and so on. This manual configuration process can be tedious, time-consuming, and hence prone to human error. Moreover the configuration process must sometimes be performed aboard ships and buoys under severe environmental conditions that challenge human physiology and psychology, thus increasing the chances for error.

An alternative approach is to embed the standards physically within the instrument; in this case the instrument will respond appropriately to standard operational protocols, and will supply descriptive information in standard format. Thus the observing system can automatically identify the instrument and utilize the instrument and its data when it is physically installed, and there is no need for technicians to manually set up a logical association between physical instrument and host drivers and configuration files. There are several challenges to this approach that can be solved by using standards such as IEEE1451, OGC SWEand MBARI PUCK protocol described below.

IEEE-1451 and OGC SWE

IEEE-1451 and OGC SWE are rather complex, which is to be expected as these standards are also quite comprehensive. This complexity presents challenges for instrument manufacturers who must thoroughly understand the standard and who must correctly implement it in firmware. Moreover embedded instrument processors are often designed for low cost and low-power environments, and hence may not be capable of fully implementing the standards. Another drawback is that manufacturers would likely have to abandon existing instrument firmware that does not implement the standard; this existing firmware often represents a very considerable investment by the manufacturer. A third drawback is that IEEE-1451 and OGC SWE are still evolving, again due to the comprehensive nature of these standards. Thus either the standard revision process must be very carefully managed to ensure "backwards compatibility", or instrument firmware must be occasionally upgraded to remain compliant with the latest standard. Both of these alternatives present non-trivial challenges to instrument manufacturers and standards bodies.

MBARI PUCK Protocol

A third approach is implemented by MBARI PUCK protocol, which does not itself implement interoperability, but rather provides the lower tier in a hierarchy of standards that achieve this goal. PUCK defines a simple standard embedded instrument protocol to store and retrieve information from the instrument. The information consists of a minimal instrument datasheet that includes a universally unique instrument serial number, a manufacturer ID, and a small amount of other metadata PUCK protocol also allows an optional "payload" consisting of any information needed by a particular observing system. The payload format and content are not constrained by PUCK protocol, and can include executable driver code that implements a standard operating protocol as well as metadata that describe the instrument in a standard way. Using PUCK protocol, technicians can store payload contents with the instrument before deployment. When the instrument is deployed, payload is retrieved by the host and utilized appropriately; e.g. the host can execute the driver code, and can use or distribute the standard metadata to other locations on the network. Thus standard IEEE-1451 and OGC SWE components can be automatically retrieved and installed by the host when a PUCK-enabled instrument is plugged in, overcoming the difficulties of manual installation. PUCK protocol is simple, and readily implemented in even simple instrument processors; several manufacturers now implement MBARI PUCK protocol in their instruments, and report just a few weeks of engineering effort to do so. PUCK protocol augments rather than replaces existing instrument protocols, and manufactures can usually implement PUCK by extending their existing protocol rather than starting from scratch. Since the protocol is simple, it is likely to be stable, so manufacturers to do not have to modify firmware to keep up with an evolving standard. As higher-level IEEE-1451 and OGC SWE standards evolve, the instrument PUCK payloads can simply be updated through PUCK protocol.

PUCK INTEGRATION

Until recently, PUCK protocol was used exclusively on MBARI moored and cable-to-shore observatories [6]. We describe tests to integrate and evaluate the protocol on several non-MBARI systems, including ESONET test-bed observatories such as OBSEA [3,4] and the SmartBay observatory in Canada. We estimate the engineering effort required to integrate PUCK into these systems, and summarize the benefits gained for that effort. We discuss possible refinements to the protocol and describe plans to submit MBARI PUCK as a formal standard.

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OBSEA WEB: DESIGN AND IMPLEMENTATION

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Abstract - In this paper we present the steps followed in order to do the design of the OBSEA project website, and also the technologies and mechanisms used to process and show the data acquired by the observatory. One of the main bases of our work plan was to take into account the destination public who the website is addressed to, both general public and scientists or engineers must find interesting contents. For the construction of this website we have used commercial programs and applications.

I. INTRODUCTION

Parallel to the completion of the OBSEA observatory development, we start the project of constructing its own website. We established two main objectives: serve as an information portal, where we would explain the objectives of the OBSEA project and its features and as a data source, where people could find the different data obtained by the observatory.

II. WEBSITE DESIGN

When it comes to decide the main design of a website, you have to think about which kind of target it is addressed, including the information and services offered. In our case we have two different matters: we have to be able to inform everybody who is interested, or that has some curiosity about the sea environment or the climatic evolution, about the OBSEA, but we also have to make them curious about the technical part of the project.
In the other hand, we have scientists and engineers, concerned about the same matters as the rest, but from a different point of view. Scientists would like to count with the obtained data for their studies, while engineers will show interest in data about the infrastructure construction, instrumentation, materials and software components, data management, etc.
Due to this fact, we came up with a design combining the two points of view, serving as an introduction for the great public and providing more interesting data for the specialized staff, all shown in a friendly, easy and intuitive environment.

III. IMPLEMENTATION AND DATA MANAGEMENT

One of the most important sections of our website is the one that gives us access to the data obtained by different instruments installed in the observatory. Depending on what kind of data to treat, we apply different procedures:

- Data sent by the CTD is completely numerical, and is received and stored in a MySQL database. From the website we can access this database, using the dynamic language PHP, obtain the last stored measures and show them on the screen, so the visitor is able to learn about the current sea conditions.

- The sound captured by the hydrophone is shown in two different ways. Through an FTP connection to the data server, we get two files: an image and an audio file. The first one will have a chart with the sound data obtained in the last 15 seconds, while the second file will allow the users to listen to the sound fragment stored during that time.

- Finally, the video captured by the webcam installed in the observatory is shown in real time. This image is sent by the webcam to the video server, which is the one who provides the streaming service to the users connected through the website.

IV. CONCLUSIONS

The results of this project can be seen at the address www.obsea.es . The first step of the website creation has been finished, but we are still working to provide new sources of information and data services to our users. One of the most important improvements to be done is the implementation of different forms which will allow our users to make queries of data relative to specific time periods, and also the creation of tables and charts from those results.

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SECURING ON-THE-INSTRUMENT "PLUG AND WORK" DEVICE DRIVERS

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Keywords – PUCK, plug-and-work, device driver, security

In the MBARI "plug and work" approach, the use of different kinds of measurement instruments is facilitated by storing machine-readable device identification within the instrument. This identification can be used to retrieve an appropriate device driver – for example via a network connection. We present a solution for offline operation by automatically loading device driver code from the instrument to the host computer using the PUCK protocol. In this setting, it can obviously not be excluded that some person equips an instrument with malicious code and connects the spoiled instrument to the measurement host. Since retrieval and execution of the driver code is performed without human interaction, the host would immediately load the malicious code and start executing it – with unforeseen damages to the measurement process. In our contribution, we propose as countermeasure to protect the byte code of the device driver by a digital signature. A valid digital signature guarantees both origin and integrity of the device driver code. After loading the code from the instrument's storage, the host checks the validity of the signature and verifies that the origin of the signature (e.g. the device driver's author) is known and trusted. In a case study, we used the Java Distributed Data Acquisition and Control framework that comes with minor overhead. However, an adaptation to other (especially Java based) frameworks should be very easy.

AN ON-BOARD DATA MANAGEMENT SOLUTION

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Abstract - A Marine Data Management System (MDM-400) has been installed on the Instituto Español de Oceanografía (IEO) research vessel B/O Cornide de Saavedra. It is an experience of how a commercial solution has been developed and fully adapted to the ship characteristics, including an external communication by Universal Mobile Telecommunications System (UMTS) connection that facilitates the maintenance works. The system runs on 4 windows based computers interconnected by a LAN (Local Area Network). The current work mainly focuses on discussing the technical solutions that have been taken, real-time integration, data storage and transmission, and external communications.

Keywords - data management system, data acquisition, communications systems.

I. INTRODUCTION.

The B/O Cornide de Saavedra (http://www.ieo.es/buques/cornide.htm) was built in 1970 and since then has been working as research vessel focused in collecting physicochemical parameters as well as in fisheries studies. As the time has been passing, the procedures, instruments and communications have been evolving and because of it, nowadays, the scientific requirements are much stronger than before. Thorough the last years, a big effort to bring up to date the ship capabilities has been done including the equipment integration and communication systems. In this course of action, during 2008, the Instituto Español de Oceanografía (IEO) has installed a SIMRAD MDM400 Marine Data Management System on the research vessel B/O Cornide de Saavedra in order to integrate in a unique database the navigation information and scientific equipment installed on board. The main difficulties are related to the special characteristics associated to an aged ship and the adaptation of the different datagrams and formats to a common one. The current system is a commercial solution that has been developed and fully adapted to the ship characteristics by IEO and SIMRAD. The system runs on 4 windows based computers interconnected by a LAN. One of the computers is configured as MDM Server, who receives the data from several instruments, and also supports the database. All the data collected underway are received, stored and distributed in real-time. The other PCs connected on the LAN act as Clients where the users are able to list, plot and download data in different formats including ASCII files that are easily readable by any post-processing software, regardless the platform.

Besides, in order to bring up to date the communication system on board, Dixita has implemented a remote connection via Universal UMTS to all the PCs in the network that has also been proved very useful in the first steps of MDM installation to check if the system was working properly and moreover remotely facilitate the maintenance works. The same connection allows an access to Internet, voIP and email services when the ship is near coast (under UMTS coverage). The whole system benefits the research activity permitting a remote access to marine data and information systems, but also an easier and faster communication between ship and research institutions onshore.

II. DATA MANAGEMENT SYSTEM

The MDM-400 system runs on 4 windows based computers connected to the Ethernet LAN. All the instruments on board are cable connected to the MDM server. Today the implemented system is capable of acquiring, sharing and storing data position from GPS systems, meteorological data from an automatic Aanderaa weather station, physic-chemical sea water properties from the SeaBird-21 thermosalinometer and Turner-10AU fluorometer, echograms from EA600 and EK60 echo-sounders, and current velocity profiles from the vessel mounted ADCP. These instruments are connected to the MDM Server via serial ports. The way to incorporate data from the installed devices is through dedicated drivers that control the incoming datagrams, interpret each of them and store data locally in a relational SQL database sited in the server. Currently all the drivers are configured to store one sample by minute, to reach a compromise solution between time resolution and storage capability, but it could be customized according to scientific requirements by changing the storing parameters in the Server Manager.

To take advantage of the possibilities given by the interconnected PCs, the specific SeaBird software used to configure and collect CTD data has been implemented on 2 clients. One of the MDM applications permits the users to store directly the obtained raw or/and processed files in the server, that in this case acts as backup, keeping data as independent files that could be retrieved in the same formats from any other client PC or removable device.

III. COMUNICATIONS SYSTEM

To facilitate the maintenance works, bring up to date the software, antivirus, etc. a remote connection via UMTS to all the PCs in the network, and also to other PCs on board, has been implemented. It allows a flexible and secure integration of an existing IP remote network into the Intranet of the vessel, enables remote LAN/WAN integration making use of the wireless data services (GPRS/3G/3G+based).

This has been proved very useful in the first steps to check if the system was working properly and also to solve problems when the vessel was on surveys.

The same UMTS connection allows an easier and cheaper access to Internet services, voIP services and email when the ship is near coast -under UMTS coverage-.With a UMTS Marine Antenna (http://www.dixita.com/docs/UMTSantenna.pdf) it's possible get a coverage about 20 miles. The system allows connecting the vessel LAN with the central IEO LAN, achieving a complete vertical integration. It facilitates the report sending of the MDM daily automatic output by direct email and data replication to the datacenter onshore. In the same way, the system permits a daily report to Coriolis of thermosalinometer data, as it is part of the international IEO commitments in the field of the operational oceanography, also allows scientists to use the software for data acquisition equipment, and manage the computers of the vessel from their research labs on land with a Virtual Private Network (VPN).

IV. CONCLUSIONS

This experience has proved very useful in testing this kind of data management systems in order to install them on the new IEO vessels currently under construction. This system reduces the complexity of the previous one and increases data sharing and device connectivity capabilities. The improvement in real time data access is very important in order to face up to new demands linked to operational oceanography programs, large amount of data storage and management and social requirements.

ACKOWLEDGES

Funding for the acquisition of the MDM400 system has been supported by Ministerio de Ciencia e Innovación through the upgrade program of large scale facilities, ICTS2007-01. We specially thank to the B/O Cornide de Saavedra crew for valuable suggestions and kindest support.

GEOGRAPHIC INFORMATION SYSTEM ARCHITECTURE APPLIED TO OCEANOGRAPHIC DATA ACQUISITION SYSTEMS

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Abstract - In this work a Geographic Information System Architecture for Oceanographic Data is presented. This has been designed by the Unidad de Tecnología Marina to be used into an Oceanographic Data Acquisition System implemented on board research vessels as a complete Service Layer integrated in the real time data services and also in to the archive data retrieval procedure. The main objective was to use opensource solutions and to follow the directives of the Open Geospatial Consortium in order to implement the different data services.

I. INTRODUCTION

The Geographic Information System developed by The Unidad de Tecnología Marina (UTM) from the Consejo Superior de Investigaciones Científicas (CSIC) has as a main goal to give facilities to access and work with the data acquired at research oceanographic vessels BO Hesperides", "BO Sarmiento de Gamboa", "BO García del Cid" and Antarctic Station "Juan Carlos I" in Livingston island.
This system is easy scalable to accept more platforms and data sources like automatic sub-aquatic stations, buoys and new vessels, where the information with important spacial and temporal components are relevant.
This solution set its developed over Open Source projects and follows the OGC (Open Geospatial Consortium) standards in order to guarantee the interoperability of the data and the offered services.

II. ARCHITECTURE

The system is designed for provide a geographic data access service layer to the acquired data. It is developed using the Data Service Layer Model implemented in the Data Acquisition and Operation System for Oceanographic Ships developed by the UTM.
We have identified and implemented four principal components for this service layer (Fig. 1):

Georepository

This component stores the information of the system and guarantees the persistence of the data. It manages all the spatial and thematic information or at least maintains a reference to the thematic information. We have chosen PostgresSQL as a relational data base with its spatial extension POSTGIS.
The upload data procedure can be in real time, using a specific data service that writes information of incoming data from the different sources to a central repository, and later it is distributed to a central node that has data from all platforms.

Geographic information server

This component publishes data as a map service using WMS, WFS and WCS following the OGC standards [1]. We have chosen Geoserver server for its flexibility and overall capabilities to implement this task. This has been deployed over GlassFish application server and it is capable to integrate heterogeneous data sources like ArcInfo shape files, PostGIS and MySQL databases, KMZ files, GML files and more. Geoserver can do tiling over the visualization layers with cache preload of the cells around of the one that is displayed.

Web client

This component is the user front end to display data, using the WMS and WFS services from GeoServer, and sends geographical queries to the server. It has been implemented as a web client and developed using the Javascript Framework: OpenLayers [2]. With this, it is possible to offer an easy data access and a simple 'first tool' to work with this data: it's possible to calculate areas, distances, select and edit different data layers and print maps in pdf format. It also provides access to numerical data associated to each element in a layer.

Thin client

This component is a desktop multiplatform GIS client application. It is developed using Java with custom plugging over the Kosmo [3] Open Source project. This client has the most common functionality for this environment.

2.1 Persistence

All the data are saved in a central server in two different ways depending on the data source and the final use of the data:
• Raster and Vector files in their different formats that system is capable to store in an ordered directory structure.
• In a relational data base. The information is stored in the relational data base PostgresSQL with the PostGIS extension that gives support to geographic objects using a Geometry data type column for the the geographic information. The system uses DBA Managment Server as a web administration and monitor tool for the data base server.

2.2 Data Services

Once the data is stored in the georepository it is served with OGC Web Services. OGS services are the integration of different OGC specifications, focused on geoprocessing (WMS, WFS, WCS, WTS, etc..), using XML and HTTP technology.
The geographic information server, Geoserver, offers the following services:
• WMS: A georeferenced map served as an image using jpeg, gif, png, svg, pdf, kml, kmz, that is generated dynamically, and accessible using a web browser through standard Uniform Resource Locators requests.
• WFS: Equal to WMS but it allows the interaction with the server map using a Geographic Markup Language, a derivation from XML.
• WCS: A geospatial data set in coverage format. As a difference with WMS this service provides the data in original semantic making possible to work directly with it and it's not only an static representation of it.

2.3 Data Acquisition

Two different ways for feeding data to the systems have been implemented:

In real time

The different sensors generate User Data Protocol (UDP) telegrams with the data that we want to integrate in the data base. These UDPs are processed and integrated as a register in a table of the database where a Trigger shoots in the INSERT to update this registry with the geographic information defined. In this case, the geometry column is calculated with the longitude and latitude data fields of the registry as follows:

UPDATE "public"."posicion" SET geometria=GeomFromText('POINT(' || longitud || ' ' || latitud || ')', 4326);

Deferred

The data can be loaded to the system from heterogeneous sources to the georepository uploading the raster and vector files to the server to load them in the Geoserver.
Several applications can do this job working directly with the georepository, like DXF_to_PosGIS. With this last application is possible to import directly from DXF files (the AutoCAD file format commonly used in several GIS environments) files to PostGIS. Other applications like Udig are suitable for working with multiple layers of heterogeneous data sources and with them, it's possible to add and modify geometries in the layers.

2.4 Data Visualization

The use of publication map services: WMS, WFS and WCS makes possible an easy access to all the information in two ways: Directly with a web browser (Firefox) or from a GIS desktop application like Kosmo, ESRI, QGIS or gvSIG for example. In figure 2 we can see the data selector layer in the top right corner and it also shows the display of the navigation line of BIO Hesperides vessel that is used to access to other acquired data by using their acquisition time relationship.

3 Future Improvements

The UTM is working in a oceanographic survey editor. This application is focused on geologic, biologic oceanographic campaigns and others and it will be possible to work with a web browser drawing sampling points and navigation lines. It works with WFS and the vector layers with the points and lines are exportable

to GPX, making possible to open this with the main navigation program used by ship's crew.
There are these basic work entities:

• sampling points.
• sampling group points.
• Navigation lines.
• Group navigation lines.

The navigation lines and the separation between them will be generated manually or automatically with the depth and another parameter.

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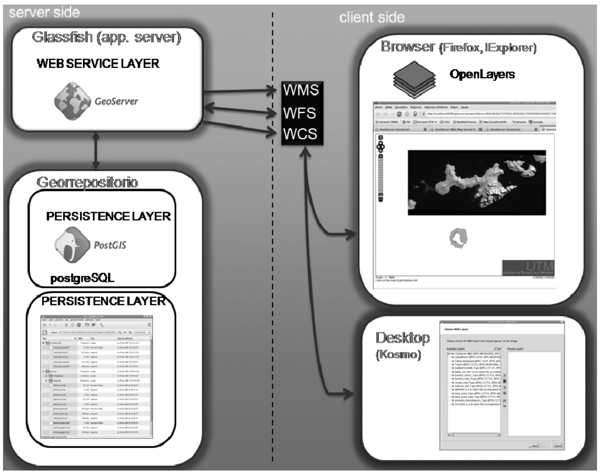

Figure 1: The four principal components of the service layer

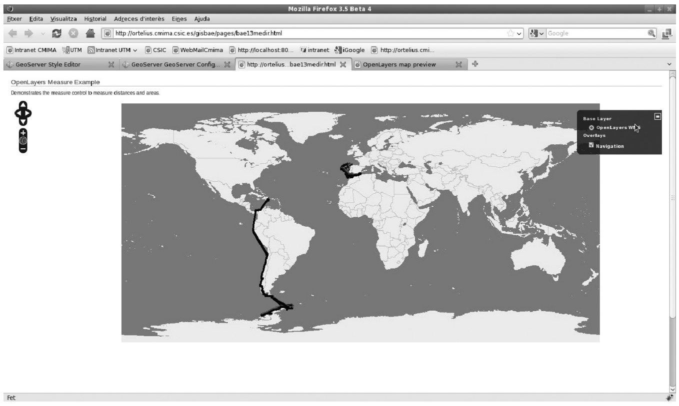

Figure 2: Data display of last 1 year data acquired by BIO Hesperides vessel (navigation track). This map frontend can be used to display data associated at each ship navigation point.

SCIENTIFIC INFORMATION RESOURCES AND BIBLIOMETRIC INDICATORS FOR THE RESEARCH PERFORMANCE ASSESSMENT

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I. INTRODUCTION:
This publication pretends to introduce the researchers and users of bibliographical databases to the bibliometric information resources and the indicators measuring scientific production.
Academic, institutional and corporate scientific production and research is in constant evolution; the Research Centers are every time more competitive, the research paths are more diverse and often requiring multidisciplinary collaboration between authors who furthermore, must take into account the scientific actuality within their own field of study.
The companies providing information resources collecting the scientific production published in journals, congresses and other sources, are aware of this dynamic situation and offer products integrating several added value databases and customization of all services.

II. EXPOSED RESOURCES:
Companies like Elsevier with their database Scopus, or Thompson Reuters supporting Web of Knowledge are leading competitors, regarding the management and commercialization of main research scientific information sources.
The platforms use their own metric tools to analyze and evaluate the scientific production hosted in their databases. Users can get information about, amongst others, number of quotes pointing a specific article, the Impact Factor of a publication during a certain period, the position of a publication according to its thematic field, the Immediacy Index in which an article is quoted, the influence of a journal and/or article within its field.

III. CONCLUSIONS:
Bibliometric indicators can provide with data on impact and visibility of publications, they can show collaborations between authors and their individual productivity, they also can establish which the trends are in scientific research.

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OBSEA SERVERS NETWORK

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Abstract – In this paper will be presented an overview of the information treatment servers structure used in the OBSEA project explaining and justifying the chosen topology.

Keywords - OBSEA, information servers, underwater observatory network .

I. INTRODUCTION

When planning network infrastructures is always recommended to study a proper topology that will provide a good communication medium maintaining the security. In the exact case of the OBSEA network it has been designed a scalable structure allowing a safety fast expansion conserving the integrity of the remaining network devices. One of the critical questions in all the systems connected to Internet is the security police, which is always confronted with the usability. When the structure is highly secure can be impossible to work with it, otherwise, if no security police is implemented foreign and unauthorized users can gain access and damage the infrastructure or use the resources for its own purposes.
In the OBSEA network there is a compromise, external access to the instruments is restricted and only acquired data is forwarded

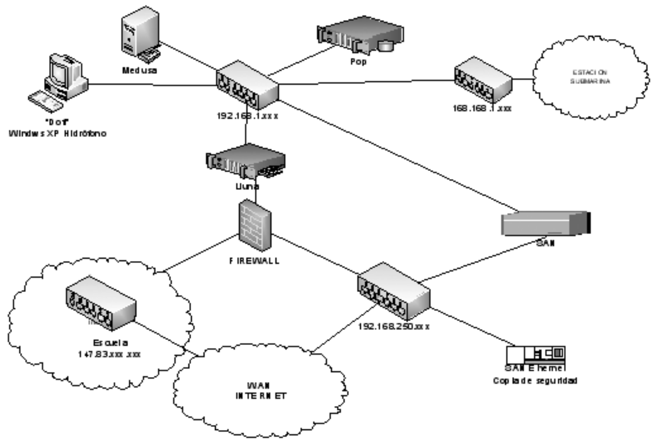

Figure 1. OBSEA servers network.

II. EVOLUTION AND RESULTS.

Servers and services:

We start from the premise that is preferable to have one server device for each provided service, for what it has been implanted the following topology.
Data communications comes from the subsea observatory to the ground station in the University building through a dual gigabit Ethernet singlemode fiber optic link. From there to the CTVG building were are located the information servers is been used an existing multimode fiber optic link ending in a GigaEthernet Switch from which are connected all the servers. As is shown in the figure one, they are currently four servers each one dedicated to one service.
In the "Pop" server are implemented the services related with the subsea webcam video recording and image provider (acquisition from webcam, video frames storage, video server, etc).
The "Dofi" server implements all the services related with the hydrophone: Data reception, sound processing, and packet forwarding to external users.
The "Medusa" server is implementing the network management and error monitoring with a SNMP (Simple Network Management Protocol) server
At last the "Lluna" server is storing the sensors information in a data base and is in charge of all the extended services.

The operative systems of the servers has been chosen according to the services and applications running in them. In the next table 1 are listed.

Server	SO
Pop	Fedora
Medusa	CenTOS
Dofi	Windows XP
Lluna	Ubuntu

Table 1. OBSEA servers names and OS.

At present people is working in the migration of the "Lluna" server to a Sun/Solaris platform to improve the reliability.

Services

Currently the data from oceanographic instruments is been stored in a Data Base in order to be used for the scientific community. This data is presented in the OBSEA website together with the climatic information from a ground observatory. This data can be retrieved and correlated with information coming from external experiments to obtain advanced conclusions.
Thanks to the flexibility of the system is possible to serve real time hydrophone data to an investigation group of the UPC involved in the LIDO project. This project have the finality to process real time data providing from several European observatories for the identification and tracking of mammals and other animals in the Mediterranean sea.

Extra services and future expansions.

Due to the OBSEA is prepared to accept new instruments, can come up the necessity from a scientific to test an instrument and for that, he will need the unabridged data in its own computers, for that has been developed a set of programs that are able to recollect information from one instrument and send to a exact computer or store it locally.
In addition is been developed the software needed to interact automatically with external men or machines using standard international protocols such as IEEE-1451 and some "web-services". With this interface external users will be able to access the real time and historic data as well as to the metadata required to interpret it.

III. CONCLUSIONES

The nowadays existing informatics equipment has been developed to be used for ground networks. When using it in marine applications must be taken in account some special considerations such as the inaccessibility which complicates the material election to grant the reliability and robustness.
Another key are data accessibility, it is almost impossible to implement a structure able to interact with any type of sensor and any type of user. For that are being developed standard interfaces for standard sensors and different ones will be adapted to one of this interface. In any case, due to the flexibility of the system, when is not feasible to interpret data from one sensor, is always possible to send raw data transparently to the client without interaction with it.

IV. ACKNOLEDGEMENTS

The OBSEA project is being founded from the Spanish Ministry of Science and Innovation (MICINN).

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[4] Gisma: http://www.gisma-connectors.de/
[5] LIDO: LIstening to the Deep Ocean environment http://www.lab.upc.es/

ICZM TECHNOLOGIES FOR INTEGRATING DATA AND SUPPORT DECISION MAKING

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Keywords - Integrated Coastal Zone Management (ICZM), Geographic Information System (GIS), Sustainability Indices, Decision support systems (DSS)

I. INTRODUCTION

This paper aims to identify strategies for Integrated Coastal Zone Management (ICZM), coastal planning and sustainable development in north Adriatic using spatial modelling based on Geographic Information System (GIS). Geographic Information System (GIS) are valuable instruments to coastal managers in data integration and in identifying coastal impacts and conflicts, conservation "hot spots". GIS allows experimentation with various management approaches to working with coastal space planning and resources management (Vallega, 2005). Decision support systems (DSS), ecosystem modelling, and resource assessment allow users to put GIS data bases to their full use for individualized applications or research studies. GIS and GIS Based DSS are recognized widely as a valuable tool for managing, analyzing, and displaying large volumes of diverse data pertinent to coastal planning activities (at both local and regional scales). Its use in coastal management and planning is rapidly increasing. In European coasts, Industrial development, urban and infrastructure sprawl, fishing, gas extraction and tourism are activity conflicting and with high impact on environmental system. Hence, the strength of sustainable planning can be enhanced by GIS applications.

II. MATERIALS AND METHODS

The study analyzed 3 study areas in North Adriatic Italian coast: Venice, Rimini and Conero. Lagoon of Venice is characterized by an extraordinary mixing of activities: tourism, fishing, industrial areas (petrochemical plants). Rimini area is one of the most important beach tourist areas in Mediterranean Sea. Conero Area is in the Ancona Province, with an important industrial port and a petrochemical plant (API, Falconara). In spite of this, Conero is a wild mountain with a cliff coast; it is a park and Marine Protected Area with important ecosystems and geositeses.

The process of ICZM can be described by an integrated set of indices, at a geo-ecological level, modelling earth processes, human society and economy, and coastal uses at multiple scales (Vallega, 1999). The study describes a methodological approaches based on the integrated use of Geographic Information System (GIS) and Multi Criteria Decision Model (MCDM) to identify nature conservation and development priorities among the coastal areas. A geographic information system (GIS), and a geographic resources analysis support system (IDRISI™, Andes version) were used. IDRISI™ was used for the analysis of coastal changes and multi criteria analysis (MCA) (Eastman, 2006). A set of criteria were defined to evaluate coastal ecological status. Those criteria are space based following the landscape ecology methods and framework. Landscape ecology investigates the effect of the spatial arrangement of patches and corridors and related processes into a geographic area (Forman and Godron, 1986). Important applications to coastal management are the definition of Homogeneous Environmental Management Units (Brenner et al., 2006), the analysis of spatial and temporal structure, hierarchy and dynamics over multiple scales (Naveh and Liebermann, 1994; Marotta, 2006), the assessment of cumulative impacts and habitat loss in coastal ecotones (Thrush et al., 2008). GIS integrate and uses different data. For the landscape analysis and individuation, two Landsat satellite scenes were used for each study area.

The used indices and indicators for sustainability/health metrics were: Emergy, defined as all the available energy that was used in the work of making a product and expressed in units of energy (Odum, 1996); Exergy of a system, as the maximum work possible during a process that brings the system into equilibrium with a heat reservoir. When the surroundings are the reservoir, exergy is the potential of a system to cause a change as it achieves equilibrium with its environment. Exergy is then the energy that is available to be used. After the system and surroundings reach equilibrium, the exergy is zero (Jørgensen, 2006). Using land-use data and development-intensity measures derived from energy use per unit area, an index of landscape development intensity (LDI) can be calculated for the coastal zones to estimate the potential impacts from human-dominated activities. The intended use of the LDI is as an index of the human disturbance gradient (Brown and Vivas, 2005). The ecosystem function is measured using the biological capacity potential (BTC, Ingegnoli and Pignatti, 2007), based on resistance stability, vegetation type, and metabolic data of vegetation. Ecosystem services are based on the values calculated by Costanza et al. (1997).

III. RESULTS

The value of indices and indicators are linked to the land/sea use. The resulting values of indices are calculated in the coastal fringe. The Sustainability weak and strong and the minimization are the used criteria. Having defined the criteria, the next step was selecting suitable indicators to measure the selected criteria. Subsequently the criteria were evaluated from industrial development, conservation and tourism development point of view. These criteria were then ranked MCA and the results integrated into GIS. Several conservation scenarios are generated so as to simulate different evaluation perspectives. The scenarios are then compared to highlight the most feasible and to propose a conservation and development strategy for the coastal area. The generation and comparison of conservation and development scenarios highlighted the critical issues of the decision problem, i.e. the dunal and wetland ecosystems whose conservation and development relevance is most sensitive to changes in the evaluation perspective. Results shows the increasing during time of impacts and the need of governance of conflicts, unsustainability in resources use, urban and infrastructures sprawl, and pollution phenomena. Planning and management based on indices benefit from landscape ecology principles. For ICZM to advance and to make legitimate contributions to coastal sustainability, it must be practiced in a transdisciplinary manner – for it must meet the system knowledge, the needs of stakeholders, benefit from the support of decision makers, engage scientists and engineers and challenge planners and designers to innovate. The proof of its success depends on the extent to which real management follow-up programs, monitoring and systematic evaluations of long and short term results are made. This study represents an important contribution to effective decision-making because it allows practical results for both resource consumption and spatial planning.

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SATELLITE COMMUNICATION SYSTEMS ONBOARD TWO SPANISH OCEANOGRAPHIC VESSELS

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I. INTRODUCTION

Two Broadband Satellite Communication Systems were installed in two of our vessels during 2008. In BO Sarmiento de Gamboa a VSAT Communication System in C band was installed with a data transfer rate of 192 kbps (CIR, Commited Information Rate) and a burst capacity of 256 kbps (MIR, Maximum Information Rate) which can be increased to 5 Mbps. While in BIO Hesperides, following Navy specifications (the ship-owner) a TNX75 Communication System in X band was installed with a data transfer rate of 128 kbps (CIR) which can be also increased to 5 Mbps.

Apart from the advantages that an Internet access has had for the researchers, one of the most important characteristics of this Broadband System is the possibility of configuring a Virtual Private Network (VPN) between the vessels and the UTM main offices on shore (Land-Site). This network enables real-time data transmission and remote systems control and operation (Figure 1). Furthermore, web browsing is possible and an IP telephone system has been installed.

The installation of this kind of networks is not easy and several difficulties can appear. Therefore, an optimal configuration of protocol architecture has to be looked for. In satellite communication where TCP/IP protocols are used, data links are very sensitive to latency, asymmetric links, and package loss due to congestion or transmission errors.

Both vessels are managed by UTM owned by different ministries. Administrative requirements were different at the time of choosing the satellite service providers. During start-up their services and their architectures were very different and they were modified until the problems were overcome, so both systems can currently offer the same services. For analysing the resolution of those problems, the behaviour of four basic parameters (jitter, round time trip, package loss and throughput) has been studied.

II. SYSTEM DESCRIPTION

The broadband satellite service of UTM ships has a capacity which enables IP networking in permanent connection. For that, VSAT technology is used which connects the ships to the satellite network. The satellite service providers are Seamobile and Hisdesat. Both of them use geostationary satellites (orbiting at 35,786 km) and a large set of ground stations to provide coverage around the globe except the polar areas (their effective coverage is between 70 º N and 70 º S).

The terminals used onboard work with the C and X band. With the current contract the providers guarantee a link with a minimum symmetrical bandwidth of 128Kbps.

The diagram for the architecture of the system is detailed in Figure 2, referring to the three locations involved: vessel, land backbone or teleport site, and UTM Land Site.

a. Vessel Site: On board both ships there is a gyro-stabilized antenna and position control unit, one modem, and the network equipment that enables IP routing, VPN establishment, access control lists, management of service quality, and links to the vessel network. In both systems the IP equipment is the same brand and model (Cisco 2800 Series routers), while the electronic equipment for satellite link is specific to each case.

b. Teleport Site: In order to allow the link between the satellites and the data backbone network or public switched telephone network (PSTN), the provider needs specific equipment. In this site the following elements are available: a modem for the satellite link, IP router for Internet connection and firewall.

c. UTM Land Site: This equipment corresponds to the end of VPN and is located in the UTM Land Site (Barcelona). The VPN links are managed by a router. This is the central node in the Private Network which is extended between the UTM site and the oceanographic vessels.

III. SERVICE CHARACTERISTICS FROM START-UP TO OPTIMIZATION

Both systems were installed on the vessels almost simultaneously, but initially their performances were very different in each case, until the equipment configuration and optimization of the system were carried out.

The "BO Sarmiento de Gamboa" start-up system didn't have any differences to the initial design made by the satellite service provider. Network traffic measurements showed a symmetric bandwidth link according to the contract. The packet loss rate was close to 1.5% including traffic inside VPN. Currently there is no change in the configuration of the standard values on-board computing facilities, except the MTU which was modified to optimize the link between the ship and Land Site.

The "BIO Hesperides" system presented a very different scenario on its installation. Although connection with HTTP servers was possible, the VPN link was extremely poor, despite using same IPSec protocol and encryption parameters used on the "BO Sarmiento de Gamboa" system. The analysis of the performance in this situation showed high packet loss rate (reaching 80%), and continuous changes on throughput values.

The PING tool was used to verify if packet fragmentation exists, and to look for the optimum MTU value. In the "BO Sarmiento" system, iDirect modems are capable of reassembling fragmented packets, but PD-25 modems in the "BIO Hesperides" cannot do that, causing high packet loss rate. Several tests with different MTU values were done to find the optimal MTU value that was set finally around 1400. After this change the quality link was improved considerably (Figure 3).

After this, the geographic location and configuration of the accelerators were changed to work within the VPN link. The accelerator on the teleport site was moved and integrated on the UTM Land Site.

IV. ANALYSIS OF EQUIPMENT CONFIGURATION AND PROTOCOLS

In order to evaluate the communication performances in the network, IPERF and PING tools were used.

In this case we use the bandwidth between the vessel and the CMIMA to send packets in both directions, evaluating packet loss and jitter variations under different conditions. This value in communications between vessels is significantly higher than jitter in a terrestrial connection (100ms).

The measurements presented were made with this tool sending packets in both directions into the VPN link, using a bandwidth of 117kbps along 1800 seconds probe.

PING lets us know the round-trip delay time or round-trip time (RTT) corresponding to the period of time in milliseconds that is needed to go and come back between source and destination hosts. Usually, this delay should be not higher than 200 ms in terrestrial communications, and around 700 ms in satellite communications.

In the "BIO Hesperides", several tests were done with IPERF tools. Initially the delay between the two hosts, connected directly to the vessel modem and the teleport modem. This measure should avoid any interaction or effects introduced by other network equipment (routers and accelerators).

The next measurement set was made through the routers after configuring the VPN and the accelerators in "BYPASS" mode. Finally, the accelerators were activated in "LAN" mode and the different results were compared. Then a new measurement set was made using PING for 1200 seconds.

In the "BO Sarmiento de Gamboa", IPERF and PING tool measurements were made.

All the tests were done with the vessels working in two surveys in different locations. "BIO Hesperides" was in Brandsfield Sea (Antarctica), and "BO Sarmiento de Gamboa" was in front of the NW Spanish coast.

The results are showed in Figure 3. Different conditions are used for plotting the data:

- In all the figures, situation "1": tests made through accelerators in LAN mode and the MTU value to 1400 (Optimal situation).
- Situation "2"corresponds to tests through accelerators in LAN mode and the default MTU value (1500) .
- Situation "3" corresponds to tests through accelerators in BYPASS mode and the MTU value to 1400.
- Finally, situation "4" corresponds to tests through accelerators in BYPASS mode and the default MTU value (1500) (Worst situation).

V. CONCLUSION

After the optimization of equipment configuration and network parameters on VSAT links of both vessels, stable links have been obtained for web navigation and VPN communication.

Accelerators reduce jitter values, and MTU optimization improves the observed asymmetry between the uplink and downlink regarding this parameter.

With respect to throughput both link senses are shown to be symmetric in optimal conditions. The action of accelerators is notable onboard the "BIO Hesperides" to reach the contractual values.

MTU optimization is quite important to reduce packet loss on both vessels. The action of accelerators is indispensable on the "BIO Hesperides".

Changes introduced by the optimizations are not significant over median RTT but can reduce extreme values.

The right selection of hardware is fundamental for successful implantation of this kind of communication systems to guarantee the quality of satellite links and for administrating the particularities of TCP/IP protocols for these links.

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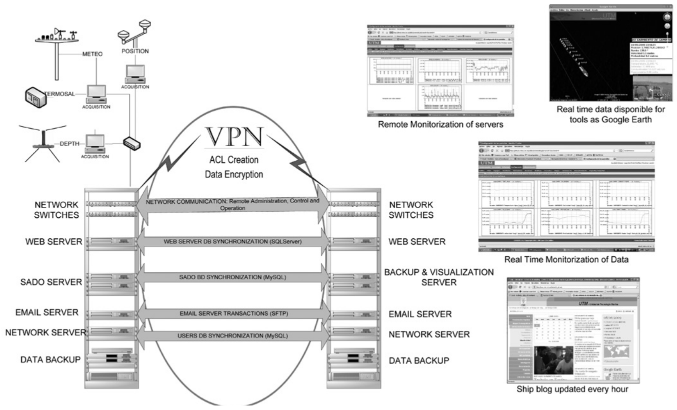

Figure 1: VPN allows remote control and operation of servers, and BD synchronization, supplying real time data for UTM web based applications.

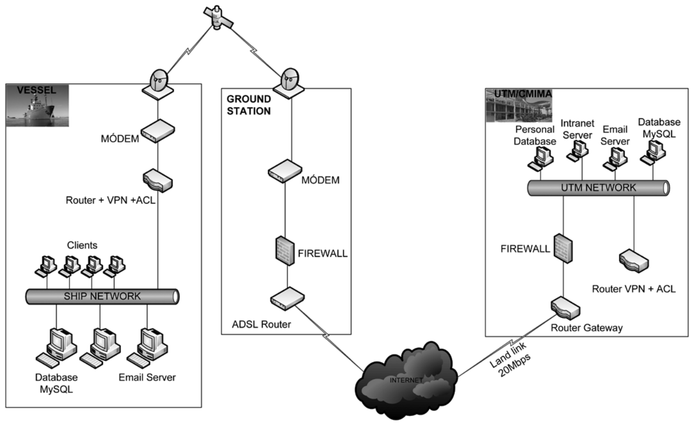

Figure 2: General schema of system communication on board "BO Sarmiento de Gamboa" and "BIO Hesperides"

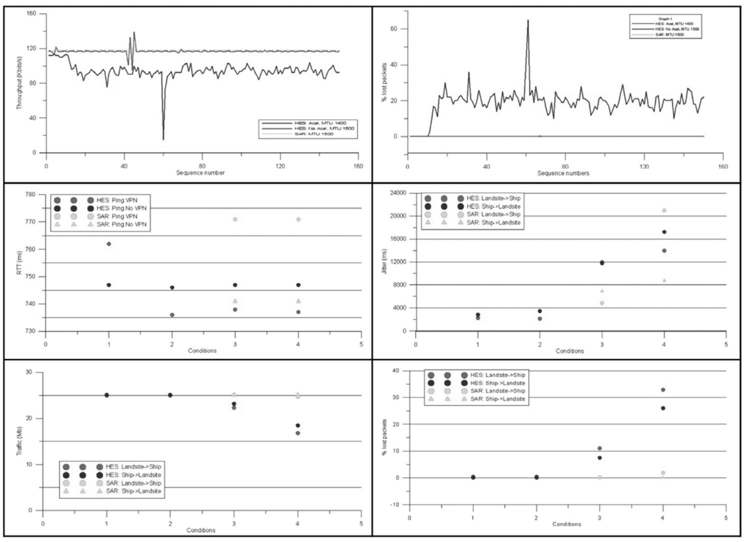

Figure 3: Results of test are showed below. In the first to graphics, we can see the improvement obtained when MTU value is set to 1400 on Hesperides. Throughput increases and percentage of lost packets decreases significantly. On next graphics, we can see the evolution of RTT, jitter, quantity of data transmitted and percentage of lost packets along four different conditions.

SMART SENSOR INTERFACE FOR SEA BOTTOM OBSERVATORIES

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Abstract - In order to be able to use all the marine sensors currently available in the market, a new module has to be built to implement the smart sensor standard IEEE-1451[1] as well as other services used in marine measurements. The smart module is aimed to be used in ALL observatory configurations: autonomous, cabled and buoy-based observatories. This module can also be used for low power data acquisition and control applications in new instrument design such as Ocean Bottom Seismometers (OBS) [3] or any other instrument where data logging, clock synchronization, and plug and play capabilities are important. Therefore, the power consumption of the smart module has to be minimized for batteries based observatories and autonomous instruments.

Keywords - Smart Sensor, Instrument Interoperability, IEEE1451, IEEE1588, OBS (Ocean Bottom Seismometer), Clock synchronization, Time stamping services

Smart Sensor project for sea bottom observatories is co-funded by Europole Mer www.europolemer.eu, ESONET and EMSO projects www.esonet-emso.org.

I. INTRODUCTION

Marine instruments commonly use RS232/RS422/RS485 as a communication interface to be connected with an observatory. The possibility to enhance the instrument capabilities and make it smarter is the objective of this development. Ifremer has been working in a preliminary hardware design of the smart sensor module, which has the capability of converting serial interface data into a low power Ethernet interface by adding several services such as: clock synchronization, time stamping, data logging, embedded instrument driver…. This way, all serial instruments (90% of the marine sensors) will be accessed through Ethernet protocol. At Technical University of Catalonia, the IEEE1451 and IEEE1588 [4] had been evaluated in order to be applied to marine instrumentation. Both works will contribute to the design of this module, which will provide IEEE-1451 output data for standardization and interoperability.

In order to use marine instruments in observatory, we have developed software layer that allows observers to communicate with instruments. In this context, we have proposed a language [2] to describe smart sensors in deep-sea observatory. It plays a major role since it provides necessary abstraction to use and interact with sensors.

II. SMART SENSOR BOARD CARACTERISTICS

The smart sensor design is based on a Stellaris LM3S8962/LM3S9B96 microcontroller from Luminary/Texas instrument[5]. This low power consumption microcontroller, with its internal peripherals, is the main core of the smart sensor board. The system is designed to have these features:

• Power supply input (network side)
  a. Power Over Ethernet (POE) from the network
  b. Battery power supply (VBAT 10V - 60VDC)
  c. Direct power supply from the network (10V - 60VDC)

• Power supply output (instrument side)
  a. Protected output with a resettable fuse
  b. Mosfet power switch for reducing the power consumption be tween data acquisition

• Data management and plug and play protocols
  a. IEEE-1451 Standard for a Smart Transducer Interface for Sensors and Actuators

• Network interface:
  a. Ethernet 100BaseT port compatible with POE (Power Over Ethernet)

• Instrument interface:
  a. Serial port (RS232, RS422, RS485) selectable by software, for the scientific instrument
  b. Bus CAN, I2C, SPI, GPIO, USB 2.0 On The Go (OTG),… if the smart board is used as a main controller in a new instrument design
  c. PPS (Pulse Per Second) output and NMEA (National Marine Electronic Association) Serial interface output for the time code

• Clock synchronization and time stamping services
  a. IEEE-1588 Precision clock synchronization protocol for networked measurement and control systems (PTP V2)
  b. Underwater GPS clock emulation (PPS+NMEA)
  c. Embedded time stamping services compatible with all existing instrument
  d. High accuracy clock from 3.10-6 to 3.10-8. TXCO (Temperature Compensated Crystal Oscillator) and MCXO (Microcomputer Compensated Crystal Oscillator including external clock: ex. Seas can MCXO)

• Memory Storage
  a. Up to 2*64GByte SDHC flash memory cards with software RAID-0, RAID-1 and JBOD capabilities
  b. Embedded generic file system or specific file system (Single File System, Fast File System,…)

• Additional features and services:
  a. Embedded Tiny Linux core system
  b. Power save modes and wake-up capabilities
  c. Peer to Peer communication between two Smart Sensor modules
  d. Synchronization of Biofouling protection system [6]
  e. UDP Server for transparent bi-directional data flow
  f. Web services
  g. FTP server
  h. Temperature sensor
  i. Vacuum sensor for measuring the vacuum inside the pressure housing before the deployment
  j. Expansion Bus for piggy back application

• Embedded Software modeling

We have proposed a language to describe smart sensors. One of the goals of this language is to model the network and to generate the software code that will be embedded in the network nodes to allow communicating with sensors. Our language describes a sensor by three levels:
• Static properties: like the location, the type, the battery power of the sensor…
• Interface: It allows observers to communicate with the sensor. It provides a set of services dedicated to physical measures that a sensor can do based on event detection. Each service is associated with events and can be obtained by invoking a set of operations or commands. The interface specification provides description of sensor events, provided services including operations (sensor commands) and parameters.
• Behavior: It indicates what the sensor can do. We have described the sensor interface behavior through an automaton, which is composed of a set of states and transitions, to indicate how and in which orders the provided services can be executed. This specification emphasizes the correlation between event reception and the invoked services. A deep-sea observatory operates on a long time period and smart sensor behavior must be sensitive to dedicated event to stop or start their observations synchronized with other smart sensors of the network. With this approach, the service interfaces are behavioral centric based on reception of real time events. We have extended this description to address the internal behavior of the sensor. It indicates how the sensor behaves during service processing. In this context, we must describe the behavior of each service included in the sensor interface. The service behavior indicates how and in

which order the service operations must be invoked. We have used a finite state machine to describe the service behavior.

This is the preliminary list of services drawn and it would be completed in the next meetings between the participating institutions. One smart module will be used for each marine sensor adding IEEE-1588 and IEEE-1451 capabilities to each sensor. PPS and NMEA data provide GPS emulation for autonomous observatories. In the case of unknown sensor data format, a UDP server for transparent time stamped data flow is used (non-smart link). The module in equipped with MOSFET switching components in order to power on/off other sensors and instruments between two data acquisition (power save mode) or if it requested by another instrument to avoid any conflict (lights, acoustic, electrolysis system such electronic biofouling device…). Flash memory cards (up to 2*64 GB) are used to store data if the link between seafloor observatory and shore station is a temporary connection (satellite link) or accidentally damaged. Moreover, autonomous observatories and autonomous sensors will store data on the flash memory cards. The smart module can be powered through the marine cable (POE or a separate power supply provided by the cable) or through a battery pack (VBAT). Figures 1,2,3 show the architecture, the services and a block diagram of the smart module under design. Pictures 4,5 show the top view and the bottom view of the smart sensor board.

This smart sensor module is based on the Stellaris® Luminary (Texas Instruments) LM3S8962/LM3S9B96 [5] microcontrollers which integrates hardware-assisted support for synchronized industrial networks utilizing the IEEE 1588 Precision Time Protocol (PTP) V1 and V2. The Stellaris® LM3S9B96 microcontroller is based on the ARM® Cortex™-M3 controller core operating at up to 80 MHz, with 256 kB flash, 96 kB SRAM and ROM . Addition of external memory will increase the power consumption, therefore we have decided not to use external memories unless is absolutely necessary. The manufacturer provides many code examples and also applications. PTP IEEE1588v2 clock synchronization is based on the Zurich University of Applied Sciences (ZHAW- development [7]. Tiny Embedded Linux implementation will be based on Unison Operating System from RoweBots [8]. However this application needs to be ported to the target LM3S8962 microcontroller [5].

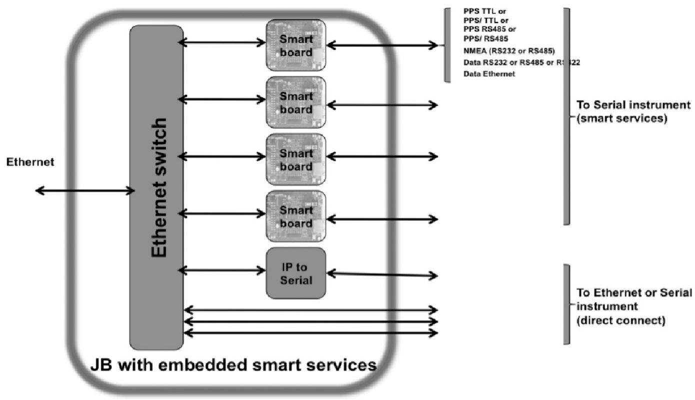


Figure 1: Junction box architecture with Smart Boards

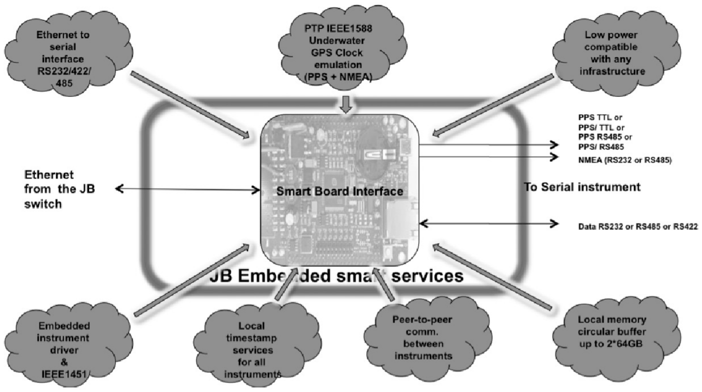


Figure 2: Smart sensor module services

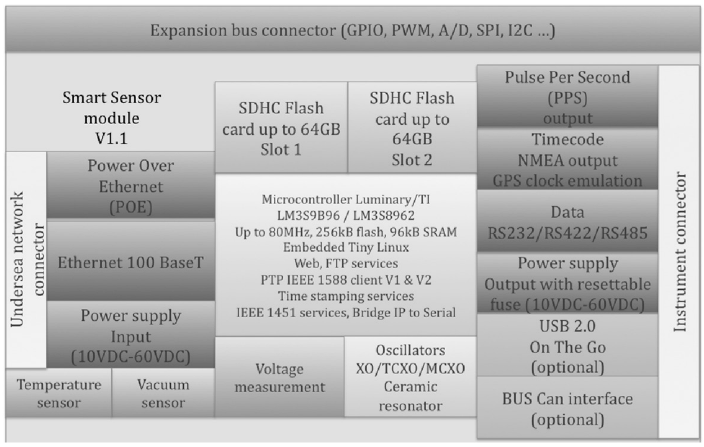
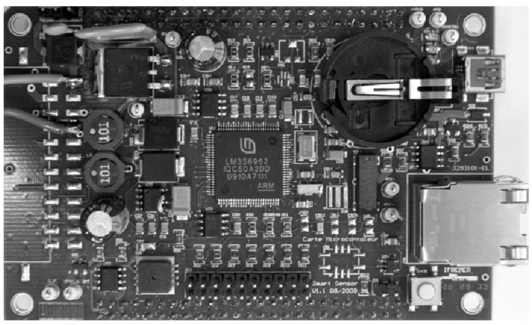


Figure 3: Block diagram of the smart module

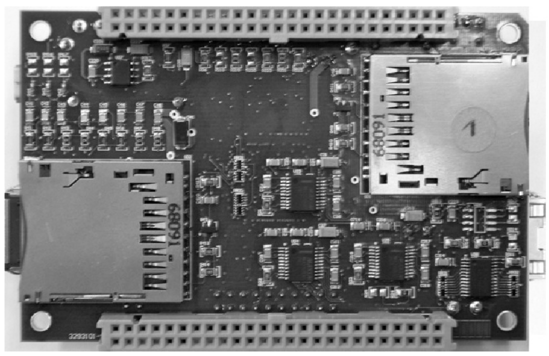
III. STANDARDS DESCRIPTION

The complete IEEE-1451 implementation can be very memory consuming, therefore we have decided to implement a simplified IEEE-1451 version on-board and use a standard Linux board (PC104, Coldfire, etc.) installed in the junction box for IEEE-1451 complete implementation. This is useful for autonomous observatories and in the case of a cable cut in the case of cabled observatories. For cabled observatories, a PC in the shore station also has to implement the complete IEEE-1451 standard. As the smart module has the size of a credit card, it can easily be integrated in the existing observatories in 3 different ways:

- Installed inside the sensor: In this case, the sensor connector on the junction box has to be Ethernet compatible.



Picture 1: Smart Sensor Board V1.1 – Top view



Picture 2: Smart Sensor Board V1.1 – Bottom view

- Installed inside the seafloor cable: In this case, the sensor connector on the junction box has to be Ethernet compatible.
- Installed inside the junction box: In this case, the junction box has to include the smart module before the deployment.

The following metadata are decided to be included in the smart board:

TEDS (Transducer Electronic Data Sheet):

- Manufacturer name
- Model number
- Serial number
- Code version
- Sensor type
- Sensitivity
- Bandwidth
- Owner
- Last calibration date
- Geo-location (water depth, longitude, latitude)

Configuration parameters:

- Number of channels
- Channel measurement type
- Measurement unit
- Parser parameters: Channel, frame length
- Pull command
- Push command
- Event: minimum and maximum values for every channel

For IEEE-1451 standard implementation, it is necessary to define the different commands that are needed for sensor data acquisition. Today, commands as Start sensor, Stop sensor, Change Sampling rate and Standby mode are needed in order to prevent interference between many sensors operating at the same time. For example, LEDs of an underwater camera have to be turned off for optical sensors to operate correctly. These commands have to be implemented for each sensor according to IEEE-1451 Standard. It is planned to include a parser script in the configuration data that implements the sensor commands providing transparency to the scientists. Currently UPC is collaborating with the NIST (National Institute of Standards and Technology) in the implementation of the IEEE-1451 standard. The commands that have not been defined by the standard will be developed in near future.

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ELECTRONIC UPGRADES ON THE SECOND GENERATION OF AN AUTONOMOUS AND PORTABLE CETACEAN AUDITORY SCREENING SYSTEM

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Abstract - While noise is now considered a marine hazard that can directly affect cetaceans and induce a stranding, no clinical approach has yet introduced the detection of a possible hearing loss at a stranding site as a necessary practice. Here we present the second generation of an autonomous and portable auditory screening system for cetacean clinical and research purposes. This system is composed by two independent and autonomous modules that build a more versatile, lighter and interference isolated system. The improvement relies on the isolation between modules and their independency on many situations. The system is separated in two modules. The first one contains the low voltage biopotential amplification system and the acustic signal transmiter . The second module will activate only when needed for some frequencies and levels driving high voltage to the transducers thus avoiding interferences with the first module containing the low voltage amplifications system. The tool has been successfully tested for research purposes in captive dolphins and calibrated for a stranding site diagnoses operation.

Keywords – Auditory Evoked Potentials, cetacean, auditory screening

I. INTRODUCTION

Acoustic trauma and other noise related lesions have now been added to the list of potential causes of cetacean stranding [1][2]. A first generation of an Auditory Evoked Potentials autonomous acquisition unit was developed to help decision taking by testing on site the hearing functionality of stranded animals [3]. The evolution of that first generation system is presented featuring higher transducing capabilities while minimizing noise interferences, size and weight. The system is separated in two modules: a low voltage and a high voltage unit (Fig 2). The main module, the Low Voltage Unit features extra security that eliminates the presence of high voltages in the system that could generate hazards to patient/user from power leaking. It also includes a Transducer Signal Amplifier, designed for capacitive loads that ensures enough current driving capacity while it shows a strict stability, overheading the limitations given by the NI-6062E card with a 48V and 240mA driving power. The attenuator is integrated in the system allowing an accurate attenuation of the output level followed by a transient filtering system to avoid high level clicks at start-up. This is of extreme importance as pulse due to manual changes in the system configuration could cause injuries or stress to the diagnosed animal. Visual and electronic feedback of the voltage drived to the transducer is monitored through the data acquisition card (PCMCIA format) and visually displayed in an analog indicator allowing a fine calculation of the levels emitted through the software interface and providing analog visual information to the user. The electrode connectors feature full IP67 protection with no electromagnetic discontinuity in the case cover avoiding possible interferences due to shield discontinuities. The electrodes are gold plated, embedded in a suction cup with mechanical protection against sudden pulls out or swim away behaviors that often happen in captive animals. The system is thought to be improved though: it has therefore been designed in a modular way that allows an easy replacement of the integrated boards in case of failure or a need of upgrading.

The secondary High Voltage Unit features a switching power supply providing noise leakage minimization via physical separation of the two units. This system is ready to work only in case it is needed (Fig 2.), when high levels are required, e.g. in the case an animal presents a severe hearing loss at a certain frequency band. The use of different transducers, depending on their sensitivity in the high frequency band, minimizes the need of frequently requesting this high voltage unit.

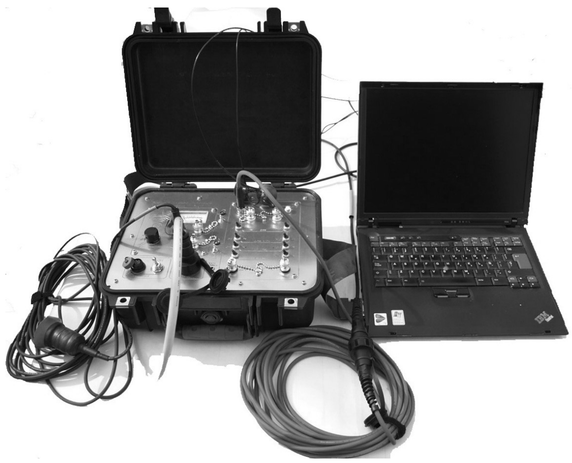

Fig.1 Complete assembly of the low voltage system

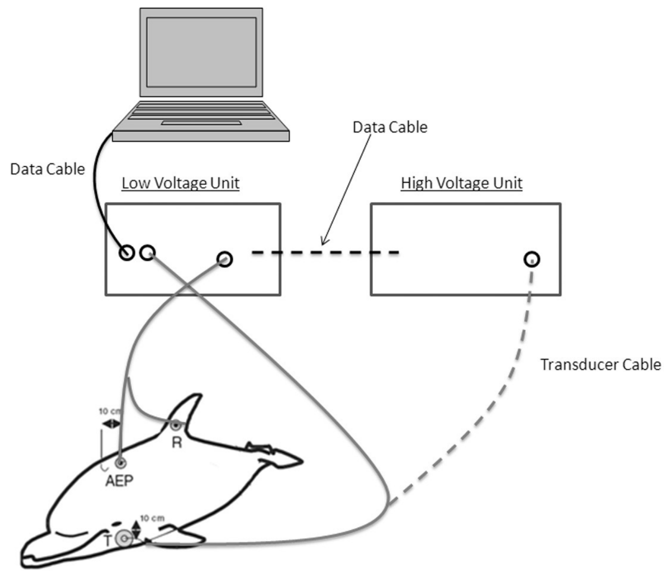

Fig.2 Complete system. Dashed lines indicate the connections between the modules when the High voltage unit is needed

II. CONCLUSION:

This portable system is more stable, independent and noise isolated than its previous first version. It's small size and small weight allows an easy carriage and maneuver.

III. ACKNOWLEDGEMENT

The Integrated boards where designed with the help of Carolina Migliorelli and Regina Solé from the Signal Theory and Communications Department at the UPC. Our thanks go to Klaus Lucke for helping to provide the material for the mounting of the measurement electrodes.

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MODELING THE UNDERWATER NOISE ASSOCIATED TO THE CONSTRUCTION AND OPERATION OF OFFSHORE WIND TURBINES

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Abstract – The operation and in particular the construction of offshore wind converters induce considerable underwater noise emissions. It is assumed that small whales and seals can be affected by noise from machines and vessels, piling and installation of the wind turbines. Piling, in particular using hydraulic hammers creates impulsive noise with considerable high energy levels. Currently, only little knowledge about the effects of different noises to marine life is available. Here, we present the objectives of the ongoing project of the Laboratory of Applied Bioacoustics (Technical University of Catalonia): to simulate the generation, radiation and propagation of underwater noise; to develop forecasting hydro sound models of offshore wind converters and future noise reduction methods during pile driving; to determine the impact area of offshore wind farms; to allow the formulation of recommendations for acoustic emission thresholds; and to develop standard procedures for the determination and assessment of noise emissions.

Keywords – Offshore wind farm, pile driving, underwater noise.

I. INTRODUCTION

Several control measurement campaigns have been conducted during construction of several wind farms in Europe, specially in Great Britain and Germany [1] [2], but the lack of accurate models on sound generation and propagation in shallow water scenarios and on the scientific evidence of the effects on marine life prevents to make a decided call for legislation on mitigation mechanisms, maximum levels, safety distances from specially sensitive areas, etc. We propose to develop propagation models to assess the structural and environmental radiating noise directly produced by the construction and operation of wind turbines.

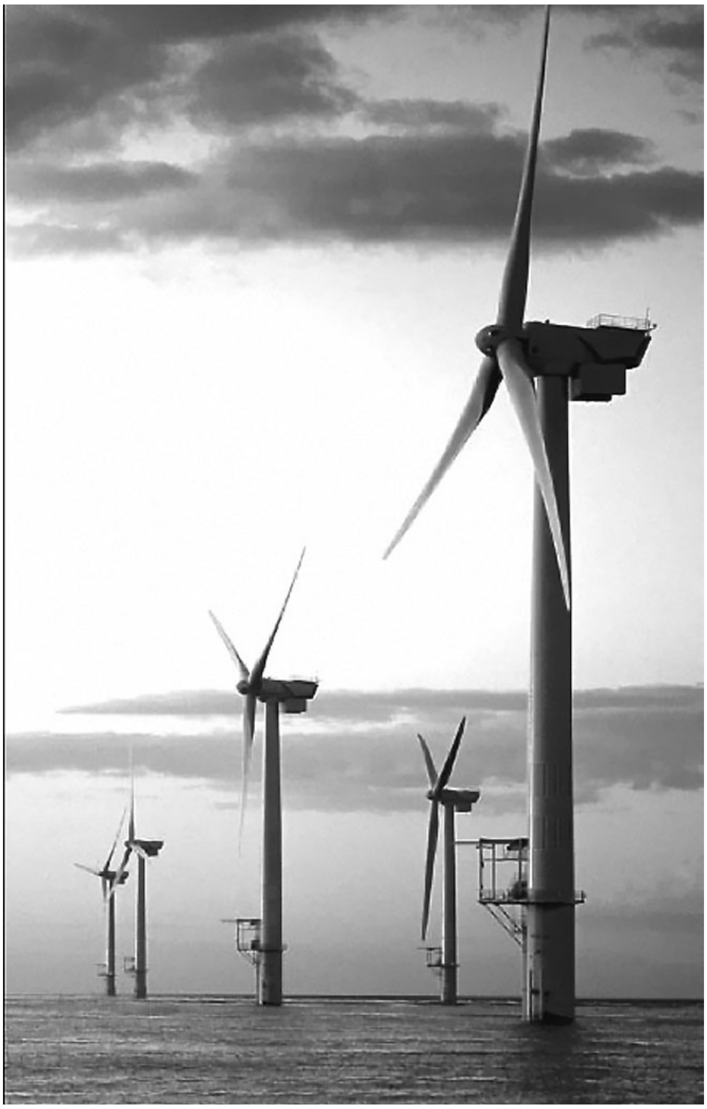
II. PILE DRIVING

Wind turbines are usually anchored to the sea bed with cylindrical steel piles that are held in place by vibration or impact hammers. The impact of these hydraulic hammers during the piling process introduces a significant acoustic energy that propagates into the marine environment and, as do other high intensity sources, may affect marine organisms [3] [4]. The structural vibration induced can be modeled using finite element simulation (FEM). For the environmental noise induction and propagation, other methods like boundary element simulation (BEM) or multipole expansion (FME) can be better suited. Long-range propagation of sound must also be simulated accounting for the complex waveguide-like scenario of the shallow waters where wind farms are constructed (wavenumber integration methods).

In order to obtain reliable results from numerical simulations of the complex mechanism of generation of transient signals and radiated noise, it is necessary to know the impact force applied to the system over time and the response of the pile at this impacts. One of the characteristics of the hammer is the maximum impact energy (for instance a hammer IHC 250 piles of 1.5 m for the maximum energy is 280 kNm). Based on experimental measurements provided by accelerometers installed in existing wind farms, one can provide the maximum power to set the input function into the simulation program. Once the data of the sound source is characterized, the use of numerical models must serve for predicting the level of noise produced by the hammer impact at any point in space.

III. WIND FARM OPERATION

The noise generated by the routine operation of the mills will also be simulated using wave propagation algorithms in shallow waters, allowing the estimation of the noise radiated from an hypothetical number of different elements (Mills) and a variety of environments. In terms of sound levels, the last process is crucial to advise on the noise introduced in the environment and accordingly decide on the maximum number of elements that would compose a sustainable wind-farm field. The very specific shallow water (less than 20m) scenario, where the effects of reflections from surface and bottom can be assessed and the structure of the problem is roughly constant over distance a propagation model based on wavenumber integration or normal mode analysis with multiple sources can be performed.



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A 3-D REAL-TIME ALGORITHM BASED ON ARRAY PROCESSING FOR THE LOCALIZATION OF CETACEANS

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Abstract - Hydrophone arrays permit to localize populations of cetaceans in real-time so as to study their behaviour in a non-invasive way and to work on their conservation. The most commonly used method based on time-difference-of-arrival can be challenged by space-time methods which can locate several simultaneous sources and separate them spatially.
This paper documents some results obtained qua bearing estimation of vocalizing mammals using a three-dimensional array with 4 hydrophones and various space-time methods such as the Capon and Music estimators.

Keywords - acoustic source localization, MUSIC, Capon, beamforming, bioacoustics, ocean acoustics, cetaceans

I. INTRODUCTION

Passive localization is a powerful and non invasive tool for biological and behavioural study, especially for the conservation of marine mammals. In the realms of the LIDO (Listening to the Deep-Ocean Environment) project with the underwater Nemo Station located offshore the Sicilian port of Catania at 2000m depth, more than 2000 hours of underwater recordings were gathered to be used for real-time passive detection of cetaceans based on their sound emissions. This requires a frequently updated and consistent three-dimensional estimation of their location under severe constraints such as extracting useful information from short duration broadband and directional signals buried in long sequences of evenly directional noise.

II. METHODS

Literature reveals that the prominent method for marine mammals' localization does not rely on STM but rather on a combination of time-difference of arrival (TDOA) estimation and geometrical exact solutions to provide an estimate of the position of the marine mammals. On the contrary, space-time methods such as beamforming or high resolution methods [2, 3] have been scarcely used though they have been applied with success in the field of digital communications, and even though they were actually created for underwater applications such as sonar.

After a pre-processing phase [5] which firstly detects cetacean and boat clicks and secondly provides their estimated time position, several methods, both in the TDOA and the STM class were tested and compared.

In the STM class, a Capon beamformer and a Multiple Signal Classification (MuSiC) estimator were computed. MuSiC is based on a data classification of the incoming signal into signal and noise subspace via a decomposition of the Space Covariance Matrix. The algorithms were run on short sequences (from 900 to 2000 samples) which theoretically lessens robustness but permits to separate direct and reflected path.

For real time purposes, the search space of the algorithm was reduced. Instead of finely examining the whole 3-D space, the estimation is firstly carried out for a bearing (both azimuth and elevation) with large 10 degrees steps. When a bearing is found to be redundant for several clicks, a more refined search is computed in a +/- 10 degrees zone around the first bearing estimation. Hence, the explored space is 70 % smaller than that for a 1 degree step. Using a 0.5 degree step in the refined search would still represent a 50 % decrease. This reduction, permitted by STM, makes the calculation time suitable for real-time implementation.

III. RESULTS

Our estimation was made on several sequences of recordings of five minutes containing sperm whale clicks.

It featured sharp peaks (fig.1) corresponding to a coherent series of slowly varying bearings possibly indicating motions of the animals.

On the whole, performed simulations show that applying the MuSic algorithm can provide consistent clustered estimates of bearing which can then be used for the spatial separation of several sources and their tracking based on the evolution of the estimated location.

Besides giving useful information on the source position and the position of the main reflections, the Capon beamformer also provides useful information regarding the spatial spreadth of underwater noise and its space-time variation. It was noticed that background noise is far from being evenly spread in space and has remarkable directionality.

IV.DISCUSSION & FURTHER WORK

These results could be compared to or combined with time-delays of arrival estimation in order to confirm that the bearings are correct enough and to obtain range estimation.

Indeed, TDOA estimation methods and STM do not have to be opposed; further work aims at merging the information coming from both methods [1] while maintaining low computational costs. Regarding real time-duties, it is foreseen that computation time could be reduced by optimizing the size of the search space via adaptive filtering.

Finally, reducing the selectivity of the detection phase in order to include reflections could facilitate the localization of sperm whales in terms of range which is yet missing.

V. ACKNOWLEDGEMENT

This project is funded under the European Commission contract FP6-2005-Global-4 - ESONET 036851-2. The LIDO consortium is formed by: Universitat Politècnica de Catalunya (UPC); Instituto Nazionale di Geofisica e Vulcanologia (INGV); Instituto Nazionale di Fisica Nucleare (INFN); Consejo Superior de Investigaciones Científicas (CSIC); Tecnomare; dBScale; Universidade de Lisboa (UL); Centro Interdisciplinare di Bioacustica e Ricerche Ambientali (CIBRA); Consiglio Nazionale delle Ricerche (CNR); Technische Universität Berlin (TUB); Zentrum für Marine Umweltwissenschaften (MARUM).

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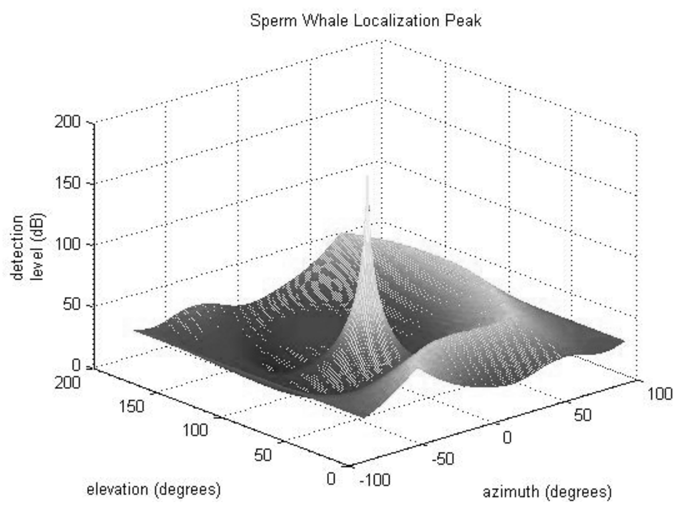

IMAGING TECHNIQUES TO STUDY THE EFFECTS OF LOW FREQUENCY SOUNDS ON CEPHALOPODS SPP.

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Abstract - The introduction of artificial sound sources in the marine environment has shown to have negative effects on marine organisms. While marine mammals have attracted most of the attention of the research conducted in that area, invertebrates are also suspected to be negatively affected after an exposure to loud low frequency noise. An ongoing study from the Laboratory of Applied Bioacoustics of the Technical University of Catalonia is studying through imaging techniques (routine histology and SEM) the possible lesions in the statocysts of three cephalopod species (Sepia officinalis, Loligo vulgaris and Octopus vulgaris) as the likely most sensitive organ to high intensity noise.

Keywords - cephalopods, noise, statocysts

I. INTRODUCTION

Between September and October 2001 and in October 2003 the natural rhythm of annual records of giant squids (Architeuthis doge) in the area of the West coast of Asturias, experienced a significant increase [1]. In both cases the stranding and collection of the bodies were related to the proximity of vessels using compressed air guns for geophysical prospecting, producing sound waves of low frequency (below 100 Hz) and high intensity (200 dB re 1 µPa at 1m per airgun).

Some of the specimens had lesions in different tissues and organs, but all presented pathologies in the gills and the receptor of equilibrium or statocists.

Because none of these lesions could be related to known causes of death, the presence of geophysical prospecting vessels suggested that the death of these animals could be related to effects produced by sound waves. However, no further study addressed this problem and the doubt remained on how and if high intensity low frequency pulses could negatively affect cephalopods.

A comprehensive study was therefore needed to assess the direct effects of the acoustic impact on these species. The first step was to choose which organ, found in all cephalopods spp. could be an indicator of noise-induced damage. Amongst other less sensitive-to-noise tissues, the statocysts are presumably the best candidates to injury if exposed to loud sources. All cephalopods have a couple of statocysts generally located within the cephalic cartilage. The statocysts are sophisticated balloon-shape bodies that present two layers of epithelial tissue (inner and outer) separated by a layer of connective tissue, and include two receptors: the macula-statolith system and the crista-cupula system. The macula indicates the changes in the position according to the gravity and the linear acceleration, while the crista indicates changes in the angular acceleration. These systems are analogous to the vestibular system of the inner ear of vertebrates. However, unlike ciliated cells of the latter, the cephalopods' are quinocilis. The adjacent accessory structures (macula/statolith, crista/cupula) are responsible for the sensory perception. When there is a stimulus, these structures cause tiny deflations in the cilia groups, which in turn stimulate the ciliated cells that transmit the information to the sensory nervous system. Within the central nervous system, the sensory input of the statocysts is used to regulate a wide range of behaviours, including locomotion, posture, control of eye movement and of the pattern of the body coloration [2].

The aim of this ongoing project of the Laboratory of Applied Bioacoustics (Technical University of Catalonia) is to try to experimentally reproduce the sound exposure scenario that took place in Asturias and make a thorough analysis of possible lesions associated to low frequency sources in individuals from three different species of cephalopods (Sepia officinalis, Loligo vulgaris and Octopus vulgaris) by imaging techniques (histology and electron microscopy, SEM). Here we present the first SEM images that were obtained from control animals.

II. MATERIAL AND METHODS

Species

Adult and juvenile specimens from Sepia officinalis, Loligo vulgaris and Octopus vulgaris were taken from the wild and kept in a structure consisting of 2 mechanically filtered tanks PRFV of 2000L capacity, connected to each other. This included a physicochemical self-filtration with activated carbon and sand, driven by a circulation pump and filtration.

Dissection, fixation and removal of tissues

10% of the individuals were sacrificed prior to the application of acoustic pulses (the noise exposure protocol that was applied to the samples is not shown here. It included a ramp-up procedure using increasing frequencies and levels) and a routine necropsy [2,3,4,5] was conducted, collecting samples of different tissues, which were further fixed in formalin 10%. These sample animals were to be used as control tissue for histological assessment and the identification of possible affected organs: mantle, and radial muscle fibres in the two inner collagen tunics surrounding mantle muscle, various organs of the digestive tract-blind digestive gland, branchial hearts, gills and ovary.

The statocysts were also extracted but fixed with Glutaraldehyde 2,5% for posterior observation and analysis in SEM.

III. RESULTS

The systematic comparison of the histological preparations obtained from exposed individuals with control animals affected by acoustic pulses did not yet allow us yet to determine whether there were injuries associated with exposure to sound in any of the tissues analyzed.

The analysis of the statocysts showed the regular arrangements of kinocilliary groups of different hair cells that are thought to be the structures likely to be affected by high intensity sound exposure.

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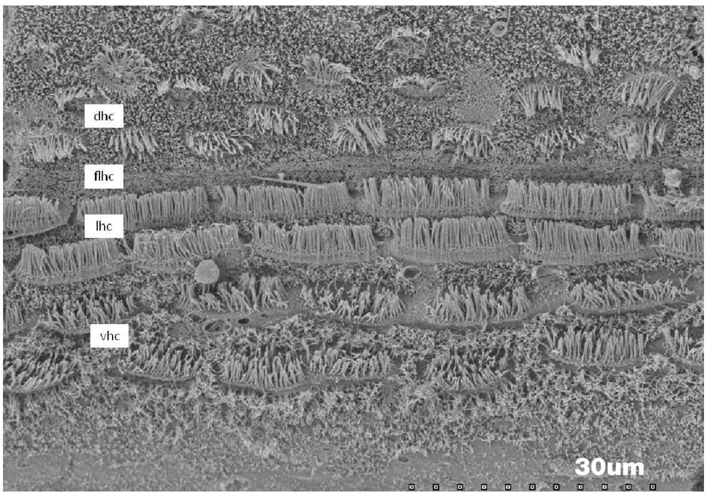

Fig. 1 - Crista of* Octopus vulgaris*, showing the arrangements of the kinocilliary groups of different hair cells. Small dorsal primary hair cells (dhc), regular row of fairly large (flhc), large secundary hair cells (lhc), small ventral secundary hair cells (vhc)

CETACEAN ULTRASTRUCTURAL COCHLEAR IMAGING THROUGH SCANNING ELECTRON MICROSCOPY

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Abstract - The control of noise interaction between artificial and biological sources is essential to assess the development of sustainable marine technologies. Therefore, there is an emergent need to conduct morphological analysis of the acoustic pathways of marine organisms and detect possible structural alterations as a consequence of sound exposure. Cetaceans, because of their use of sounds in their daily activities, represent today the best bioindicators of the acoustic balance of the oceans. To access this information it is necessary to extract the ears of very fresh stranded individuals. One of the challenging steps after extraction and fixation of the samples is to decalcify the bone envelope to access the cochlea without damaging the soft tissues. A fast commercial decalcifier (RDO®) was used in 93 ears from 11 different odontocete species stranded in the Mediterranean Sea, the North Atlantic and the North Sea. Depending on the tympanic-periotic volume of the species, the decalcification time ranged from several hours to a few days, instead of taking few months with other decalcification agents, allowing a subsequently faster observation of the cochlear structures. Here we present images from cetacean cochlear ultrastructure through scanning electron microscopy. Following this protocol it is possible to obtain a fast diagnostic of possible acoustic trauma and relate the results to documented sound exposure. The output of this analysis will help calibrating theoretical results derived from deep-sea observatories.

Keywords - Decalcification, noise pollution, cochlea, ultrastructure, scanning electron microscopy

I. INTRODUCTION

While there is an increasing human pressure on the oceans, very little is known about the effect of underwater noise on marine organisms. Because of their vital dependence on acoustic information and their role in the food chain as top predator, the study of the effects of noise on cetaceans (Mammalia, Cetacea) has recently become ecologically essential [1]. Although some of these effects can be found in organs not directly related to the acoustic pathways [2], other lesions are expected to affect hearing, particularly the organ of Corti and its associated hair cells [3]. The problem relies in accessing fresh samples and in determining the relationship between a pathological change in the cochlea morphology and a possible sound exposure. Moreover, basic morphological and comparative descriptions of the cetacean ears are still lacking, probably because of the difficulty in obtaining suitable material, and a reliable protocol for analysis.

A detailed description of the cochlea morphology was presented for Tursiops truncatus [4, 5, 6] and studies of the basilar membrane and osseus spiral laminae in different odontocete species have been conducted to compare their hearing capabilities [7, 8, 9]. Despite of these early findings in a limited number of cetacean species, little data are available to comparatively describe inner ear structures. Stranding events may represent a unique opportunity to help building knowledge on cetacean hearing morphology and potential sensitivity when exposed to noise.

II. METHODOLOGY

Decalcification

Ninety three (93) ears from 11 different odontocete species that stranded in the Mediterranean Sea, Spanish North Atlantic and North Sea have been extracted. Specifically, the species processed were: Phocoena phocoena (n=48), Stenella coeruleoalba (n=13), Stenella frontalis (n=13), Tursiops truncatus (n=8), Delphinus delphis (n=2), Kogia simus (n=2), Kogia breviceps (n=2), Globicephala macrorhynchus (n=1), Globicephala melas (n=1), Steno bredanensis (n=2) and Lagenodelphis hosei (n=1).

After extraction, the samples were fixed with 10% buffered formaline or 2,5% glutaraldehyde and used subsequently to precisely determine the decalcification time with different concentrations of RDO®. RDO® is a rapid decalcifier based on hydrochloric acid (Apex Engineering Products Corporation, Aurora, Illinois, USA). Specifically we tried with 100% RDO®, 80% RDO® (diluted with 80% ethanol), 75% RDO® (diluted with distilled water) and 50% RDO® (diluted with distilled water and changing the media after 24h by or 50% RDO® or 25% RDO®, also diluted with distilled water).

Scanning Electron Microscopy (SEM)

Twenty three very fresh ears from Stenella coeruleoalba (n=14), Stenella frontalis (n=4), Tursiops truncatus (n=1), Delphinus delphis (n=1), Lagenodelphis hosei (n=1), Globicephala melas (n=1), Ziphius cavirostris (n=1) have been processed for the observation through SEM using the facilities of CRIC (Montpellier) and the Universitat Autònoma de Barcelona (UAB).

III. RESULTS

Following a routine protocol with a specific dilution of RDO®, the odontocete ear decalcification time ranged from several hours to a few days, depending on the tympanic-periotic volume of the species [10]

Some of the samples observed with SEM presented an advanced necrosis stage and it was not possible to identify the ultrastructure of the organ of Corti, but in the fresher samples we could identify the outer hair cells prints on the tectorial membrane.

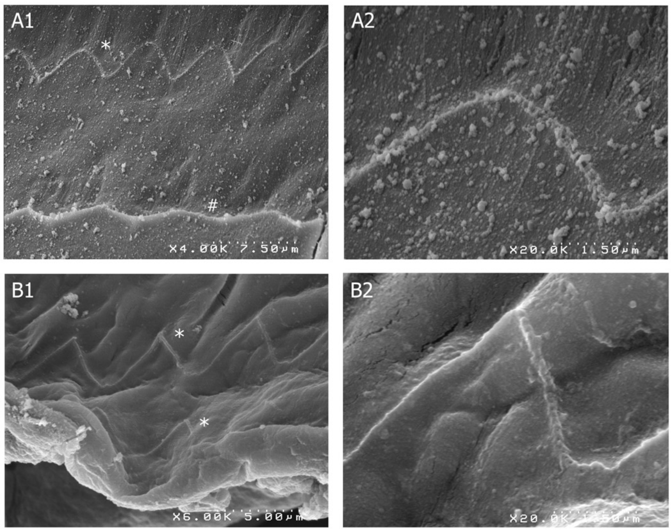

Fig. 1. SEM images of the tectorial membrane of a A) Delphinus delphis in 4.00k and 20.00k magnification and B) Stenella coeruleoalba in 6.00k and 20.00k magnification. In A1 and B1 are highlighted the position of the outer hair cells rows (*) and Hensen Stripe (#) while in A2 and B2 it is possible to observe the outer hair cells stereocilliae prints

IV. DISCUSSION

Following this protocol it is possible to obtain a fast diagnostic of possible acoustic trauma and relate the results to documented sound exposure, although further studies should be done with fresher and better conserved and fixed ears. The preliminary results presented here represent a step forward in the inner ear ultrastructural morphology study. The output of this analysis will help calibrating theoretical results derived from deep-sea observatories.

V. ACKNOWLEDGEMENTS

We would like to thank the Generalitat de Catalunya, the technician Chantal Cazevieille (CRIC, Montpellier), Manel López-Bejar (UAB), our colleagues and the stranding organizations who helped us collecting the ears, especially Paco Toledano (PROMAR), Alfredo López and María Llarena (CEMMA), Marisa Ferreira and José Víctor Vingada (SOCPVS), Beatriz González (Fundació CRAM), Encarna Gómez (Biologia Animal-Vertebrats, UB), Willy Dabin (U. of La Rochelle), Mardik

Leopold (IMARES) and Kees C. J. Camphuysen (Royal NIOZ).
This study was funded by the Spanish Ministry of the Environment under contract 083/SDGTB/2007

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REAL TIME CLASSIFICATION OF SPERM WHALE CLICKS AND SHIPPING IMPULSES FROM FIXED OCEAN OBSERVATORIES.

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Abstract - The automated acoustic detection of cetaceans in real time is an important tool to study their behaviour and distribution and for activating mitigation measures in the context of harmful anthropogenic activities at sea. Acoustic data from the NEMO ONDE deep sea observatory (Sicily) indicated that sperm whale clicks were present in 15 % of the recordings and impulsive ship noise in 10 %. The ship noise poses a serious challenge to the detection of sperm whale clicks, since it is an important source of false positives. As part of an integrated classification system, we present a classification module aimed at the automated and real time classification of impulses from sperm whales and shipping. The achieved classification performance indicates that it reliably separates a large proportion of sperm whale clicks from shipping impulses.

Keywords - Signal processing, bioacoustics, ocean observatories, shipping noise.

I. INTRODUCTION

The automated acoustic detection of cetaceans in real time is an important tool to study their behaviour and distribution in the field and for activating mitigation measures related to human activities that are potentially harmful to them. However the classification in a fully automated way is challenging due to the diversity of acoustic events and background noises. Acoustic data from the NEMO ONDE deep sea antenna (-2000 m) indicated that impulsive ship noise was present in 10 % of the recordings and sperm whale clicks in 15 %. The ship impulses pose a serious challenge to the detection of sperm whale clicks, since they often share similar time frequency properties and hence could be the cause of many false positive detections.

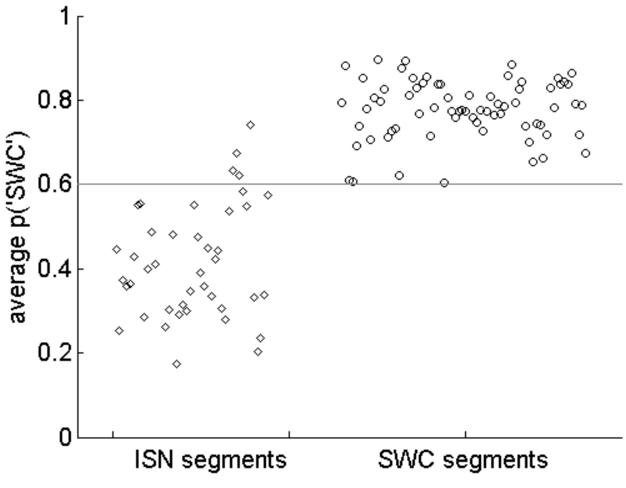
As part of an integrated classification system, we present a classification module for the automated and real time classification of clicks from sperm whales and click-like sounds produced by shipping. The system also addresses the classification of other acoustic events (e.g. cetacean calls, ultrasonic cetacean clicks, tonal sounds from ships), which are not discussed here.

II. METHODS

The data used to assess the module's accuracy consisted of 42 and 70 segments containing Impulsive Ship Noise (ISN) and Sperm Whale Clicks (SWC) respectively. These segments have been chosen manually from data recorded at the NEMO ONDE deep sea observatory between 6 and 20 of May 2005.

The module is composed of two stages: The first stage, detects segments that contain mid frequency impulses and returns their location. The second stage only processes segments that contain a sufficient number of mid frequency impulses. It first extracts a set of features, which describe the temporal and spectral shape of each impulse. Then, it uses a feed forward neural network that returns, for each impulse, an estimated probability of being a Sperm Whale Click, p(SWC).

In order to assess the classification accuracy, a cross validation was performed, where data from an entire day was left out for testing and the remaining data used to train the neural net.



(right) Fig. 1. The predicted probability of being a Sperm Whale Click p(SWC) has been averaged for each segment and is plotted as diamonds (ISN) and circles (SWC). For illustration a possible decision threshold is drawn at p = 0.6.

III. RESULTS

In order to obtain a decision value representing the whole segments, the average of p(SWC) was computed for each segment (Fig. 1). When a threshold is set at $p = 0.6$, such that all SWC-segments were correctly classified, 4 out of 42 ISN-segments were falsely predicted to contain SWCs.

IV. DISCUSSION

The first stage detects segments containing SWCs but also many segments with ISN. Therefore this detector cannot be used as a proper SWC detector. Its main usefulness is to selectively return a reduced volume of data to the second stage, which divides the data into SWCs and ISN. The classification obtained from long data series could be used to estimate the relative changes in sperm whale presence around an observatory.

V. ACKNOWLEDGEMENT

This project is funded under the European Commission contract FP6-2005-Global-4 - ESONET 036851-2. The LIDO consortium is formed by: Universitat Politècnica de Catalunya (UPC); Instituto Nazionale di Geofisica e Vulcanologia (INGV); Instituto Nazionale di Fisica Nucleare (INFN); Consejo Superior de Investigaciones Científicas (CSIC); Tecnomare; dBScale; Universidade de Lisboa (UL); Centro Interdisciplinare di Bioacustica e Ricerche Ambientali (CIBRA); Consiglio Nazionale delle Ricerche (CNR); Technische Universität Berlin (TUB); Zentrum für Marine Umweltwissenschaften (MARUM).

AN AUTOMATED, REAL TIME CLASSIFICATION SYSTEM FOR BIOLOGICAL AND ANTHROPOGENIC SOUNDS FROM FIXED OCEAN OBSERVATORIES.

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Abstract - The automated, real time classification of acoustic events in the marine environment is an important tool to study anthropogenic sound pollution, marine mammals and for mitigating human activities that are potentially harmful. We present a real time classification system targeted at many important groups of acoustic events (clicks, buzzes, calls, whistles from several cetacean species, tonal and impulsive shipping noise and explosions). The achieved classification performance indicates that the system will be useful to pre-process the very large data volume that can be gathered during long term acoustic monitoring campaigns or to detect the presence of cetaceans in real time for mitigation.

Keywords - Signal processing, ocean acoustics, bioacoustics, ocean observatories.

I. INTRODUCTION

Passive acoustic monitoring (PAM) of the marine environment has important applications for the study and monitoring of marine mammals and to understand how anthropogenic sounds affect marine life. PAM can be implemented continuously and over extended time periods, thereby enabling the recording of large and representative datasets. However, PAM campaigns inevitably result in a high rate of audio data acquisition. This can be problematic when the data needs to be transmitted, stored and analysed.

In case of continuous and long term PAM from fixed ocean observatories, it is generally expected that long sections of the data stream may not contain any acoustic events of interest. It is then desirable to automatically identify the interesting sections of the data.

The automated detection of a particular acoustic event in the marine environment is challenging for many reasons: (1) The large baseline level of background noise reduces the ability to detect weak acoustic events with a reasonably small false positive rate. (2) The intensity and the spectrum of the background noise is generally variable over time periods of hours or even minutes due to changes in sea state or local anthropogenic activity. (3) The occurrence of non-targeted events may falsely trigger a detector or, conversely, suppress the detection of a targeted event. (4) Targeted events such as cetacean vocalisations and sounds from shipping are very variable per se.

II. METHODS

The detection system is composed of two stages: The first stage, made of several detection algorithms, detects segments that contain acoustic events and tags them according to broad classes (e.g. low frequency impulses, ultrasonic impulses, short tonal sounds). The second stage, made of several classification algorithms, classifies events that have been detected in the first stage into more specific classes, which have practical relevance (e.g. impulsive ship noise, ultrasonic cetacean clicks, cetacean buzzes, whistles).

The accuracy of the system was assessed on a test data set that is representative of a diversity of situations that are to be expected at ocean observatories: It contains recordings from several geographic areas; impulsive, tonal and broadband ship-sounds; sounds from airguns/explosions; cetacean clicks, creaks and buzzes; cetacean whistles and calls; segments with only ambient background noise.

III. RESULTS

The first stage reliably tagged segments according to broad classes: short tonal sounds (whistles and calls of cetacean), constant tonal sounds (sounds produced by shipping), low frequency impulses (airgun, explosions), mid-frequency impulses (sperm whale clicks, impulsive ship noise), high frequency impulses (ultrasonic clicks from cetaceans, impulsive ship noise). The second stage reliably classified events that have been detected in the first stage into more specific classes. Cetacean calls were classified according to their frequency. Mid and high frequency impulses were classified as sperm whale clicks, ultrasonic cetacean clicks and impulsive ship noise. Fast bursts of impulses (e.g. creaks, buzzes) were identified. Fig. 1 shows how the system detects and classifies impulses.

IV. DISCUSSION

The palette of detected events is highly relevant when studying marine mammals and their interaction with anthropogenic noise. The detection system has been shown to work reliably under diverse and challenging situations expected during PAM campaigns at ocean observatories. This system will be useful to pre-process the very large data volume that can be gathered during long term acoustic monitoring campaigns or to detect the presence of cetaceans in real time to activate mitigation measures.

V. ACKNOWLEDGEMENT

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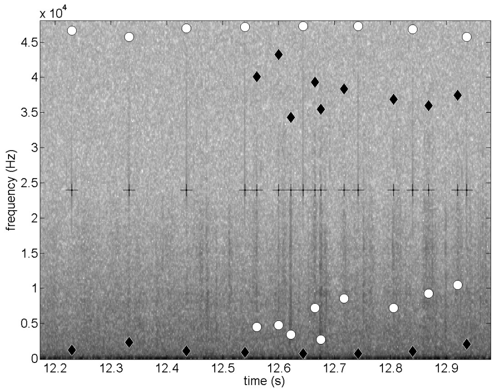

Fig. 1. Spectrogram of a segment with ultrasonic cetacean clicks (UCC) and impulsive ship noise (ISN). The detection of impulses in the band 20-46 kHz are plotted as black crosses (arbitrarily plotted at 24 kHz). At this stage UCC and ISN are confounded. The second stage classifier returns the estimated probability of being a UCC or ISN, plotted as white circles and black diamonds respectively (0 kHz: p=0, 48 kHz: p=1). By setting a threshold at p=0.5 the regular train of UCCs is separated from the ISN.

ARCHITECTURE FOR THE REAL-TIME MONITORING OF NOISE POLLUTION AND MARINE MAMMAL ACTIVITY

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Abstract - As acoustic pollution in the oceans is increasing, it is becoming more important to monitor it, with special attention on its effects on the behaviour of cetaceans. In the near future governments may require constant monitoring during sea construction projects or operations. One major construction activity in the coming years will be the construction of wind farms. Not only will these farms produce a constant low level noise in their direct environment while operating, but the building of the foundations necessary to support the wind mills will produce impulsive noise dangerous to any cetaceans in the area and lethal to, for example, fish larvae. For these reasons, noise monitoring has become one of the objectives of the European Seafloor Observation Network (ESONET), to investigate the level of noise produced around European coastlines and its impact on the environment and cetaceans especially.
Presented is the architecture for noise and marine mammal monitoring as it is currently implemented in ESONET through the LIDO (Listening to the Deep Ocean Environment) project. LIDO will detect in real-time changes in the background noise levels and register acoustic events (natural, biological and anthropogenic), and identify and track the sources when possible. As the system will be implemented in varying environments, a modular design is used that can be adapted easily, based on local requirements. While the system will most often run from a shore station, a more limited version is developed that can run autonomously with minimal power requirements.

Keywords – real-time monitoring, acoustic pollution

I. INTRODUCTION

The LIDO (Listening to the Deep-Ocean Environment) acoustic data management will be first implemented in the east of Sicily at a test site operated by the Laboratori Nazionali del Sud of the INFN, as part of a platform for the detection of geohazards and neutrinos, located at 2100 m, about 25 km offshore the Port of Catania (Sicily, Italy). Recordings are made on four channels at 96 kHz and are digitized at 32 bit at the hydrophone array. The digital data is then sent to a harbour station through an optical cable where it first arrives at the Acoustic Data Server (ADS). This server has a graphical user interface that allows an operator to see a spectrogram of the incoming data and is responsible for distributing the data on shore. The ADS will forward the data to real-time analysing servers operated by the UPC and CIBRA and a local Raw Acoustic Data Server (RADS). The RADS takes care of buffering and compressing the data before sending it over a wireless link to the LNS. Additionally, a Processed Acoustic Data Server (PADS) can be used by the analysis systems to temporarily store analysis results before they are sent to the LNS. The raw acoustic data will be stored permanently at the LNS in the Main Acoustic Data Server (MADS) where it can be accessed by collaborators. Other data, such as the analysis results, can be distributed through a webserver to the internet. The UPC data analysis is performed in two stages. The first stage is designed to be able to run on an autonomous system, close to the hydrophone array itself. It makes a quick decision on the contents of a data segment. If it does not find any interesting signal (impulse sound, frequency modulation, constant tonals), it will discard the segment and only keep some statistical information on the noise level found. If the system is configured to make the information available to the public in real-time, a spectrogram and 1-channel compressed audio stream are retained as well. The resulting information and data segments that are considered interesting can either be stored locally or transmitted directly to shore for a second stage analysis. For LIDO, this stage is done in the harbour station. At the second stage, sound sources are identified, located and tracked. Impulse sources can be located if the system has enough channels available, based on the time delay of arrival at the hydrophones. Accumulation of information at this stage may give more precise locations over time, and will allow tracking of the sources. Sources will be identified as natural events, shipping traffic (with possibly the type of ship), or the animal species that produced the sound. In order to correctly identify the sources a catalogue will have to be compiled with information of the natural and anthropogenic sound sources in the area.

From the streaming server at the LNS in Catania, a number of data streams will be made available. Apart from the analysis results that are sent to the LAB to be stored in a database, the server will also provide a compressed audio stream and analysis results to the general public. Conforming to the Sensor ML standard, sensor and hardware information will be made available from the website. Additionally, it is foreseen that Sensor Alert Services will be made available where visitors can subscribe to receive notification of specific events (e.g. cetacean presence or high background noise levels). The web server at the LAB collects analysis information from all platforms that have implemented the LIDO framework. This will allow correlation analysis between events or to find long term trends at a specific site as well as between different sites. The information will be available to the general public through graphical representation, together with a library of compressed audio recorded at the platforms for educational purposes. Furthermore, a flash client will be available to visitors that can be used to access the real-time data streams directly from a platform.

II. ACKNOWLEDGEMENT

This project is funded under the European Commission contract FP6-2005-Global-4 - ESONET 036851-2. The LIDO consortium is formed by: Universitat Politècnica de Catalunya (UPC); Instituto Nazionale di Geofisica e Vulcanologia (INGV); Instituto Nazionale di Fisica Nucleare (INFN); Consejo Superior de Investigaciones Científicas (CSIC); Tecnomare; dBScale; Universidade de Lisboa (UL); Centro Interdisciplinare di Bioacustica e Ricerche Ambientali (CIBRA); Consiglio Nazionale delle Ricerche (CNR); Technische Universität Berlin (TUB); Zentrum für Marine Umweltwissenschaften (MARUM).

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