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Hidroboya: An Autonomous Buoy for Real Time High Quality Sea and Continental Water Data Retrieval

Xulio Fernández-Hermida[1], Carlos Durán-Neira[2], Manuel D. Lago-Reguera[2] ,
Carlos Rodríguez-Alemparte[1], Fernando Martín-Rodríguez[1]
[1]Signal Theory and Communications Department. University of Vigo.
ETSET, Ciudad Universitaria S/N, 36310 Vigo (Pontevedra). Spain.
[2]Centro de Investigaciones Submarinas (CIS). Via Nobel 9, 15890 Santiago De Compostela

***Abstract-* This communication presents Hidroboya^{tm}, a buoy that is already working on the sea and whose purpose is being an autonomous source of ocean and continental water data that will be automatically sent to an "on land" server which organizes them in a database system. Server can handle information from several buoys and authorized users can see and browse data over the internet. Furthermore, buoy sensing design is very innovative, because it keeps sensors dry the most of the time and uses a hydraulic system to feed fresh ocean water to them when required. This design keeps sensors free from sea particles sedimentation, problem known as "fouling".**

I. Introduction

A. Operational Oceanography

Operational Oceanography is a developing area that needs to be fed with oceanic data, in order to produce continuous information. These data can be obtained from Remote Sensing Satellites (CREPAD [1]: "Centro de Recepción, Proceso, Archivo y Distribución", Spanish for "Reception, Processing, Archiving and Distribution Center") but these data need to be combined with data from the column of water taken directly form the sea. Infrastructures such as CREPAD can help the whole society to have a better knowledge about the ocean and continental waters state. It will help in a more efficient use of our waters and coastal profitability. Hidroboya is born as a powerful tool to integrate with this operational oceanography systems.

B. Hidroboya General Overview

The buoy main part is a strong hose hanging from a floating body (Fig. 2). The hose contains several sampling catheters which are used to get water from different depths (as these tubes go out from the main hose and finish at the desired sampling depths). The main hose is securely bound to the anchor chain in one or more points to avoid excessive hose movement.

The sampled water will go through a "sampling chamber" located inside the floating body. Sensors inside the chamber will get the desired data. These data will be transmitted o an "on land" station that will save them on a database system. These data will be available to all authorized users through a Web application.

This Web page was named "Pagina Continuata Sensorum" (Fig. 1) a Latin phrase that emphasizes that with this system we get a continuous feed of water data over the internet.

Fig. 1.- Hidroboya and "Pagina Continuata Sensorum" logos

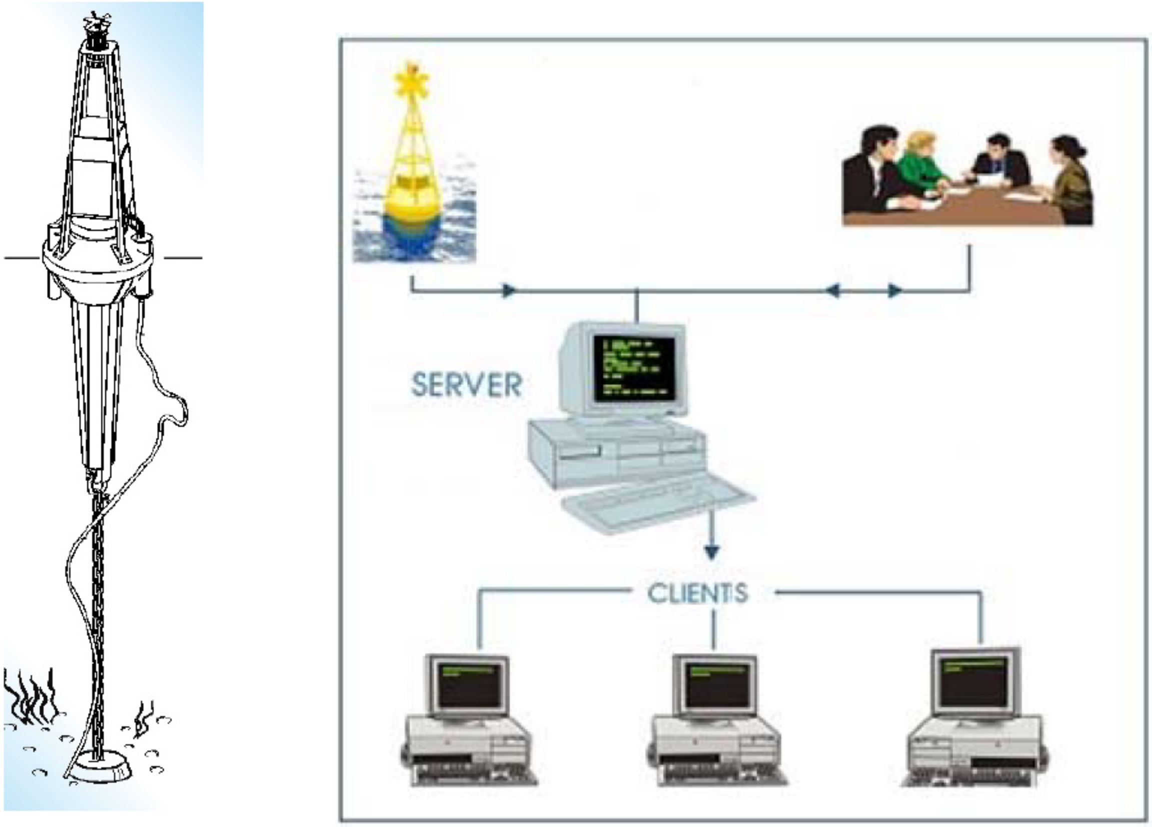

Fig. 2.- Buoy and "on land" system.

II. Sensing Design

Main originality of this buoy is the special sensor arrangement (Fig. 3). In classical systems sensors are directly contacting sea water and they soon became polluted (fouled) by particle sedimentation. Nevertheless our buoy keeps sensors dry when they are not being used so that they are not affected by fouling (Fig. 4). Due to this we have longer sensor life and less maintenance needs.

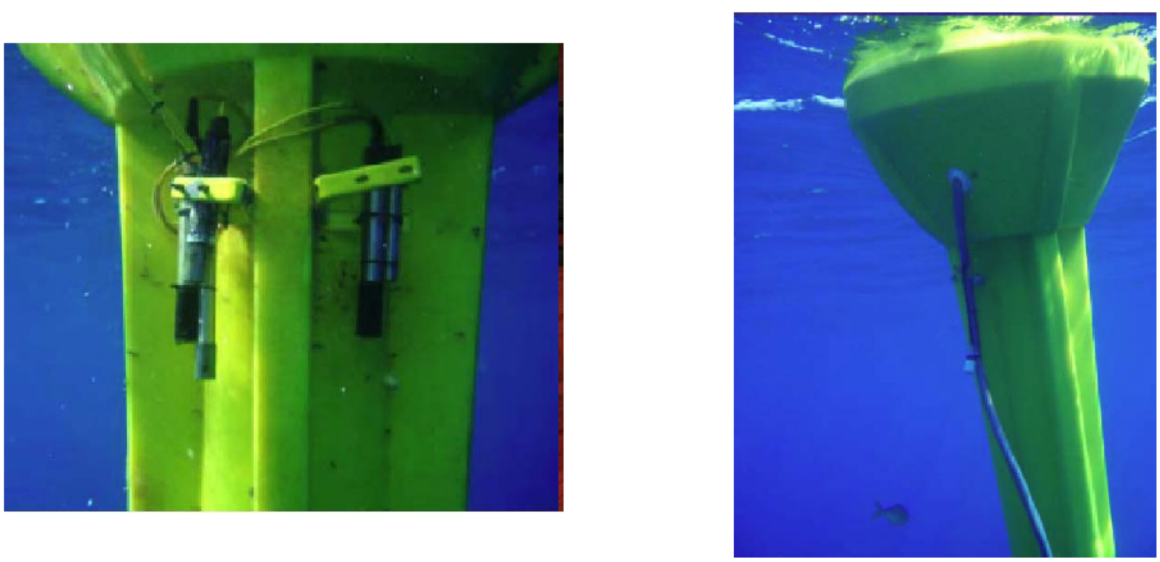

Fig. 3.- Sensor arrangement: classical buoy (left), Hidroboya (right).

Fig. 4.- Fouling in a classical buoy (left), clean sensors in Hidroboya (right).

The fouling problem is really a very big one as long as a fouled sensor is producing incorrect data. What's more, we normally have no idea about the speed of fouling sedimentation, so we do not know when received data are beginning to have errors.

This especial arrangement has another important advantage: due to the fact that sensor are dry most of the time, we can integrate some sensors that are not feasible to be used in the classical mode. Examples of this are nutrient components meters, hydrocarbon meters, particle counters, plankton classifiers…

Nevertheless the special sensor arrangement has some disadvantages. These are the following:

- Data are measured over a sampled portion of water that is always at 1 atm pressure. This is an intrinsic characteristic of the water pumping system. Design of a system that preserves original pressure is possible yet difficult. This fact makes totally different some measurements (like solubilized gases concentration). Nevertheless until now it has not been necessary to upgrade the pumping system.
- Water temperature will be modified by measurement chamber temperature. This effect is minimized pumping water at high speed and putting measurement chamber under water level. Also catheters are made of a thermal insulated material.
- As temperature sensors are not affected by fouling we have put such meters at the different sample depths, so that we can know the temperature difference between the sampling point and the measurement chamber.

III. Buoy Control and Information Handling

Buoy has an on board control system (Fig. 5) that consists of the following:

- Sensor reading system: sensor outputs are converted into a normalized digital stream.
- Communications system: based on GPRS (General Packet Radio Service [2]) data communications, this is used to send the data stream to the land station (this design imposes a condition: buoy must be floating "near" the coast line: coverage on the sea can reach so much as 20 Km or more). We can also send commands to the system from the land station. Communications through UHF radio modems and/or through SATELITE can be done in the same manner.
- Data saving system: buoy saves all retrieved data in a kind of "black box" that could be recovered after a catastrophic event.
- Water filling control: the sensor chamber must be filled with water when we want to take data and water must be removed after that. We get this with pumps and solenoid valves (Fig. 6) controlled by the buoy intelligent control system. We also use auxiliary sensors to control water filling (flooding and pressure sensors).

On land, data are saved on a database server that permits accessing them through a Web interface (Fig. 7). With this system we can monitor water conditions in many interesting circumstances: pollution control, bath water quality in touristic areas, control of mollusk farming zones, etc. We have designed two separated software subsystems: one for data management and other for data representation. This independence permits allowing access to different clients with different needs without affecting data gathering. The client interface permits seeing data evolution via graphical representations, allowing one different curve (of a different color) for each sampling depth.

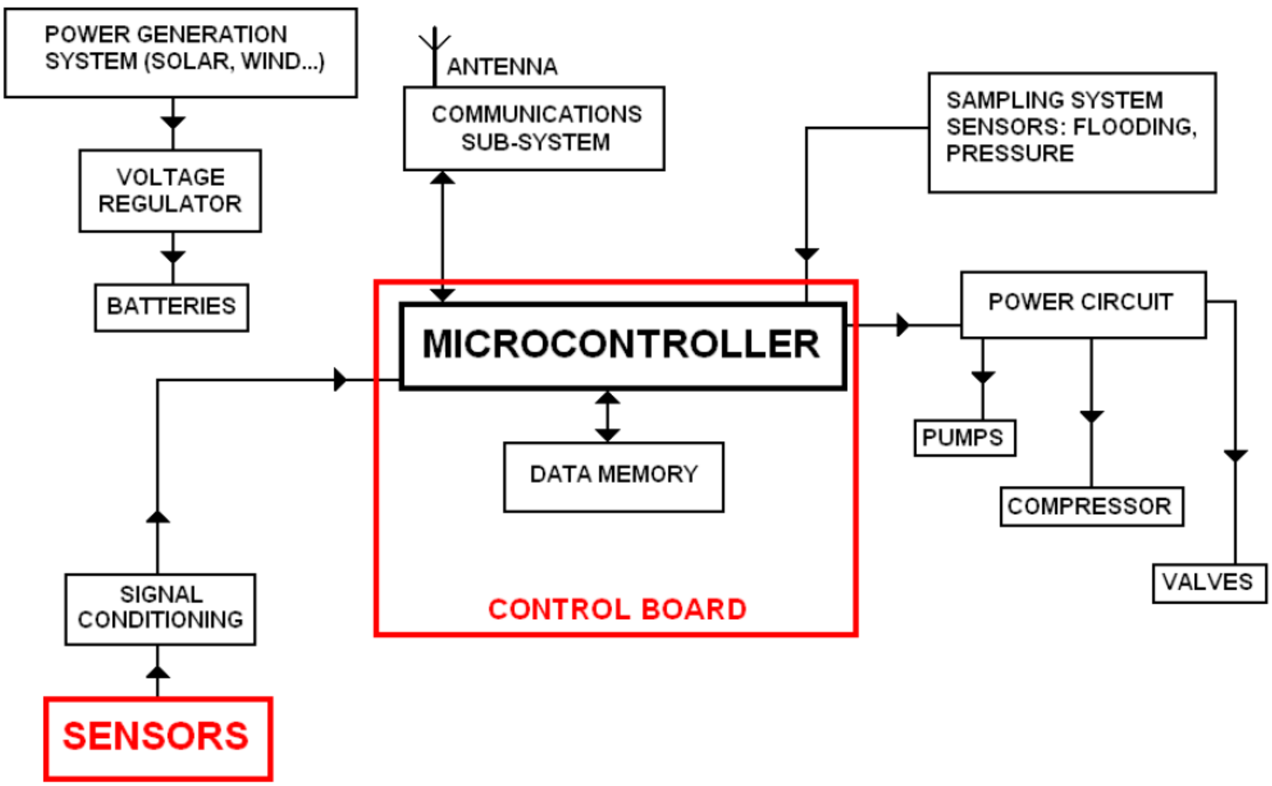

Fig. 5.- Buoy electronics scheme.

Fig. 6.- Water filling system.

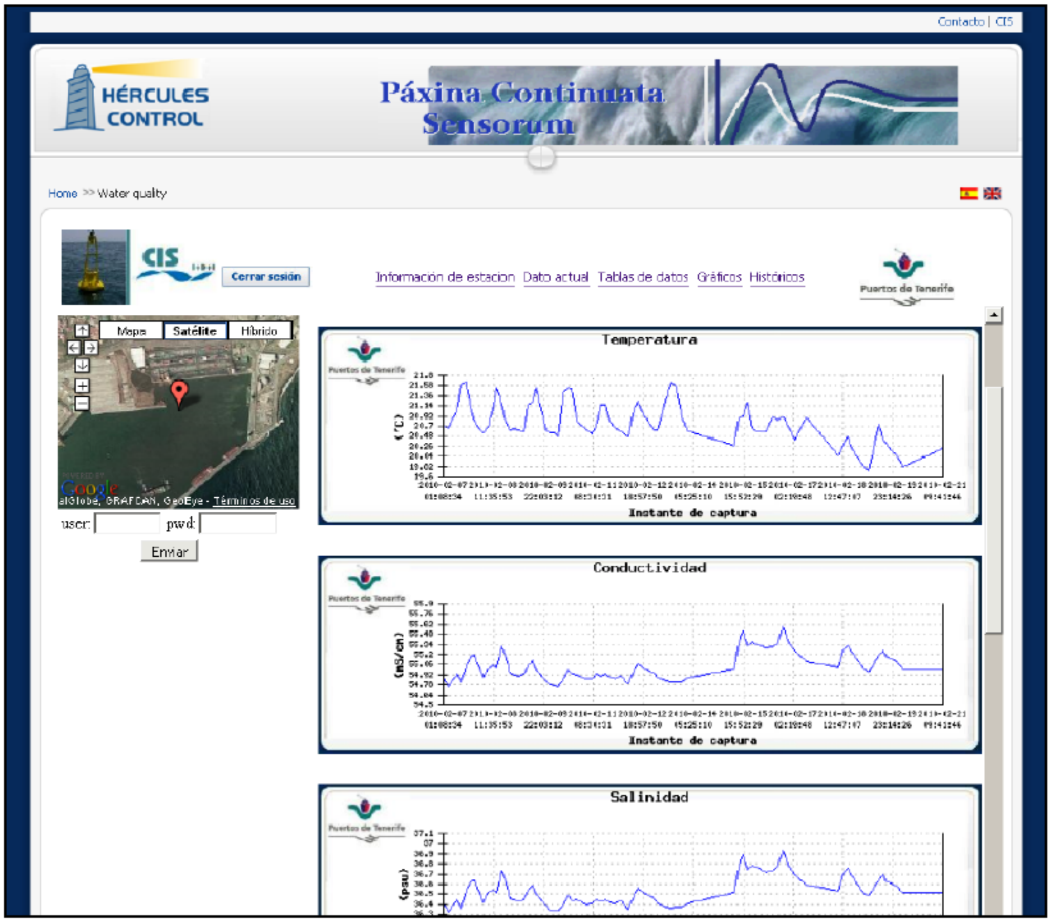

Fig. 7.- Retrieved data (from a real buoy) displayed on the data website.

IV. Virtual (Simulated) Hidroboya

In order to test the control board (Fig. 5) and also as a help for pumping system design, we have developed a software simulator for Hidroboya. This, in fact, a software emulator that accepts orders from the control board (connected to the PC through a serial port) and applies physical laws (fluid mechanics) to predict Hidroboya behavior under desired test conditions. The simulator computes air pressure on each catheter and shows it using a color code. A red color indicates a pressure higher than 1 atm (if color saturation increases, that means bigger pressure). When pumping water through a catheter, air pressure inside it will be less than 1 atm. That is shown using a yellow color. Lower saturation means less pressure. In Fig 8, we see how Hidroboya is beginning to pump water through catheter number 5. Air pressure is very low (color has become white due to its low saturation) and water (blue color) is beginning to ascend though the duct.

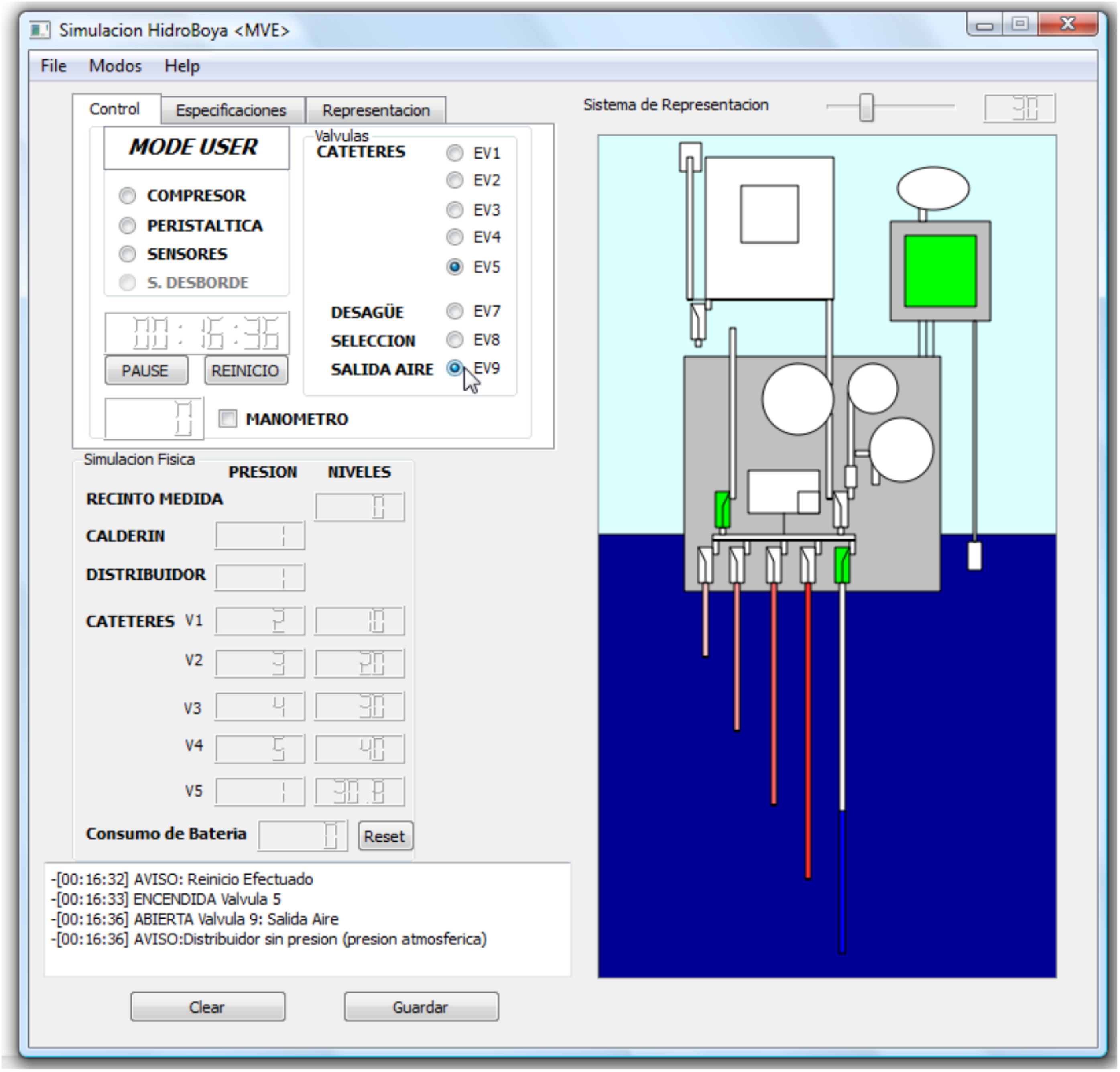

Fig. 8.- Software simulator for "Hidroboya".

V. Power System

Buoy batteries and solar panels are used for power needs and in the currently installed system (see next section) this has proven to be enough as this installation is located in a very sunny place. Nevertheless, we are developing other alternatives to generate power:

- We tested a generator that uses sea waves to create an air current and move a small generator. This idea needs to be analyzed in more detail.
- We are now studying the possibility of using wind generators and other ways to obtain energy from the buoy movement.

VI. Results

Our first prototype buoy was installed at the harbor of Santa Cruz de Tenerife (Canary Islands, Spain) and it has been retrieving data from September, 2009 until June, 2010. This buoy has installed a multi-parametric sensor that measures: temperature, pH, electrical conductivity, redox, turbidity and solubilized oxygen concentration. This system performs samples on only two depths: 1 meter and 15 meters.

In a test performed three months after installation, sensors were checked to be absolutely free of fouling. We also proved that data acquisition, processing and sending to the Web server were correct.

We also discovered that the inner face of catheters was affected by fouling. Although this is not so serious as if it were on the sensors, we decided to have the catheter always dry injecting compressed air into them (this first version kept catheters full of water).

Hidroboya is right in the line pointed by the Water Framework Directive [3], about controlling different waters quality (bath, rivers, Marine Environment and Coasts, drinking water, water pollution, etc). It uses the technologies pointed by [4] to construct the framework for Marine environmental observation and control.

An U.S. patent has been requested for this system with application number 61224557 and title "Autonomous and Remote-Controlled Multi-Parametric Buoy for Multi-Depth Water Sampling, Monitoring, Data Collection, Transmission and Analysis".

VII. Conclusions

The development of the Hidroboya has been done looking for an effective way to avoid the fouling effect in sensors that are directly exposed to the water. Overcoming the fouling problem lets Hidroboya to have very large maintenance intervals. The sensors are protected on board of the buoy. This brings the possibility of self calibration of sensors enlarging the maintenance intervals even more. These facts make Hidroboya ideal to be used to fed data for the numerous projects of sea observation and also for control of continental waters [1], [5], [6], [7] ... .

We firmly believe that the Hidroboya can make a difference in the systems for parameters measurements directly in the water [1].

From information from leading companies devoted to this market, it can be observed that all the available solutions are traditional systems that in no case surpass the enormous problem of fouling [8], [9]...

VIII. Future Lines

The main efforts in development are nowadays directed towards:

- Development of a new subsystem able to capture water samples that could be retrieved by a boat and analyzed in the laboratory. This could be used to research further when some indicators reach worrying values.
- Developing new energy systems to improve buoy autonomy (see section IV 'Power Systems').
- Integrating collected data into Operational Oceanography databases.

Acknowledgments

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