Low Cost Buoy for Monitoring Recreational Areas

C. Albaladejo Pérez[1], H. Navarro Hellín[1], F. Soto Valles*[2], A. Iborra García[2], Roque Torres[2]

[1] Widhoc Smart Solutions S.L., CEDIT, Crta. Del Estrecho-Lobosillo, km. 2, 30320 Fuente Álamo
[2] DSIE, Universidad Politécnica de Cartagena, Campus Muralla del Mar s/n, 30202 Cartagena
*pencho.soto@upct.es

***Abstract* — Using a buoy-based coastal monitoring systems we can build innovative solutions to address, among other activities, monitor the marine coastal conditions. This technology is evolving continuously but due to the high costs of the buoy based installations, it is really hard to show the potential added-value applications in the market. A Smart System for Marine Environments is proposed in this paper. This is a novel concept to monitor coastal areas, based in the concepts of low-cost, light weight, energy-efficient that could be used for several end-users applications in the near future.**

Keywords – buoy, marine environment, GPRS.

I. INTRODUCTION

The main objective of Smart System for Marine Environments (SSME) is to obtain a versatile solution to monitor the coastal marine areas, such as beaches and diving areas, which are particularly vulnerable to the effects of human activity and are an important economic resource for the touristic sector as important in Spain.

In comparison with other marine monitoring technologies, surface buoys provide simple installation and autonomy, becoming the most appropriate solution for measuring and controlling the status of waters located close to the coast. There are several solutions based in this idea associated to projects funded by the European Union ([1], [2], [3]), patents [4], investigations published in the specialized literature [3], and commercial products ([5], [6], [7], [8]) and trial prototypes [9]. In these, buoys use satellite communications and other solutions consider the capture of the video, audio or image and remote control.

However, important concerns are still not solved, difficulting the the market penetration (size, cost, etc.). It implies that the amount of applications is limited and that the number of possible end-users reduced to a few large companies and public administrations.

For this pupose, the design and built of a buoy-based coastal monitoring system is described. The buoy transmits the data from several sensors in real-time.

This surface buoy system will provide a flexible/modular infrastructure to fit the buoy's equipment to a specific application. The marine system includes physical sensors that measure water temperature, pressure, ultraviolet radiation, weather conditions, etc. With this information the user can perfectly know the state of a beach and diving areas.

This can be interesting for public administrations, and citizens, because the information from the SSME (see Fig. 1) could be offered to the citizens via Internet, smartphone app, etc. Knowing which of their beaches are the most suitable for the swimming or diving, among others activities.

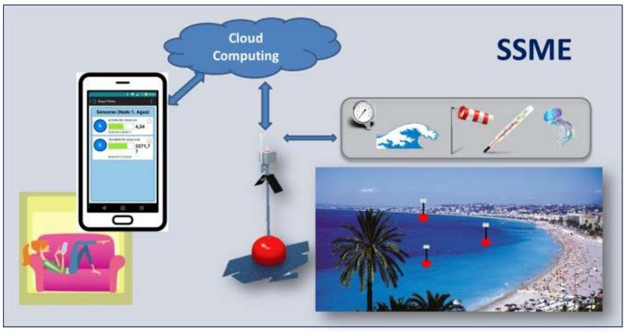


Fig. 1. SSME system

This paper is focused on the development of a low cost buoy to monitor marine areas like beaches and diving areas.

After this introduction, section II describes the electronic design of the buoy. Section III details the mechanic structure of the buoy and describes the requirements and characteristic. Section IV presents the deployment of a buoy, and finally, sections V and VI show the conclusions and future works.

II. ELECTRONIC DESIGN

The electronic design of the buoy is an improvement of device presented in [5]. This design includes basic components plus several functionalities and characteristic described in this section.

The modular design is composed of two electronic boards:

1) A main board named *MEWiN Main-Board* (*MultiEnviromental Wireless Node Main-Board*) that it was already presented in [5]. This board includes the common components used in any application of Wireless Sensor Network. Some of these are microcontroller, radio modules, real time clock, microSD interface, etc.

2) A new second board, *MEWiN GPRS-Board*, whose block diagram is showed in Fig. 2.

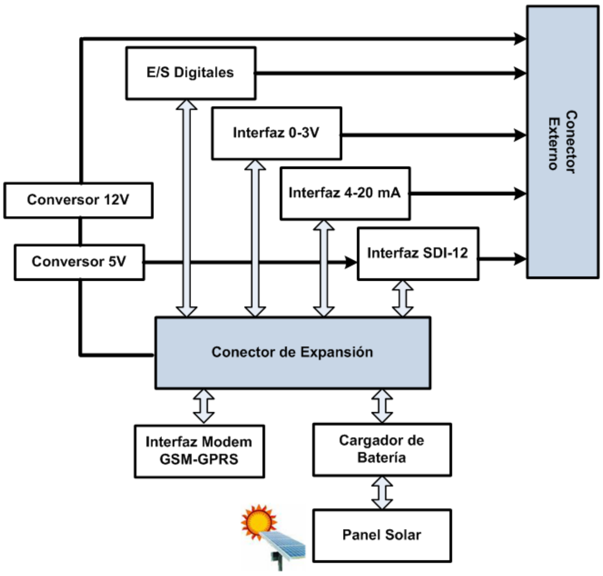


Fig. 2: GPRS-Board block diagram.

MEWiN GPRS-Board is connected to *MEWiN Main-Board* through expansion connectors. These are redirected to different analog and digital I/O, UART from microcontroller, and energy supply and ground lines.

MEWIN GPRS-Board is made up of several interfaces and voltage converters (two CC/CC converters to 12V and 5V; SDI-12, 0-3V and 4-20mA interfaces; and digital I/O) to connect the device with a large range of commercial sensors to use in several applications.

One of the main characteristic of this interface board is the connection of a GSM modem in order to send information to data server. The modem used is the SIM900 from SIMcom Ltd..

Fig. 3 shows the final set up with three boards: *MEWiN Main-Board, MEWiN GPRS-Board* and commercial module SIM900.

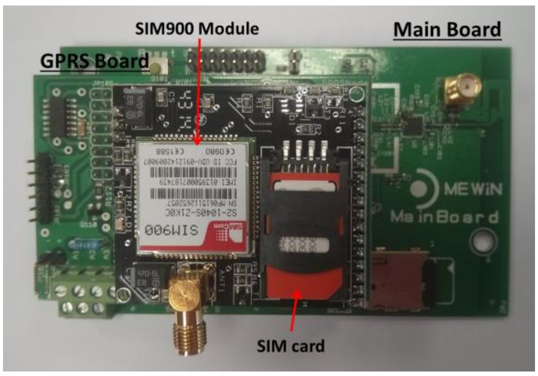
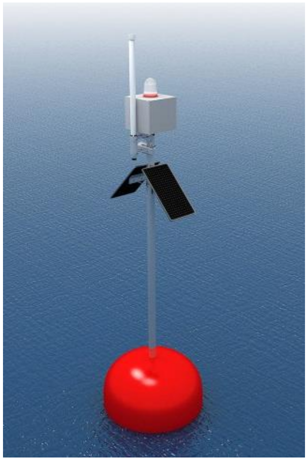


Fig. 3: Device MEWiN.

The battery used is a Li-Po of 2300mAh, 3.7 nominal voltage and is charged with an external solar panel of 0.8W (5V/160mA) using an integrated circuit on *MEWiN GPRS-Board*. Thus, to maximize the lifetime of the batteries. The circuit charges only when the voltage is lower than a threshold and it stops charging when the battery charge is upper another upper threshold.

III. MECHANIC DESIGN OF THE BUOY

The sensor buoy is mounted on a mechanical structure with some important requirements dictated by conditions in the marine environment (see [10] for a detailed description). Fig. 4 details the mechanic characteristics of the buoy presented in this paper.



Protocol	GPRS
Antenna	GSM, 900 / 1800MHz
Range	Mobile network
Harvesting system	Rechargeable PoLi (3.7 V, 5 A·h) 2 2.5 W solar panels
Electronic housing	12x12x7 cm IP68 box
Signalling	Beacon light & flag
Float system	50 x 40 cm polyvinyl chloride float
Counterweight	7 kg
Anchor system	Mooring line & anchor
Dimensions	3 m (longitude) x 0.4 m (diameter)
Weight of buoy	12 kg

Fig. 4. Marine buoy and buoy characteristics, including the adopted protocol designed and manufactured by the DSIE (*División de Sistemas e Ingeniería Electrónica*/Electronic Systems and Engineering Division) of the Universidad Politécnica de Cartagena.

In general, given the final purpose of the sensor buoy, a number of requirements were defined. These are:

- Flexibility: the sensor buoy system must be designed to facilitate different configurations in terms of the physical magnitudes that can be sensed, and the sampling and sending time to the remote server.
- Energy autonomy: the system should harvest energy from the environment in order to be able to operate without human intervention for a long period of time. Maintenance requirements and the associated cost will be reduced even further if the useful life of the buoy can be prolonged (buoy autonomy), as less intervention will be needed. We have used energy collection systems so that their batteries can be recharged using solar.
- Robustness and fault tolerance.
- Mechanical design: components should guarantee an appropriate level of insulation and corrosion-proof.
- Resource optimization: the sensor buoy system should be designed with efficient resource utilization in order to reduce the costs of

manufacture, deployment, operation and maintenance.

IV. Deployment

This section describes the operation of the full system. The buoy has been deployed near to the harbor to check mechanic robustness and the functionality of the system (Fig. 5 shows a full buoy before deployment and already installed on the sea).

Fig. 5: Buoy near port

The periodic procedure of the system starts to sample from sensors, whose measures are sent through GPRS communication to central data server.

This server processes information received and stores it in Relational Data Base on MySQL language. This storage system allows to store organized all data received (sampling value, timestamp, geographic location of the buoy, sampling period, etc).

A Web application has been developed to provide users the information efficiently using HTML5, PHP, and MySQL, accessible by authentication control in any place through Internet. Fig. 6 shows the main page of this Web application. On top it shows the geographic location of the installed buoys and on bottom includes data related with the sensors of the selected buoy. This last part offers the possibility of selecting several parameters together ranges of measurements, ranges of date, data download in Excel format, image downloading, etc.

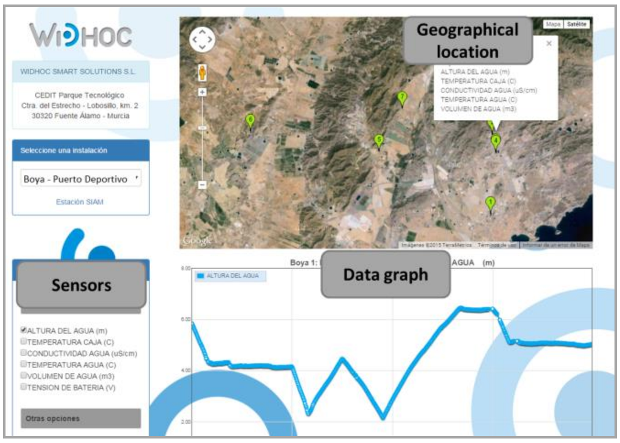


Fig. 6: Web application

V. Results

Mechanic robustness tests have been satisfactory and maintenance works were not necessary. Thanks to use intelligent charge systems of batteries through solar panels, the device autonomy is almost unlimited. The power supply system and the battery recharge system by solar energy are working correctly.

Data processing and reception is made suitably and an intuitive and interactive Web application shows the information to users.

VI. Conclusions y future works

A full system (electronic design of devices, mechanical structure of the buoy and Web application) to monitor recreation marine zones has been presented. The main characteristic is the easy deployment u of the buoy, easy data visualization, the large autonomy and robustness of the buoy.

As future works, we want commercialize this system to possible clients.

Acknowledgment

This work has been feasible thanks to the collaboration of the company EIBT Widhoc Smart Solutions S.L.

REFERENCES

[1] DISMAR Project (ref: IST-2001-37657).
[2] Hab-Buoy Project (ref: Q5AW-CT2001-01925; FP5-LIFE QUALITY).
[3] AMASS Project (ref: 218290; FP7-Security).
[4] Patent US7585914.
[5] Barnes, C.R.; Best, M.M.R.; Bornhold, B.D.; Juniper, S.K.; Pirenne, B.; Phibbs, P. The NEPTUNE Project—A Cabled Ocean Observatory in the NE Pacific: Overview, Challenges and Scientific Objectives for the Installation and Operation of Stage I in Canadian waters. In Proceedings of the Underwater Technology and Workshop on Scientific Use of Submarine Cables and Related Technologies, Tokyo, Japan, 2007, 308–313.
[6] Cella, U.M.; Shuley, N.; Johnstone, R. Wireless Sensor Networks in Coastal Marine Environments: A Study Case Outcome. In Proceedings of the 5th International Workshop on UnderWater Networks, Berkeley, CA, USA, 4–6 November 2009, 1–8.
[7] Albaladejo, C.; Soto, F.; Torres, R.; Sánchez, P.; López, J.A. A Low-Cost Sensor Buoy System for Monitoring Shallow Marine Environments. *Sensors*, 2012, 12, 9613-9634.
[8] Jiang, P.; Xia, H.; He, Z.; Wang, Z. Design of a water environment monitoring system based on wireless sensor networks. *Sensors*, 2009, 9, 6411–6434.
[9] NOAA (National Oceanic and Atmospheric Administration) buoys eyes coral reefs.
[10] Albaladejo, C.; Sánchez, P.; Iborra, A.; Soto, F.; López, J.A.; Torres, R. Wireless Sensor Networks for Oceanographic Monitoring: A Systematic Review, *Sensors*, 2010, 7, 6948-6968.