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Pop-Up Buoys - Improving the Environmental Seafloor Monitoring Capabilities of Stand-Alone Oceanographic Platforms

Matias Carandell[1], Steve Hernández[2], Daniel Mihai Toma[1], Marc Nogueras[1], Enoc Martinez[1], Ikram Bghiel[1] and Joaquín del Río[1]

[1]*SARTI Research Group, Universitat Politècnica de Catalunya, 08800 Vilanova i la Geltrú, Spain*
[1] *Department of Computer Architecture and Technology, Universitat de Girona, 17003 Girona, Spain*

***Abstract* – The Platform for Long-lasting Observation of Marine Ecosystems (PLOME) project seeks to enhance communication capabilities for stand-alone seafloor platforms. A pivotal innovation within PLOME is the integration of pop-up buoys, enhancing monitoring by transmitting crucial data and enabling its early access. These buoys, evolving from conventional retrieval mechanisms, now incorporate sensing, processing, and communication features, representing a significant advance in marine observation technology. The ongoing development focuses on electronics integration, buoy design, autonomy optimization, release mechanisms, and satellite transmission enhancement, aiming to overcome operational limitations and improve observational capabilities in marine environments.**

Keywords - *Argos-based Satellite Communication, Stand-Alone Oceanographic Platform, Environmental Seafloor Monitoring and Pop-Up Buoys.*

I. INTRODUCTION

Underwater cabled observatories play a vital role in gathering oceanographic and biogeochemical data necessary for overseeing marine ecosystems and species variety. Nonetheless, their considerable deployment and maintenance expenses have driven the shift towards using stand-alone platforms, like the Lander designed in PLOME's frame [1], for short-term monitoring. Yet, accessing data from these platforms relies on recovering the physical units, emphasizing the ongoing necessity for devising real-time communication methods to guarantee continuous and uninterrupted data collection.

To tackle these issues, the Spanish Ministry of Science and Innovation-funded Platform for Long-lasting Observation of Marine Ecosystems (PLOME) project seeks to enhance communication capabilities for stand-alone seafloor platforms. Integrating various remote stations with Autonomous Underwater Vehicles (AUVs) and Unmanned Surface Vehicles (USVs), and aims to create a cooperative network for near-real-time data acquisition via satellite links, eliminating the need for stand-alone platform retrieval. In this line, one of the pioneering innovations under investigation within the PLOME project is the integration of pop-up buoys, previously presented in the publications [2] and [3].

II. THE POP-UP BUOY CONCEPT

As exposed by J. H. Haxel et. al. in [4], pop-up buoys are traditionally employed for the retrieval of seafloor instrumentation. At the end of the deployment phase and upon receipt of an acoustic command, a buoy tethered to the seafloor node is released to retrieve the instrumentation. In the context of PLOME, the concept of pop-up buoys has evolved with the incorporation of sensing, processing, and communication functionalities. The stand-alone monitoring node (right seafloor side of Fig. 1.A) incorporates multiple pop-up buoys (left seafloor side of Fig. 1.A) that are periodically released freely (no tethering line to the seafloor node). Throughout the deployment phase, the buoy accumulates scientific and engineering data collected by the monitoring station. Upon release, the pop-up buoy turns into a drifter, transmitting the stored data and its precise location via satellite link. Consequently, scientists can access a portion of the data prior to station retrieval, while engineers can ensure the correct operation of the experiment.

Pop-Up buoys improves three main limitations of stand-alone oceanographic platforms; 1) To prevent potential downtime due to malfunctions during observatory deployment, transmit crucial engineering parameters along with battery status, camera focus or orientation, and data accumulation levels at specific critical intervals, 2) Transmit segmented data at regular time intervals, specifically with each buoy release, before retrieving the stand-alone observatory and 3) Notify about significant and unique occurrences, such as the re-establishment of the thermocline resulting in vertical mixing or the specific appearance of a species of interest.

The development of Pop-up buoys faces several challenges. In [2] we presented a series of preliminary tests that showcase the selection and evaluation of specific technologies to address these challenges. These evaluations encompass the utilization of WIFI technology for the subaquatic data transmission from the stand-alone platform to the pop-up buoy, the implementation of magnet-based mechanisms for the release operation, and the selection of Kinéis as a low-power, satellite-based, data transmission system.

III. RECENT ADVANCES

Currently, work is underway on the development of Pop-Up buoys on various fronts. Firstly, a development board (Fig. 1.C) has been created to integrate the necessary modules for the operation of Pop-Up buoys. These modules consist of an ESP32 module (EZSBC) as a microcontroller, an RTC module (DS3231) for managing buoy wake-ups, an SD module for storing data from the stand-alone observatory, a GPS module (GY-NEO6MV2) for buoy surface location, a KIM1 module for data transmission via the Argos network, a set of relays for turning on/off different modules in each state, and a step-up converter (U3V16F5) to adjust battery voltage.

Secondly, efforts are focused on fitting the electronics into a Blue Robotics acrylic cylinder measuring 150mm in height and 75mm in diameter (seen in Fig. 1.B). The cylinder incorporates a dome to ensure good visibility for the ARGOS antenna (data transmission), and for GPS to quickly fix the position. The weight of the cylinder has been adjusted to provide adequate buoyancy and surface orientation, enabling only the dome to protrude from the water.

The project is also addressing autonomy concerns. Presently, four 18350 Li-Ion (2.4 Ah each) batteries provide a 15-day autonomy on the surface, enough for either recovery by boat or, depending on the surface currents, reaching the coast in some offshore areas. Efforts are underway to optimize consumption to significantly extend this duration, thereby enhancing its utility as a drifter.

Integration of the buoy release method has commenced. This will be accomplished using a Goudsmit electro-permanent magnet (GM17853), which retains positive magnetization and, when activated at 24V, generates a magnetic field that demagnetizes the permanent magnet, thus releasing the buoy. Lastly, ongoing work includes optimizing satellite ARGOS transmission parameters and predicting satellite passes to reduce consumption.

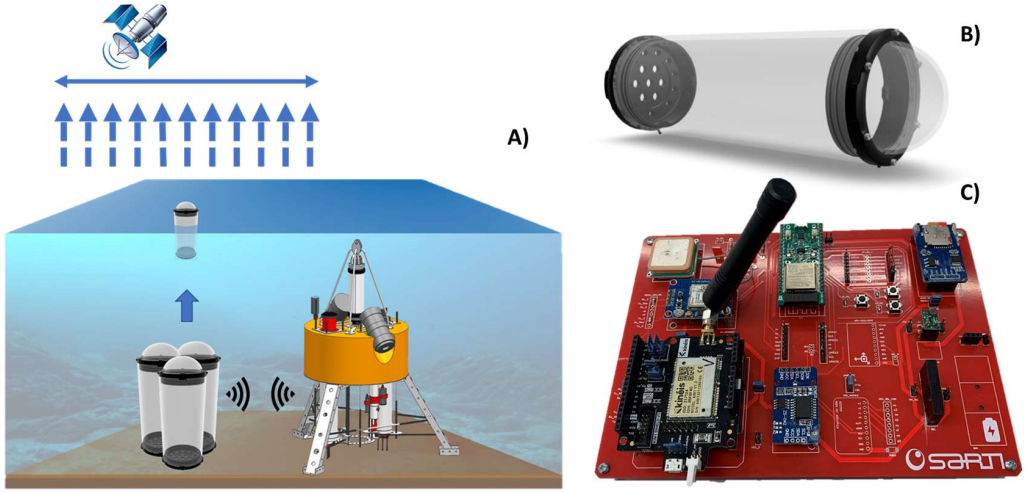

Fig. 1. A) Stand-Alone oceanographic platform together with the under-design pop-up buoy. After the release, the buoy transmits the oceanographic data on the satellite passes, B) 150mm in height and 75mm in diameter Blue Robotics cylinder C) Pop-Up development board

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