M5 OPERATIONAL VALIDATION OF GIRONA500 AUV

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Abstract
GIRONA500 is a lightweight 500 meters rated hovering type AUV designed and built at the University of Girona. It has been conceived as a highly reconfigurable research platform, able to carry our advanced research in marine robotics as well as an applied research in applications like science or cultural heritage. During the summer 2012, GIRONA500 was operationally tested as a high-resolution opto/acoustic imaging platform in 2 cruises: CALDERA and "La Lune". This paper reports the experience about the operational use of the AUV.

Keywords – Marine Robotics, AUV, Seafloor Mapping.

I. INTRODUCTION
GIRONA500 AUV was the result of the GIRONA500 Subproject of the RAUVI Spanish funded coordinated project, which had the aim of building a low cost, low weight intervention AUV. During the design, our team tried to conjugate two goals: 1) Building a flexible and reconfigurable platform for advanced underwater robotics research and, 2) Building an operational capable vehicle. The project started in 2009, and the first dive in a water tank happened at the end of 2010. Since then, the AUV has been successfully used in 2 Spanish (RAUVI & TRITON) and 3 European projects (TRIDENT, MORPH & PANDORA) achieving objective 1. During the summer 2012, two cruises were scheduled to face objective 2: making GIRONA500 AUV an operational vehicle for field operations up to 500 m. This paper presents the vehicle and its operation validation in CALDERA12 EUROFLEETS and "La Lune" cruises.

II. GIRONA500 AUV
The GIRONA500 (Fig.1) is a compact-size AUV designed for a maximum operating depth of 500m. The vehicle is built around an aluminium frame, which supports three torpedo-shaped hulls as well as other elements like the thrusters. The overall dimensions of the vehicle are 1m in height, 1m in width, 1.5m in length and a weight (on its basic configuration) of about 140 Kg. The two upper hulls, which contain the flotation foam and the electronics housing, are positively buoyant, while the lower one contains the more heavy elements such as the batteries and the payload. This particular arrangement of the components provides the vehicle with passive stability in pitch and roll, making it suitable for tasks requiring a stable platform such as video surveying or intervention. The most remarkable characteristic of the GIRONA500 is its capacity to reconfigure for different tasks. On its basic configuration, the vehicle is equipped with typical navigation sensors (DVL, AHRS, pressure gauge and USBL) and basic survey equipment (profiler sonar, side scan sonar, stereo camera and sound velocity sensor). In addition to these sensors, almost half the volume of the lower hull is reserved for mission-specific payload, which allows an easy modification of its sensing and actuation capabilities, as required. A similar philosophy has been applied to the propulsion system which can be set to operate with a different number of thrusters, ranging from 3 to 8, to actuate the necessary degrees of freedom and provide, if required, some degree of redundancy.

III. FIELD VALIDATION
During the summer 2012, GIRONA500 was operationally tested as a high-resolution opto/acoustic imaging platform in 2 cruises: CALDERA and "La Lune".
A. CALDERA 2012 cruise
During the cruise GIRONA500 performed 20 dives. Dive 1 was dedicated to the calibration of the multibeam-heading sensor. Dives 2-4 revealed problems with the acoustic telemetry. Beyond 150 m depth, the robot disappeared from the USBL tracking system. Those dives were automatically aborted after a pre-programmed timeout and before starting the actual mission. The issue about the USBL tracking was then systematically investigated in dives 5-10. In those dives the robot was deployed from the ship crane to the bottom of the caldera. Different operational configurations were investigated until we found that the noise generated by the thrusters was disturbing the USBL at depths beyond the 150 m. During the dives, an alternative transponder and an alternative transponder location were found and the system was reconfigured. Dives 11 to 14 were devoted to solve engineering issues and dive 15 was the first operational dive. It consisted in a square trajectory at 20 m altitude while gathering multibeam data. During dive 16, the robot explored the northing-base hydrothermal site at 10 m altitude, gathering multibeam data. In Dive 17, the WHOI mass spectrometer was mounted on the robot payload area. The robot was programmed to perform the same survey but a 4 m altitude capturing monocular imagery, multibeam and spectrometric data. A significant drift was observed during the mission in the USBL telemetry. The robot was recovered far from the expected recovery point. Next, dive 18 performed a vertical profile followed by a small square trajectory at 3 m altitude to test visibility and dive 19 targeted the northing base again at low (3 m) altitude, but the navigation still drifted. Under the hypothesis that the navigation drift was due to interference from the mass spectrometer, we decided to remove it for the final survey in dive 20. In this dive, the mission consisted on the execution of a bathymetric survey over a lava landslide found at depths between 280 and 330 m and covering an area of approximately 230 x 300 m. The vehicle flew 15 m over the seabed. The mission was carried out as expected and the USBL telemetry tracked the expected trajectory.
B. The Survey of a XVII Century Shipwreck
The GIRONA500 AUV was deployed from the R/V Bon Pigal. This 24m vessel illustrates an important advantage of low-weight AUVs, which can be deployed from small ships. Also, the ship's 200Kg crane was enough for the deployments and recoveries of the AUV. The data were collected in two consecutive dives of one hour each. At the nominal survey altitude of 3.45 m, the imaging setup leads to a pixel footprint of 0.66mm. Such high ground resolution enables accurate artefact interpretation while allowing for a safe navigation clearance from the bottom. Part of the data collected during the survey were used to rapidly produce a highly detailed optical base map of the whole site. This map was created using an offline, batch optimization approach based on monocular image registration in 2D. This process encompasses the following steps: (1) image preprocessing for the correction of lens distortion, uneven illumination and loss of contrast; (2) feature based pairwise image matching; (3) Global alignment, (4) Image blending, and (5) texture draping over the acoustic bathymetric data previously collected by IFREMER. The acoustic bathymetry was also used to provide ground control points as additional constraints in the global alignment step.

IV. CONCLUSIONS
This paper has reported the operational validation of GIRONA500 AUV in two field cruises: CALDERA2012 and "La Lune". In these cruises, the optical and acoustic mapping capabilities of the vehicle have been demonstrated. The conjugation of the operational and advanced research capabilities of the robot is not an easy task, since often they have contradictory needs. Nevertheless, this is a challenge path that we must follow if we want to achieve new field capabilities.

V. ACKNOWLEDGEMENTS
This research was sponsored by national (COMAROB project - DPI2011-27977-C03-02) and European projects (Eurofleets CALDERA 2012 grant n. 228344, PANDORA project - FP7-ICT-2011-7-288273 and MORPH project - FP7-ICT-2011-7-288704).

Fig. 1 (Left) GIRONA500 being deployed at Santorini (Greece) Caldera. (Middle) GIRONA500 being deployed at "La Lune" Shipwreck. (Right) 2 Amphorae and a canon of "La Lune" Shipwreck.