ON THE SETUP OF AN OPERATIONAL AUTONOMOUS UNDERWATER GLIDER FACILITY

S. Cusi[1], M.Torner[1], M. Martinez-Ledesma[2], D. Roque[1], J.P. Beltran[1], S. Ruiz[2], B. Casas[2], C. Castilla[1], I. Lizaran[1], S. Lora[1], E. Heslop[2], J. Tintore[1,2]

[1] SOCIB, Balearic Islands Coastal Observing System, Palma de Mallorca, Spain

[2] IMEDEA (CSIC-UIB), Mediterranean Institute for Advanced Studies, Esporles, Spain

Abstract *– We present the evolution, from its conception until today, of an established and internationally recognized Glider Facility. During 8 years of glider activity, new infrastructures and methodologies have been developed increasing glider missions, data, quality and availability. From 2005 to 2010, IMEDEA operated 4 Slocum G1 gliders following a research project approach. Since 2011, SOCIB, with in kind contribution from IMEDEA, is in charge of gliders' operation and maintenance, increasing the glider fleet with 4 new vehicles (2 Slocum G2 gliders and 2 iRobot Seagliders). SOCIB has established one permanent endurance line in the Balearic Islands and provides open access glider time to third parties. We describe the progress of the Glider Facility, the results obtained and the objectives and actions foreseen in the near future.*

Keywords *– Autonomous Underwater Glider, Operational Oceanography, Western Mediterranean Sea, Meso and Submesoscale variability, Glider Observatories*

I. INTRODUCTION

Underwater gliders are growing in number worldwide and their applications are still being extended to multiple domains. These efficient buoyancy-change propelled AUVs [1]–[3] are to complement Argo floats [4] covering coastal areas and giving this way a more complete view of our oceans. Unlike Argo floats, gliders' ability to dive for months following a programmed trajectory, allows scientists to observe repeatedly the same area –endurance line–, or to monitor a specific process, such as an eddy. The possibility of mounting new commercial and custom sensors enhances their potential and predicts a promising future for these platforms.

With mature and reliable gliders, Stommel's futuristic view [5] is becoming a reality 25 years later. Governments are funding initiatives to systemize the use of gliders for ocean monitoring. IMOS in Australia or IOOS in USA are two remarkable examples. In Europe, JERICO FP7 project includes gliders in a joint coastal observation infrastructure; PERSEUS FP7 project also includes significant glider activity in the Mediterranean. GROOM FP7 design study focuses on a glider observatory for marine research and operational oceanography in line with MYOCEAN2 project. Aside of that, there is an initiative to unify worldwide glider activity and standards [6].

IMEDEA and SOCIB [7] are actively involved in the development of the European glider observatory by participating in the above mentioned projects. IMEDEA acquired the second European glider in 2005 in the frame of the EU funded MERSEA project and, since then, it has been one of the pillars for the promotion of glider technology in Europe [8]. SOCIB Glider Facility took over IMEDEA's gliders operations in 2011, increased the fleet to 7 units –one Slocum G1 shallow glider, two Slocum G1 deep gliders, two Slocum G2 deep gliders and two iRobot Seaglider 1KA– and is maintaining a semi-continuous endurance line in the Mallorca and Eïvissa channels while providing glider time to external users.

II. SOCIB GLIDER FACILITY

The Glider Facility is one of the eight facilities that form SOCIB, a multiplatform observatory focused on the Balearic Sea and Western Mediterranean. After almost three years of taking over IMEDEA's gliders operation, SOCIB's Glider Facility reached its operational phase and is technically ready to maintain permanent endurance lines and to offer glider time to third parties –Open Access.

A. Infrastructure and personnel

From the acquisition of the first Slocum glider in 2005 until nowadays, the physical structure for glider operation has been similar as the essential components needed to run glider missions do not change. Until SOCIB took over gliders' operation, a ballast tank and a crane to lift the gliders were the most visible infrastructures. Gliders shared labs at IMEDEA with other instruments. Regarding personnel, one engineer was in charge of glider management, maintenance and operation; with the intermittent support of one instrumentation technician (Fig. 1).

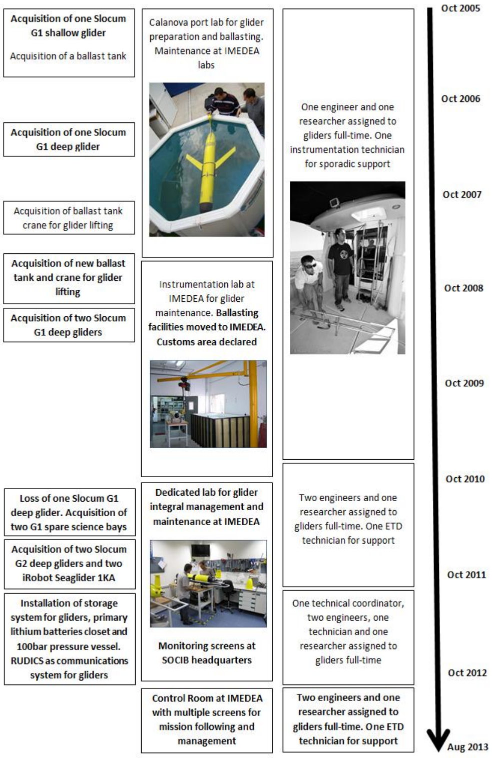

Fig. 1. Evolution of the Glider Facility. On the left, acquisitions; in the center, labs and spaces; on the right, involved personnel. In bold, still being used

By the end of 2010, SOCIB hired two full-time engineers and equipped one of the IMEDEA labs to be exclusively used for glider management, maintenance and operation. During 2012, major improvements to the infrastructure were done to increase glider reliability –RUDICS became the primary communications system between gliders and land server substituting PSTN, left as a backup; and a 100 bar pressure vessel capable to accommodate a full glider was installed, diminishing considerably water leaks and sea test time. One facility coordinator and one full-time technician were incorporated to implement these new systems and to overcome a period of failed missions. The acquisition of four new gliders, two of a different nature, implied an extra effort that reinforced the need of personnel. In 2013, with the new SOCIB capacity of refurbishing Seagliders –up to now platforms not open to users–, these will join the same working scheme the Slocums follow. Also, primary lithium batteries have been used for the first time in Slocum gliders, which will reduce the number of lab interventions on these platforms.

From the beginning, one researcher has been leading glider missions and several PhD students and postdocs have been working on glider data. Aside of that, SOCIB's Modeling Facility is incorporating glider data for model validation and specific process studies.

B. Mission protocol

Initially, a basic check was performed to the glider before the mission's deployment and a final mission report was generated. The issues encountered with deep gliders, especially leaks, urged the adoption of the manufacturer's pre-deployment checklist by the end of 2008. This checklist was customized and extended during 2011.

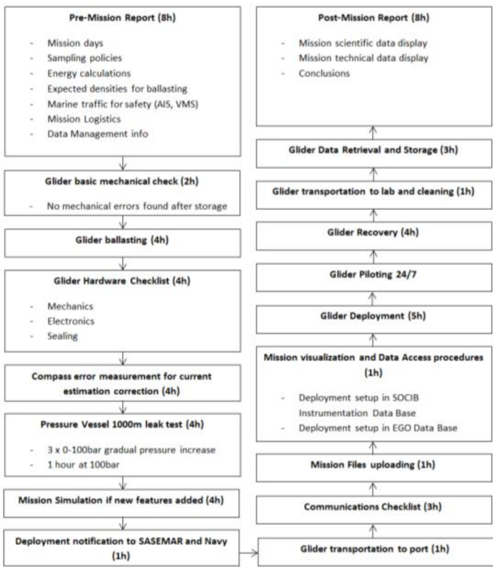

Fig. 2. SOCIB's mission procedure for Slocum gliders

In 2012, after a period of glider failures –mainly leaks and satellite communications

issues–, glider preparation was improved and became more complex. The checklist was split into independent parts that could be carried out by different people at different times (Fig. 2).
Before a new mission is run, an engineer spends approximately 42 hours preparing it. Once finished, about 16 hours are needed to close the mission procedures.

In 2013, an effort to push Seaglider procedures to those established for Slocums is being done.

C. Data Management

SOCIB gliders are set to transmit about 15% of the data via Iridium satellite communications when surfacing (Near Real Time, NRT). With these data and the deployment features, set by the glider pilot on SOCIB's Instrumentation Data Base, the Data Centre's scripts –basically composed of the Matlab toolbox started in 2006– generate three levels of NetCDF files addressed to different end users –L0 containing raw data; L1 performing QC, correcting the thermal lag effect [9] and defining the different profiles; L2 binning the data and providing vertical instantaneous profiles. These NetCDF files are available online in NRT through the Thredds catalog for Slocum gliders (Fig. 3).

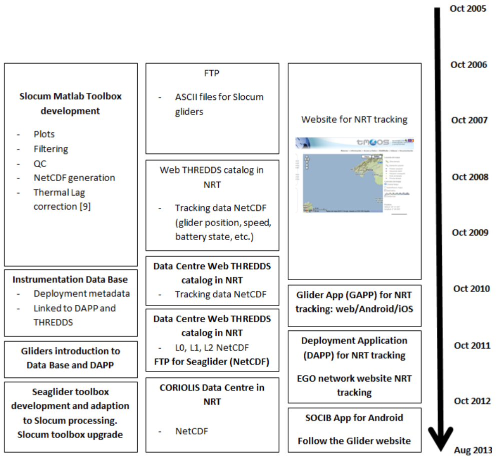

Fig. 3. Evolution of glider Data Management. On the left, new tools development; in the center, dissemination data formats and sites; on the right, display of glider activity. In bold, still being used

In an international level, SOCIB glider data are disseminated through Coriolis Data Centre and its gliders' activity shown on the EGO Website. In Delayed Mode (DM), when the glider is recovered, the complete dataset is processed by SOCIB's Data Centre and NetCDF files are generated and made available. Seaglider data will be treated in the same processing chain for Slocums by the end of 2013.

D. Operations

The labs SOCIB uses nowadays are located in Esporles, 20 km away from the Calanova port, were the vessels are docked. Ground transportation means (Fig. 4) are needed to overcome this distance and to perform deployments or recoveries from casual ports, where the Valiant rubber boat can be slid into the water from a ramp.

The use of the Zodiac Hurricane, since mid-2012, reduced deployment/recovery time from one day to half day. It also allows for fast and independent of SASEMAR emergency recoveries up to 60 miles off the coast. The new 24m Rodman Catamaran R/V can be eventually used for a far emergency recovery complementing SASEMAR rescue services and also for a multi-glider experiment.

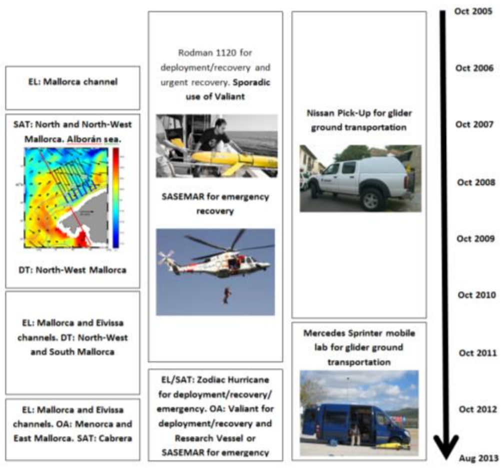

Fig. 4. Operational features. On the left, areas of operation; in the center, water operation means; on the right, ground transportation means. In bold, still being used.
EL: Endurance Line; SAT: Satellite related missions, DT: Depth Tests; OA: Open Access

III. OPERATIONAL RESULTS

From the end of 2006, when the first glider was ready to be used, 48 missions have been done (Fig. 5) –some of them required an emergency recovery. Aside of those, a considerable number of one day technical tests at sea have been performed.

Until 2011, missions were project driven; mostly focused on combining glider measurements with satellite altimetry, such as in [10]. Some research was also carried out in the field of path planning techniques for gliders, [11]. Those missions took place when the PI required them and their duration was of 10-15 days. SOCIB's implementation of an endurance line [12] in 2011 increased the frequency and duration of the missions to about 23 days; consuming an entire alkaline battery pack. The objective was to allow a maximum of one month between missions in order to capture the variability in the Mallorca and Eïvissa channels. In 2013, SOCIB run the first glider mission in the JERICO Trans National Agreement program with a primary lithium powered Seaglider. This 44 day mission, devoted to sample the central part of the Algero-Provencal sub-basin [13], was the longest ever performed by SOCIB.

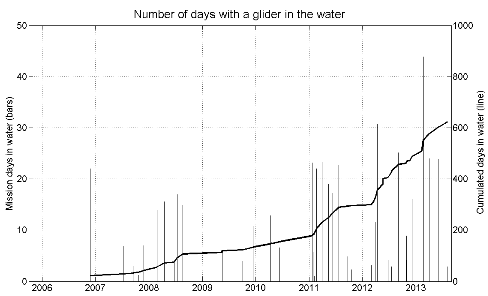

Fig. 5. Performed missions with their duration in days. The line indicates gliders' cumulated time in the water.

IV. CONCLUSIONS AND FUTURE WORK

Each one of the aspects that compose the Glider Facility has evolved at a different pace during these 8 years. Today, the Glider Facility is compact and has reached a stable phase; it can be considered operative and ready to take new challenges.

For 2014, SOCIB plans to turn the semi-continuous endurance line into a continuous one, having a glider sampling it 365 days/year. Aside of that, it is planned to keep with 90 days/year of Open Access glider time yearly. In 2015, a new endurance line is foreseen; planned to be working 365 days/year in 2016. This will make 820 days/year of glider time in the water in 2016. Such level of activity will require the development of automatic piloting tools to relief manual glider piloting. The Glider Facility will participate actively in defining GROOM standards –such as sensor validation or data management methods– and will adopt them to provide high quality data to users worldwide.

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