Helping marine science reach new depths

The development of underwater and wave gliders has provided two new and flexible platforms for marine observation. **Dr Laurent Mortier** discusses current EU efforts to create a supportive infrastructure for these platforms to ensure they effectively feed into marine observation objectives at global level

Could you begin with an overview of Gliders for Research, Ocean Observations and Management (GROOM)? What led to its establishment?

The main objective of GROOM is to design a European Research Infrastructure that uses underwater gliders for the benefit of research and industry. Gliders are new marine platforms requiring highly-skilled personnel and a strong network of organisation. The even newer wave glider – a surface vehicle with promising capabilities – has similar characteristics and is being included in the GROOM activity. An EU Seventh Framework Programme (FP7) project was the perfect tool to establish the right infrastructure for that and above all to overcome the challenge of avoiding fragmentation in the establishment of such an infrastructure at national and international level.

How do you foresee the integration of this work developing? What challenges are associated with this?

Gliders represent a very attractive platform for research in a wide range of marine sciences. This first led to the EGO initiative, yet issues of sufficient finance for effective research and organisation of hardware remained. GROOM allows for the integration of national initiatives started in labs to ensure good science and observations are made and they reach governmental level so finance is made available. What makes glider research different from other marine platforms is the extent to which the infrastructure is distributed between many countries with glider ports where gliders are serviced, controlled and data stored. This requires a very strong network of workshops, computers and personnel. The logistical challenges are therefore huge.

Can you outline the purpose of the Global Ocean Observation System (GOOS) and how GROOM will become integrated into its objectives?

GOOS is a permanent global system for observations, modelling and analysis of marine and ocean variables to support operational ocean services worldwide. The main GOOS infrastructure at present relies upon the ~3,000 ARGO profilers which are freely drifting devices scattered in the global ocean. As ARGO profilers cannot be directed towards specific locations with higher interest, there is a need for a versatile platform that can be steered. Against this context, the goal of GROOM is to fill the gaps left by other devices including profilers, moorings and boats. As gliders can remain in the sea for a long time, move over large distances and be sent to specific regions of interest, they are now the best candidates.

What biogeochemical and bio-optical properties do gliders try to analyse? Are there scientific innovations driving this understanding forward?

Gliders have versatile payloads and can be used to collect a large number of types of data. This includes basic ocean variables such as temperature and salinity, but also biogeochemical data including oxygen and nitrates measured by optical sensors. In the near future, they will be able to collect additional optical proxies and even images, suitable for biological data and species recognition. This new capability will offer researchers high-density information on the plankton ecosystems being observed. In addition, acoustic sensors can provide useful information for higher trophic levels by listening to the noises made by these larger animals.

What role does industry play in driving innovation and how does GROOM facilitate industry in trying to successfully utilise oceanic resources sustainably?

Gliders were initially developed by US labs, including the Webb Research Corporation, which is a company tightly linked to the Woods Hole Oceanographic Institute and the Massachusetts Institute of Technology. These partnerships allow for the effective exploitation of technological breakthroughs. This collaboration between oceanographers, engineers and industry has underpinned the success of the gliders. Gliders cannot be developed without industry as they are very complex systems. Companies are interested in them because gliders are multipurpose and can also be used for industrial applications, in particular by the oil and gas sector. Moreover, the wave glider is a pure industry-driven

The slocum glider 'Crate' and the wave glider 'Hermes' being deployed for the TOSCA experiment in the North Western Mediterranean, Nov 2011.

project of an US company with environmental and business motivations.

In Europe we are not as advanced in such partnerships. This is now a priority for the EC in particular for building marine instrumentation. To this end, GROOM promotes the integration of innovative optical sensors developed by European companies and labs which can provide interesting data on hydrocarbons for pollution monitoring. Acoustic sensors that can measure wind and rain at the surface will also be integrated on gliders. Field measurements are planned in GROOM to demonstrate the interest of such sensors.

Finally, can you outline the perceived benefits to society as a result of remote platforms?

The benefits such platforms can bring should be compared with meteorological services that rely on a global network of daily measurements. The same services must now be delivered for the ocean. This is being spearheaded by MyOcean, which delivers products such as tailored datasets for specific goals. For this, a large amount of data is required, and so MyOcean aggregates datasets from a broad array of platforms, including gliders. This benefits research of course, but it also benefits society. A good example is the monitoring of heat contained in the ocean – which is vital for addressing climate change – and here gliders can bring invaluable information where profilers cannot operate. The situation is the same for ecosystems and biodiversity where other platforms are useless or prohibitively expensive.

At a more local scale, there are pollution problems around coastal areas near cities or due to accidental oil spills. Gliders are able to deliver accurate information in these areas. There is also a need to ensure industry does not cause excessive destruction to the marine environment, which again provides societal benefits. All these aspects fulfil the aims of the EU's Marine Framework Directive. To help deliver this, efficient marine platforms and infrastructures such as GROOM are necessary.

Into the depths

Initiated in 2011, the GROOM project is making significant headway with creating and evaluating a new European glider infrastructure, using both underwater and wave gliders for monitoring and sampling oceanographic data

MARINE OBSERVATION is not a new field. Since the time of Elizabeth I and Napoleon III, collaborative efforts have been made ensure safe shipping conditions and this gave birth to the World Meterological Organization (WMO). More recently, a large cooperative effort with oceanographic vessels has supported the World Ocean Circulation Experiment conducted by the global ocean community, mapping for the first time the global thermohaline circulation. However, despite the many advantages to these vessels, including voluntary observing ships and free drifting profilers, significant gaps remain in ocean monitoring and sampling activities. In the late 1990s, underwater gliders equipped with miniaturised sensors were developed to address these knowledge gaps. These gliders are controlled remotely and have the ability to move over vast distances, making extensive and complex studies of the ocean more viable and accessible.

Underwater gliders are a novel type of autonomous underwater vehicle (AUV). They can control their own buoyancy and thus move vertically. Thanks to their wings they can change these vertical motions to forward movement. This saw-tooth trajectory from surface down into the depths of the ocean can be done with minimal power consumption and long-term missions can therefore be organised. At present, several types of underwater gliders are being used in the ocean (Oceanographic labs for research, by national Navies, monitoring during the Blue Horizon disaster, etc.) because of their flexibility, durability and longevity. These novel devices are capable performing ocean sampling missions lasting weeks or even months, covering thousands of kilometres of range. Furthermore, the recently developed wave glider can remain at surface and propel itself forward by harvesting wave energy. It also carries several sensors and can travel almost indefinitely as it recharges its battery with solar panels.

Underwater gliders are used to take measurements from surface to depth such as temperature, salinity, currents, turbidity, fluorescence, dissolved oxygen and other optical and acoustic measurements. The wave glider performs similar measurements at the surface and can also record atmospheric parameters.

The potential of underwater gliders and wave gliders is vast, including their ability to detect hazardous or toxic substances in the ocean, as well as biological, chemical and radioactive threats. They also allow researchers to track water masses for their physical and biogeochemical properties and collect thorough information on the health of marine ecosystems (eg. ecosystems shifts, eutrophication events, etc.).

THE GROOM PROJECT

The capability of gliders as observation platforms is clear, but at present, there is a pressing need to create an infrastructure upon which data can be effectively acquired, utilised and translated into useful services for global level research, industry and societal benefit. The Gliders for Research, Ocean Observation and Management (GROOM) project is a design study for a European glider Research Infrastructure (RI). The project is part of the EU Seventh Framework Programme (FP7) and coordinated by the Université Pierre et Marie Curie. The consortium comprises 19 European partners from different countries (France, Germany, Finland, Greece, Italy, Spain, the UK,

GROOM

GLIDERS FOR RESEARCH, OCEAN OBSERVATION AND MANAGEMENT

OBJECTIVES

To design a new European research infrastructure to use underwater gliders for the benefit of European citizens, researchers, and industry. GROOM will define the scientific, technological and organisational/legal levels, of a European glider capacity for research and sustained observations of the oceans, in line with the other European and international initiatives for marine *in situ* observations.

PARTNERS

UPMC, France • **UCY**, Cyprus • **IFM-GEOMAR**, Germany • **HZG**, Germany • **AWI**, Germany • **UT**, Germany • **FMI**, Finland • **CNRS**, France • **Ifremer**, France • **HCMR**, Greece • **NURC**, Italy • **OGS**, Italy • **UIB**, Norway • **NERSC**, Norway • **CSIC**, Spain • **PLOCAN**, Spain • **SAMS**, UK • **UEA**, UK • **NERC-NOC**, UK

FUNDING

EU Seventh Framework Programme (FP7) – contract no. 284321

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Norway and Cyprus), which strengthens the importance of their research efforts.

Since its inception in October 2011 – and with an overall duration of three years – GROOM has set out to demonstrate a number of objectives, including:

- The creation and distribution of 'gliderports,' not only in Europe, but also overseas
- Keeping costs to a minimum and providing effective cooperation and coordination whilst operating glider fleets simultaneously with other traditional observing systems
- Maintaining a suitable glider infrastructure for continuous effective monitoring and research activities
- Offering a world-class service to those associated with research and environmental monitoring

The group hopes to assess and evaluate the use of a roadmap – for adhering to a number of short- and long-term goals – and tools for the implementation of a sustained and coordinated glider component that meets the standards and expectations of a European Network of Marine Observations, eg. contributing to the Global Ocean Observation System (GOOS). The focus is on delivering a safe approach to operating large fleets of gliders, as well as individual vehicles, much like air traffic control at an international airport. This should ensure that multitudinous observations can be made effectively in a safe way.

The potential impact of GROOM has recently been analysed in a vision statement, created by the European Science Foundation's Marine Board. This statement stressed the paramount requirement for stability and integration in the marine observatories arena, 'installed and operated through multinational cooperation and support, providing consistent *in situ* data from the seas and oceans in support of the EU Integrated Maritime Policy and as a driver for smart, sustainable and inclusive growth in Europe'.

Given the number of teams addressing similar issues, this management project aims to reduce duplicate research efforts. GROOM has the ambition to become the 'glue' between the members of the ocean community that performs marine work to harbour creative investigations and provide useful applications, whilst avoiding 'copycat' work.

TASK MANAGEMENT

By following five Work Packages (WPs), GROOM is able to distribute time and labour effectively among each important area of the project. The WPs consist of:

- WP1: Scientific coordination – the first task for the project is to coordinate the partners' scientific and technological activities, so that they are in line with the other WPs and all the specific objectives. GROOM coordinators are hopeful that conforming to this WP will enable better communication, timing and evaluation of scientific work that has been and will be accomplished
- WP2: Integration in GOOS – three introductory actions regarding the creation and maintenance of a sustainable glider component in GOOS will be assessed. Here, in addition to the design of the glider component in the GOOS, monetary and legislative guidelines will be analysed, as well as a legal framework required by EU standards
- WP3: Scientific innovation – split into three tasks (developing sensors and sensor combinations, designing a glider data portal and providing innovative communication training), WP3 aims to improve Europe's research and development infrastructure
- WP4: Targeted experiments – existing glider data and metadata, eg. data flows, sensors, mission design, software and logistical aspects, is taken into consideration. During this WP, new techniques and methods will be tested at sea for a better assessment
- WP5: Observatory infrastructure – GROOM will define all architecture of the single glider port as well as the network of glider ports and data centres that need a dedicated IT infrastructure. Here all the operating costs will be analysed

FUTURE PLANS

The programme is in the process of creating the roadmap for the implementation of the infrastructure, these include: 'glider ports' for effective glider operations; free and accessible data exchange; soft and hardware services; rules for sensors; and organised steering of glider fleets. They will also be helping to integrate wave gliders, another exciting development in this developing field. A legal entity may be built to better support these activities.

Optimal configuration of the RI that GROOM proposes will clearly be successful if it can conform to both marine research and operational oceanography requirements – performing both intense and innovative research studies and continuous monitoring, but keeping costs low. For this reason, underwater gliders and wave gliders show tremendous promise and could revolutionise future ocean observations while improving Europe's position in the global competitive research infrastructure.

2014

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