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SeaExplorer:

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ACSA's record-breaking glider confirms potential for scientific, commercial and military applications

To support scientific research and commercial activities at sea, technological developments have tried to reduce the reliance on ships, which have high and rapidly increasing operating costs, delivering robotic platforms ranging from remotely operated vehicles to autonomous underwater vehicles. However, because these platforms depend on support vessels (an economic drawback) and/or have relatively limited endurance (leading to short missions), the need for a cost-effective platform enabling affordable long-term and large-scale exploration and environmental monitoring of vast ocean regions still remains.

Underwater gliders show unprecedented promise as affordable subsea data collection platforms. The technology provides the necessary tool for exploration and monitoring exploitation of the marine environment while assuring its long-term preservation. The power of the glider lies particularly in its ability to deliver low-cost data of the entire water column on a large spatio-temporal scale. Unlike AUVs, you can forget about the constraints of operating gliders in relative proximity to a support ship. Gliders are highly capable sensing platforms that can navigate completely autonomously for weeks on end, covering thousands of kilometres.

SeaExplorer navigating in a sawtooth path

This incredible endurance capability, enabling coverage on local, regional or basin scales, comes from the energy savings granted by the glider's propulsion system. While AUVs use a traditional electrical propeller, the principle of glider

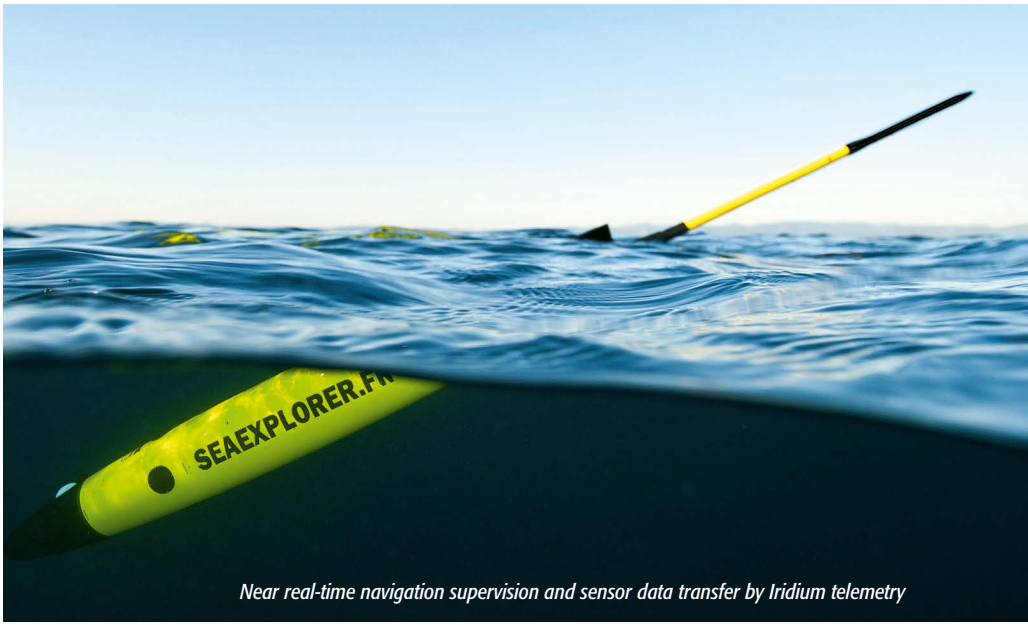
bags of potential

propulsion is based on buoyancy variation, which allows efficient navigation at low speed. Glider robotic platforms are designed to constantly collect a variety of data (physical, chemical, biological, acoustic, etc.) along the water column and to surface regularly to provide a GPS position fix and to establish a satellite communication link with a ground station. Data collected are then sent by Iridium telemetry while the supervision and piloting station, accessible from a simple web interface, also allows new navigation instructions to be sent back to the glider for any modification of the previously planned mission file. The integrated hardware and software suite allows 24/7/365 supervision of gliders from any place in the world as well as near-real time basic data examination and dissemination.

LOW LOGISTIC MULTI-MISSION GLIDER

In 2014, after six years of research and development, ACSA introduced the SeaExplorer glider to the market. The vehicle became the first autonomous underwater glider to be industrialised and manufactured in Europe. Robust, cost-effective and easily deployed, it supports autonomous, long-term, large-scale, in-situ ocean exploration, monitoring and protection operations.

Multi-purpose capability is enabled by the modularity provided by an interchangeable sensor payload section which includes flooded and dry sections, open source firmware and an auto-ballasting mode. Engineers have designed the vehicle so that users can quickly and easily replace the scientific payload section with another nose section already equipped and available off-the-shelf. There is no longer a need to dismantle the vehicle and have technicians spend a few days adjusting the buoyancy and trim of the vehicle, provided that the glider operates in the same salinity environment. This makes SeaExplorer a real multi-mission glider.



Near real-time navigation supervision and sensor data transfer by Iridium telemetry

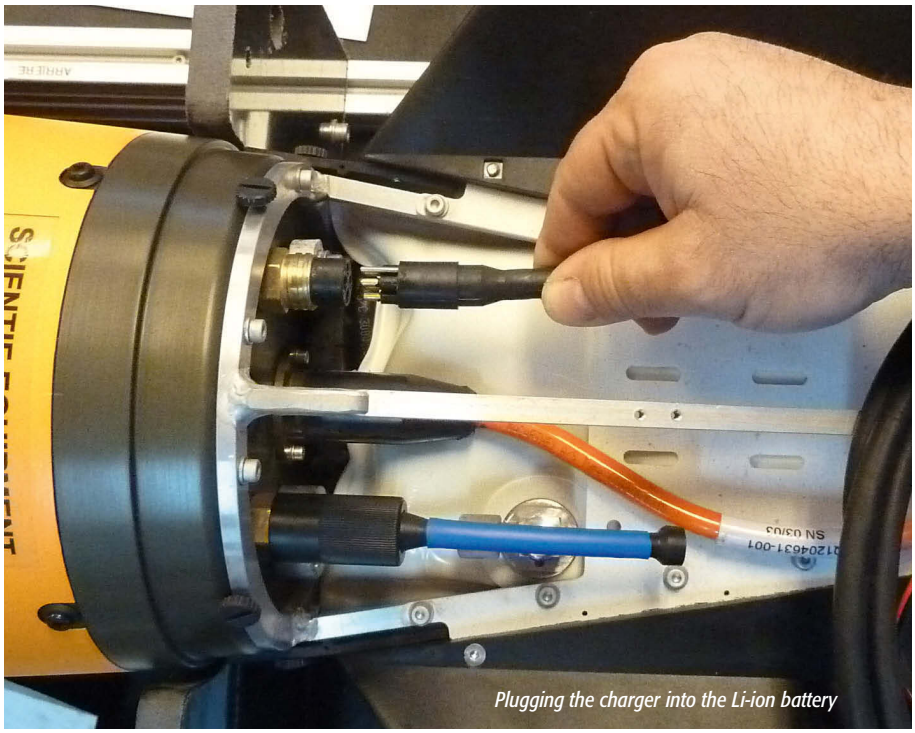
FIELD PROVEN

SeaExplorer has proven its capabilities in the operational environment. In 2013, the glider broke a double world record (distance and duration) for an unmanned underwater vehicle powered by rechargeable batteries. With a single battery charge of 20 hours, it completed a 60-day mission and 1200 kilometres, averaged a speed of 0.5 knots and provided more than 1168 profiles of the water column (from near surface to 500 metres depth), with communications 100% successful, even in high sea states. Supervised by satellite telemetry from an onshore office using IRIS software, the mission was manually stopped with internal parameters indicating that 18% of the glider's battery energy still remained. Since this success, the company has been continuously deploying the glider so as to increase SeaExplorer's level of reliability and implement new developments.

INCREASING COMPETITIVENESS

While there is no doubt that there is a strong demand for data that can facilitate knowledge in ocean science and help effective decision-making in the industrial and civil domains, this market is being tempered by the cost of this data to industry, government and academia.

Gliders are renowned for their endurance at sea and their cost-effectiveness. Traditional methods cost approximately 20 times more per sample. With gliders being largely vessel independent, savings can reach up to 13,000 to 42,000 euros (GB£10,000 to GB£33,000) per day. Put



Plugging the charger into the Li-ion battery

another way, one week's use of a small research ship would pay for the acquisition price of a SeaExplorer unit.

In fact, SeaExplorer's value goes far beyond typical glider cost-efficiency standards thanks to the savings a rechargeable glider brings to operations. All gliders are traditionally powered by primary alkaline or lithium batteries. However, SeaExplorer has seen the introduction of rechargeable lithium-ion batteries. This smart design greatly helps glider reconditioning operations between missions, to a point never achieved before on gliders. This green technology means free reconditioning, removing forever the need for battery replacement and the related tricky ballasting operation. Recharging can be done by a workforce with a low level of expertise, whereas traditional gliders require at least one week of two full-time technicians' time to replace primary alkaline (required every two months) and lithium (required every four months) batteries. SeaExplorer only requires 20 hours for refuelling! Immobilisation time is reduced by 40 to 80%, enabling unprecedented availability of the glider for almost continuous missions. And finally, the absence of having to open/close the vehicle after each mission makes the glider safer and should demonstrate an increased MTBF (mean time between failure). As a result, with six months of annual at-sea operations over a five-year period, rechargeable batteries save on average US$145,000 (GB£86,000) per glider on the sole cost of primary battery reconditioning. It is worth calculating the total cost of ownership (TCO), taking into account annual reconditioning costs (batteries and technicians-hours), to realise that SeaExplorer's TCO is half that of traditional gliders.

Given this drastic cost reduction, the affordability of data delivered by SeaExplorer should increase the regularity of monitoring, largely improve the coverage of areas being environmentally monitored, and accelerate the development and deployment of this platform in new markets. Moreover, using such a cost-effective capacity for long-term exploration and environmental monitoring should increase the competitiveness of the existing and new 'Blue Economy' and facilitate the sustained exploitation of ocean resources, increasing efficiency in resource use and performing safe offshore operations.

A RANGE OF SCIENTIFIC, COMMERCIAL AND DEFENCE APPLICATIONS

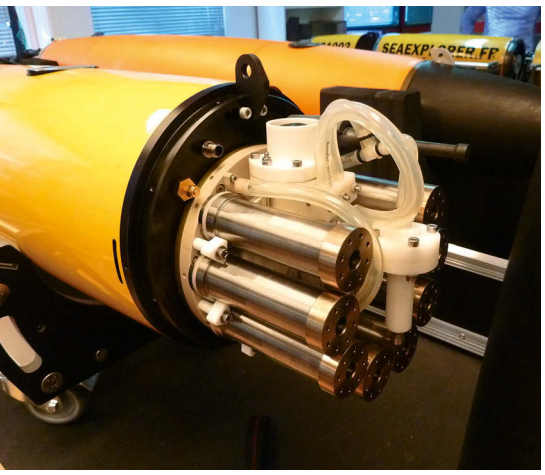
Although originally developed to improve the scientific capability of observing and understanding the water column, SeaExplorer assumes great value in addressing specific targeted missions if specialised sensor suites are embedded. ACSA expects SeaExplorer to support programmes in oceanographic research, but its significant potential to several energy company majors and turnkey data service providers has also been identified. The range of sensing capabilities enables:

- monitoring of essential ocean variables and ecosystem-related parameters
- oil and gas-related parameters
- support of defence operations.

SCIENCE AND RESEARCH

Capable of carrying a wide suite of sensors, gliders are an excellent platform to autonomously monitor different aspects of the marine environment for long periods of time. This explains why the scientific and research sector, particularly universities and government organisations which conduct oceanographic monitoring of the planet's waters, has traditionally been the largest market for gliders. With increased concerns surrounding global warming, the pollution of the oceans and the strong effect the oceans have on the planet's weather, this should continue to be a strong market. The Mexican laboratory Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE), for example, uses the rechargeable glider to study ocean circulation and analyse the variability of the coastal current along a 600-kilometre transect, "more intensively than with traditional oceanographic means", according to Dr Emilio Beier of CICESE.

In Europe, within the frame of the FP7 project Arctic Climate Change Economy and Society (ACCESS), the laboratory LOCEAN, France, deployed its SeaExplorer unit to collect water column data along a 500-kilometre transect in the Barents Sea, between the polar front and the Norwegian town of Vardø. The ACSA field team performed services that included mission plan preparation, onsite glider preparation, sea trials and 24/7 piloting service from its premises located in the South of France. Another end-user, the French laboratory LOV, is finalising the implementation of a scientific



Mini water sampler developed by IFREMER

biogeochemical payload comprising a miniaturised optical nitrate sensor, together with basic (temperature, salinity and oxygen) and bio-optical (fluorometer, backscattering meter) sensors, on its SeaExplorer in order to study phytoplankton development in the Ligurian Sea. Although nitrate concentration, which is a key variable of biogeochemical and ecosystem models, is generally measured from a research ship during an oceanographic campaign, the equipped glider will be used to periodically cross the current, filling in a lack of sufficient nitrate concentration data on the datasheets.

OIL AND GAS

Although the commercial market, which is concentrated in the oil and gas sector, is still emerging and currently represents the smallest market for the glider business, it might be considered as the most promising for growth, with the potential for applications in exploration, ocean condition monitoring and environmental impact assessment at all phases of field development. Some strong challenges faced by the oil and gas industry lie in increasing sustainable practices and improving security, while reducing costs. Environmental concerns include oil discharges from routine operations, the use and discharge of chemicals, the settling of drill cuttings and the early warning of accidental hydrocarbon leakages or spills. The glider's capacity for the long-term and persistent monitoring of the marine environment surrounding the exploitation site could provide the oil and gas industry with the answers to these key issues.

The French Mediterranean Institute of Oceanography (MIO) has achieved significant advances in this field with the development of the miniaturised, low consumption MiniFluo hydrocarbon sensor. Since last July, MIO's SeaExplorer, equipped with the MiniFluo, has regularly performed sea trials in the Bay of Marseille, measuring water quality. Comparison of the results collected during the qualification campaigns with a laboratory spectrofluorimeter has confirmed the MiniFluo as field proven. This advanced sensor is particularly good at detecting crude oil contaminants, such as NAPHtalen and PHEnanthren, as well as the hydrocarbon compounds PYRen and FLUOren. So far, it is the sole hydrocarbon sensor technology available for persistent glider oil risk management missions.

DEFENCE SECTOR

In the field of naval warfare, to enhance battlespace characterisation, it is envisioned that gliders will conduct constant, stealthy, cost-effective and sustained surveillance of large hostile regions, carrying sensors into areas where it may not be safe for a manned platform to venture. In addition, since long endurance is fundamental for constant and sustained underwater anti-access and denial missions, gliders could also represent a desirable solution here. Last June, two SeaExplorers were deployed in the REP14-MED sea trial conducted by the NATO Centre for Maritime Research and Experimentation (CMRE) in the Sardinian Sea to enhance environmental knowledge and operational effectiveness (EKOE) capabilities. This large trial lasted three weeks and involved 21 partners and six nations. One SeaExplorer was used to collect physical ocean data in order to improve the performance of ocean forecast models, while the other glider was dedicated to the recording of underwater ambient noise. Once again, both gliders were operated by satellite telemetry from the ACSA control room in France. ■

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SeaExplorers deployed at NATO trial