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# SeaExplorer Glider Breaks Two World Records

*Multisensor UUV Achieves Global Milestones for Endurance, Distance*

**By Hervé Claustre • Laurent Beguery • Patrice PLA**

Ocean gliders are revolutionizing underwater surveys and missions for ocean data collection. Navigating autonomously in water for weeks or months, depending on the mission, and covering thousands of kilometers, gliders persistently collect a variety of data (physical, chemical, biological, acoustic, etc.) along the water column. Those data are then sent by satellite telemetry to a ground station, avoiding the need for a support ship.

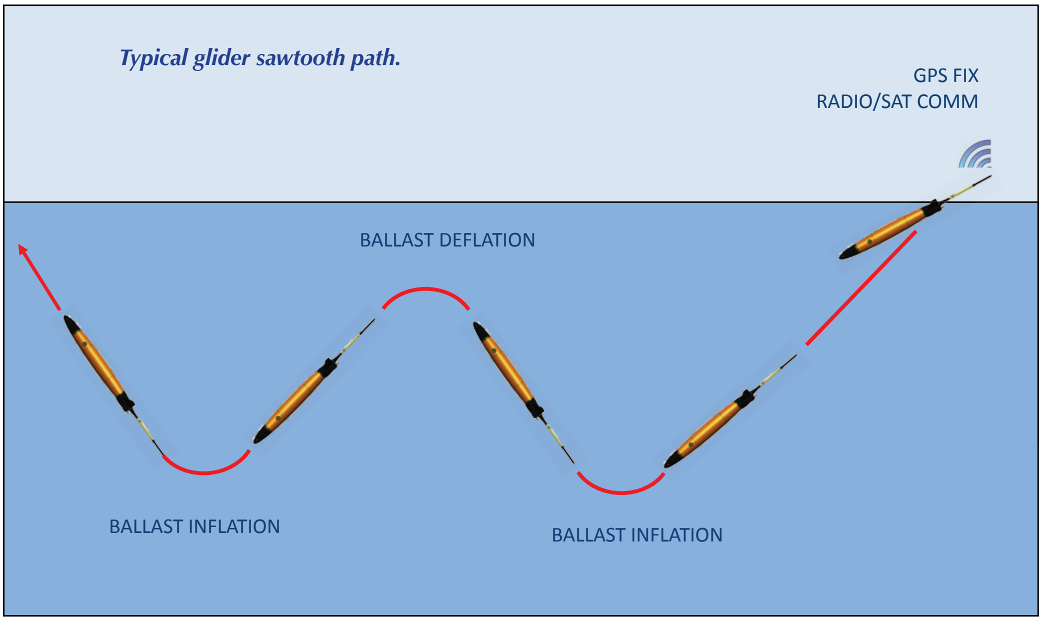
The main difference between a glider and an AUV is a glider's propulsion principle, which is based on buoyancy variation, instead of a propeller. This allows efficient navigation at low speed, resulting in lots of energy savings. Materials with higher density than water sink, and ones with lower density are buoyant. Materials with the same density remain stable in water. Most gliders change their density through an external bladder. When the bladder deflates, the glider dives and glides using wings. When the bladder inflates, the glider climbs to the surface and glides the same way. This results in a particular sawtooth path. The actuator allowing bladder inflation and deflation for propulsion is named the ballast. This propulsion device allows months of endurance, which makes for another big difference between gliders and AUVs, as well as making gliders a very convenient platform to collect data from the water column at a very cost-effective price.

In terms of telemetry, gliders regularly surface to establish a communication link for supervision, data transfer and piloting. Once its antenna is in the air, its GPS position is computed and data collected are transmitted by Iridium communication link to the control station based onshore. The supervision and piloting station (SPS), which is accessible from a simple Web interface allows, when required, new navigation instructions to be delivered back to the glider for any modification of the previously planned mission file.

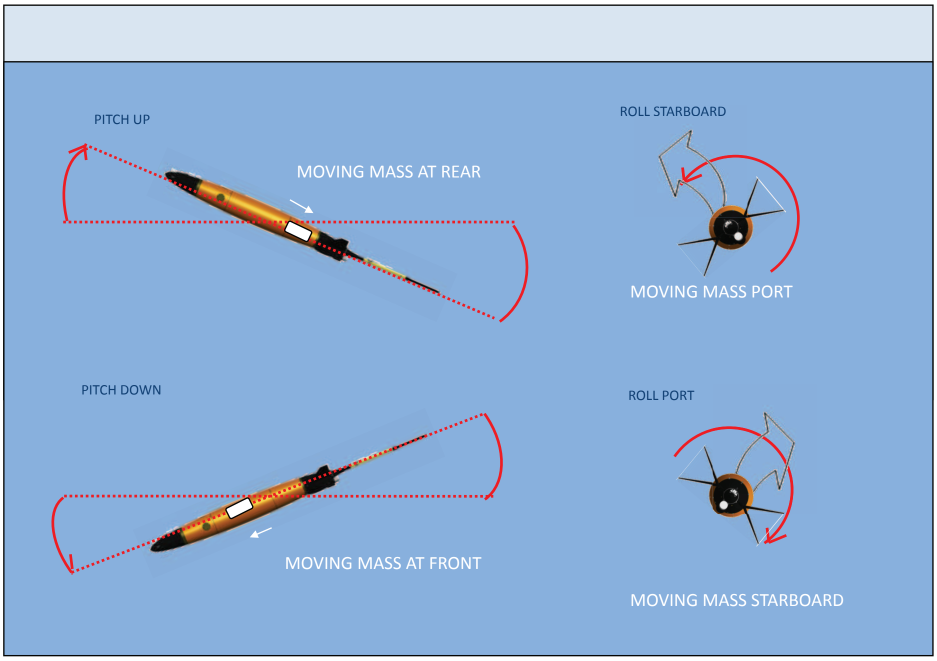
In some situations, close communication can be established with a glider by radio frequency giving convenient wireless access for test procedures before a mission or making recovery at sea easier.

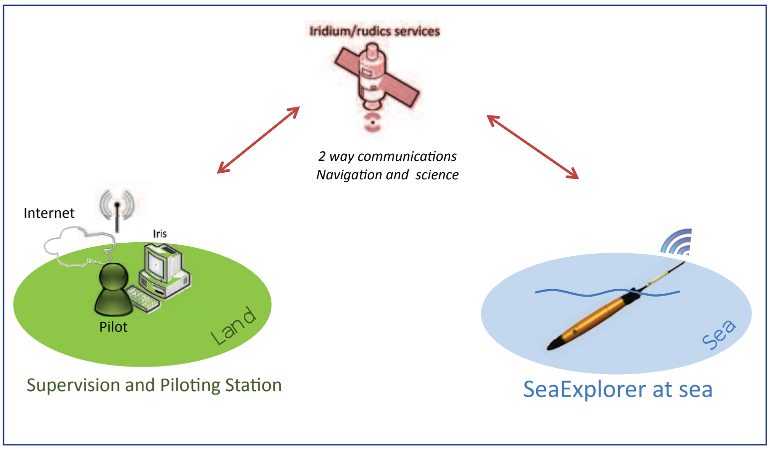
The first gliders were traditionally designed with wings. At-sea experiences demonstrated that this design was a drawback, leading to critical situations, such as wing break during launch/recovery or entanglement in seaweed, plastic debris or fishing nets. It explains why the latest generation of gliders now uses a typical hull shape and short fins instead of wings.

Another identified weakness of gliders designed with external actuators is that users have reported leaks at the mechanical interfaces over time. To tackle this problem, smart




*Typical glider sawtooth path.*




***(Top) Navigation using internal actuators. (Bottom) Telemetry for supervision, scientific data transfer and piloting.***

devices using internal mass displacement as internal actuators were designed and introduced on gliders. But for scientists, the strongest recommendations have always concentrated on a more open scientific payload architecture to finally achieve the capability to enable the integration of custom sensors by themselves.

With this idea came the need for sensor payload interchangeability and modularity. In terms of piloting, low speed (a particularity of gliders due to propulsion generated by the ballast) makes glider navigation quite challenging in current.

## SeaExplorer Design

The new SeaExplorer glider is a cooperation between the ACSA company (Meyreuil, France), several French oceanographic institutes such as Ifremer and the CNRS (Centre National pour la Recherche Scientifique), and ACRI-ST and ACRI-IN as industrial partners. Taking into account end-users' feedback, the SeaExplorer glider integrates lots of innovations.

First, the project resulted in a wingless platform design (no wing, no break). Benefits of such small wingspan fins include a reduced drag and less surface area subject to biofouling, which modifies buoyancy and compromises piloting.

The SeaExplorer is steered by two internal actuators for attitude. The first one displaces the moving mass forward and backward to pitch up/down, and the second one rotates the moving mass port and starboard for roll and heading control. Regarding attitude actuators, the SeaExplorer is fitted with long-range displacement, providing ease in piloting and more flexibility for glider calibration.

For propulsion, this glider has the biggest ballast volume (1 liter) to increase speed (1 knot horizontal) and navigation capability in current. This also grants the glider high ballasting dynamics and greater maneuverability, especially in shallow water. This ballast is extremely efficient in both shallow- and deepwater.

Communications with the glider are enhanced by using piloting commands instead of downloading long mission files. Synthetic frames are exchanged with the glider to make communications faster and more reliable.

Engineers have designed the vehicle to offer an interchangeable sensor payload. This way, scientists can easily and quickly replace sensor payload with equipped nose cone sections available off-the-shelf, depending on the mission. There is no need to open the "guts" of the vehicle and spend a few days adjusting the buoyancy and trim of the vehicle. As such, it can be said that the SeaExplorer is really a multimission glider. Furthermore, the scientific payload has open-source firmware for easier integration of custom sensors.

The SeaExplorer is powered by rechargeable batteries. Indeed, although all gliders on the market traditionally use alkaline or primary lithium batteries, ACSA is the first glider manufacturer to introduce rechargeable lithium-ion batteries as an effective, reliable and affordable solution for the market. This green technology means free reconditioning, low work force and no opening/closing of the vehicle after each mission, which makes it safer for the internal components and offers a highly cost-effective solution.

## Breaking Records

The SeaExplorer has completed a two-month record mission in collaboration with the Laboratoire d'Océanographie de Villefranche (LOV) of the National Center for Scientific Research (CNRS) and Pierre and Marie Curie University (UPMC). The glider was launched south of Nice, France, on September 5, 2013, and was recovered on November 5 at the Bay of Angels on the French Riviera. Completing a two-month mission, the SeaExplorer became the first glider to break two world records for endurance for multisensor UUVs powered by rechargeable batteries. Reaching the milestone of 60 days and a total of 1,183 kilometers on a single battery charge, the SeaExplorer successfully set a world record for duration and distance. The SeaExplorer averaged 0.5 knots speed and provided more than 1,168 profiles of the water column from near surface to 500 meters depth with 100 percent successful communications, even in high sea states. Supervised by satellite telemetry from an onshore office using ACSA's IRIS software, the performance was manually stopped with internal parameters indicating 18 percent of the glider's battery energy still remaining.

## Conclusion

The success of this record-breaking mission performed by a small, rechargeable UUV highlights the reliability of the SeaExplorer glider. Besides the platform's endurance record, the scientific payload was equipped with Sea-Bird Electronics Inc. (Bellevue, Washington) CTD and dissolved oxygen sensors recording continuously at four seconds inter-sample time (metric resolution) for a total of 90 megabytes of data. First comparisons of the SeaExplorer data set with simultaneous profiles from a ship-borne CTD-rosette show excellent data quality, even across strong temperature gradients.

*Interchangeable nose sections (scientific payload).*

The mission objective was to evaluate the endurance of the first glider equipped with rechargeable batteries while performing several round trips between France and Corsica Island. In doing so, the SeaExplorer glider also acquired a wealth of high-resolution data along its transects. The results were presented by the LOV at the February 2014 Ocean Sciences Meeting in Hawaii.

The SeaExplorer revolutionizes data collection at sea by offering a green technology. For example, scientists in charge of monitoring climate change will benefit from battery replacement only once every 10 years, instead of consuming kilograms of primary cells after each mission.

The success of the endurance test means that the first rechargeable glider has reached maturity as a reliable alternative to alkaline and primary lithium-powered gliders. Refueling only requires 20 hours of immobilization time. This creates savings in battery replacement, technician man-hours and ballasting time, and could increase the mean time between failures (MTBF).

> ***"The mission objective was to evaluate the endurance of the first glider equipped with rechargeable batteries while performing several round trips between France and Corsica Island."***

For 10 months of at-sea deployments per year, rechargeable batteries not only grant longer availability time but also reduce operating costs between €75,000 and €150,000 per glider over five years compared to alkaline and primary lithium batteries traditionally used.

By setting an endurance world record, the SeaExplorer has proven to be an affordable and sea-proven rechargeable glider that can perform cost-effective missions for up to two months. ■

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