

Successful first experiences in multiple AUV coordination, November 2008

While into its third year of development, the GREX project reached an important milestone in the early part of November 2008 when a series of successful sea trials took place off the Mediterranean coast around the French city of Toulon.

The main objective of the trials was to gather first hand experience at operating simultaneously two AUVs, which relied on inter-vehicle acoustic communication to perform a series of simple coordination tasks.

The achievement of this goal represents an important step forward for the GREX consortium because vital experience and knowledge has been gathered that will provide the multi-partner development team the elements to bring the project to a successful conclusion.



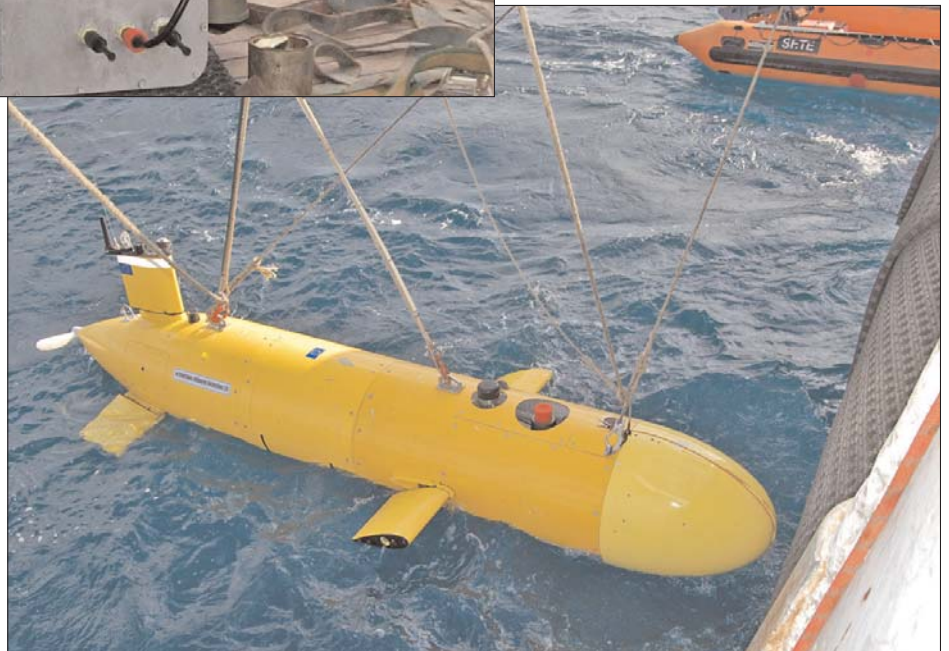
IFREMER's oceanographic vessel "l'Europe"

The trials were organised by IFREMER that together with Atlas Elektronik, the Technical University of Ilmenau, the Instituto Superior Técnico (IST) and the companies Orange Energy and SeeByte form the technical core of the GREX consortium. The work of the technical team is developed in cooperation with the strategic partnership with the University of the Azores for scientific application, and the marketing, communication and exploitation activities coordinated by MC Marketing Consulting and Innova.

The November trials featured inter-vehicle acoustic communication as the main focus. In order to gather useful data and experience in realistic condition two AUVs owned by IFREMER were equipped with the acoustic modem chosen by the GREX consortium.



*AUVortex (left)
and Aster^X (right)
the two AUVs that featured
in the 10 days trials*



For many reasons, the two AUVs used in the tests are very radically different vehicles. The first is a survey type, 3000 m capable, operational AUV "Aster^X", a non hover torpedo shaped vehicle whose typical velocity ranges between 1.2 m/s and 3 m/s.

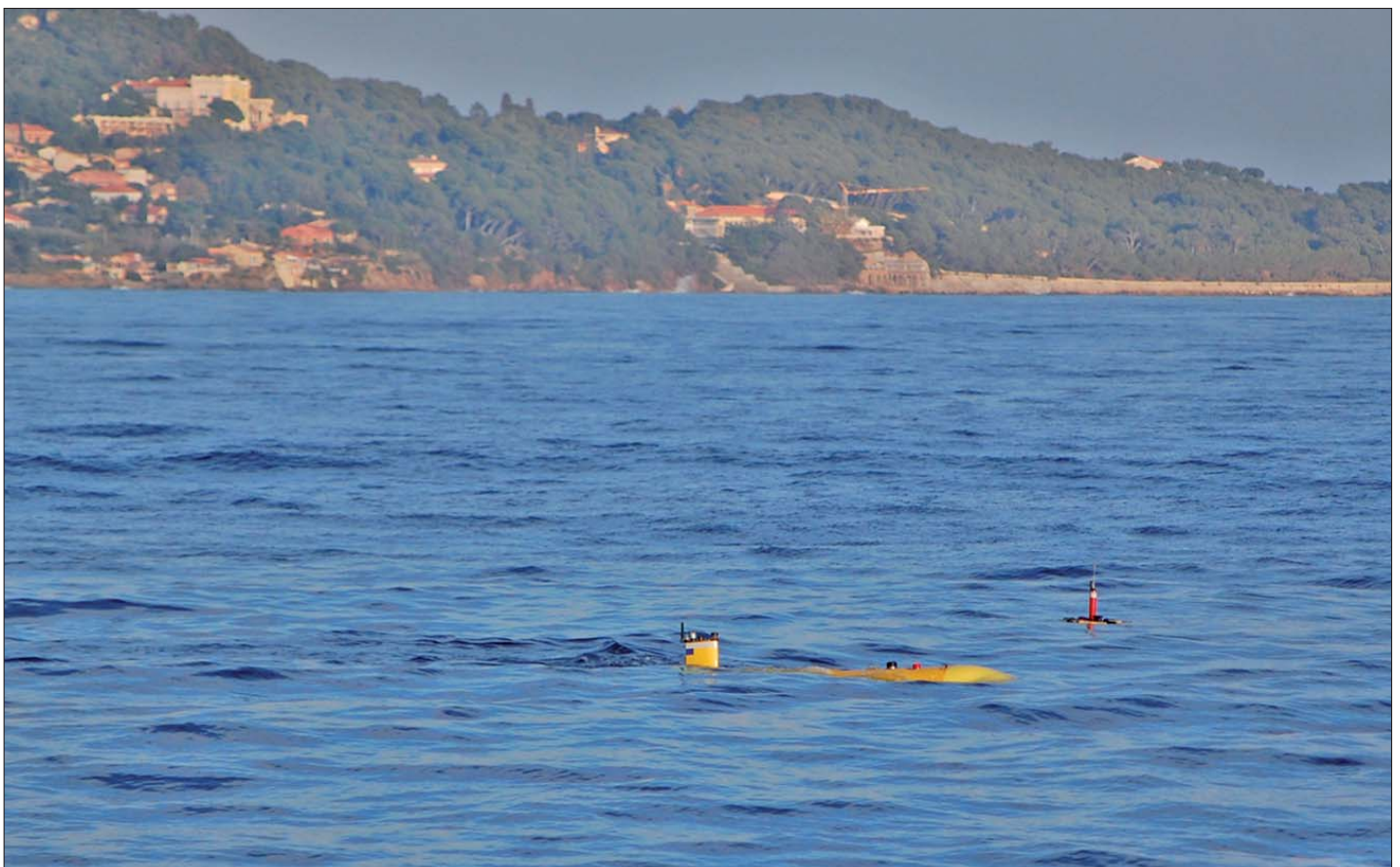
The second vehicle used is the experimental AUV "AUVortex", a laboratory test platform developed by IFREMER and specially fitted for the trials. Vortex is a 200 kg hover capable AUV, equipped with 6 thrusters and able to reach a maximum speed of 0.7 m/s. The vehicle is 50 m max depth rated.

Given the radically different architecture and nature of the vehicles, a series of operational scenarios have been devised, allowing the two AUVs to perform some cooperation tasks.

The scenarios all focus on inter-vehicle communication, and feature the computation of an index of coordination based on the positional data exchanged by the two vehicles.

As the two AUVs move along their pre-programmed paths, they exchange navigation data using a preset TDMA (Time Division Medium Access) synchronisation architecture, allowing the exchange of compressed data packets of about 20 bytes 5 times per minutes and avoiding packet collisions.

The exchanged data is used in both vehicles to compute the index of coordination, based on considerations on the current distance between the two AUVs. When a set threshold is overrun, a coordination behaviour is activated.

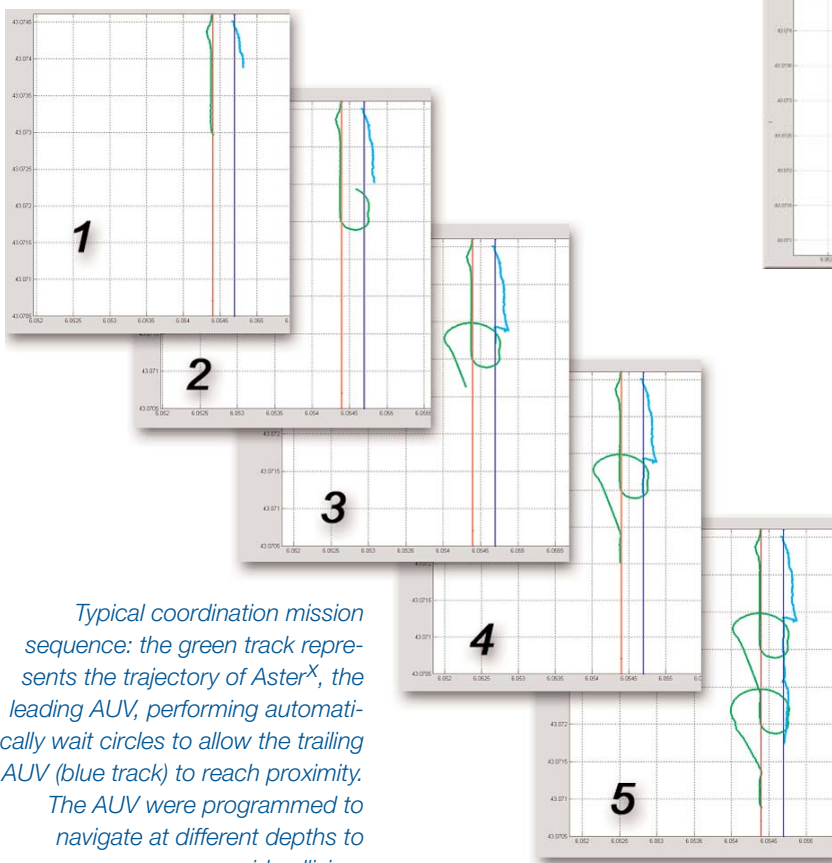


The two AUVs at the surface

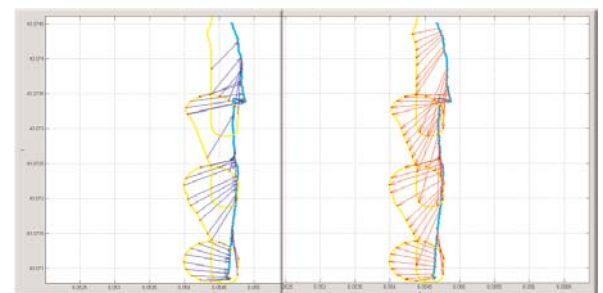
The different scenarios that have been tested involved an increased complexity in the coordination task. The most comprehensive scenario featured the survey type AUV starting a series of wait circles at set altitude and communicating the coordinates of the centre of the circle to the slower AUV.

This allows the trailing vehicle (AUVortex) to reach the given point while the leading AUV (Aster^X) waited and monitored the distance gap getting reduced.

When confirmation of the completion of the wait task has been acknowledged by both vehicles, they were automatically released on the original paths.



Typical coordination mission sequence: the green track represents the trajectory of Aster^X, the leading AUV, performing automatically wait circles to allow the trailing AUV (blue track) to reach proximity. The AUV were programmed to navigate at different depths to avoid collision.



Inter-vehicle communication statistics: bottom-up communication (left) and top-down (right)

The overall behaviour is fully automatic, as both vehicles are both untethered and autonomous. The performance of the task relies heavily on the acoustic communication exchange which is affected by the known issues of reduced bandwidth, packet loss due to ambient noise, absorption, multipath and doppler effect. For this reason a specific Communication Module has been developed to handle packet exchange and synchronisation. This module will form the core of the GREX communication handler to be developed in the later stage of the project, that will extend the capabilities to several vehicles therefore supporting a comprehensive underwater acoustic communication network (including adaptive network management, network discovery, message forwarding and retransmission).

The success of the GREX trials is further enhanced by the fact that for the first time two fully autonomous vehicles have been operated by IFREMER from an operational oceanographic vessel. A further important milestone reached is having two vehicles communicating automatically among themselves underwater.

For the logistics of the trials the oceanographic vessel "l'Europe" was made available by IFREMER for the duration of the trials (ten days). The operational AUV Aster^X was taken onboard accompanied by the three men crew necessary for operating the vehicle.

Further scientists and engineers from the GREX consortium were also onboard for the duration of the trials both for operating the second AUV, AUVortex, and for handling the acoustic communication module. A great deal of data has been collected using the ship's hydrophones set and ship mounted acoustic modem, allowing for a deeper analysis of the performance of inter-vehicle communication.

The development team was completed by an ESR (Early Stage Researcher) from the EC funded Research Training Network FreesubNET, further symbolising the achieved synergy at European level between different research efforts in this field.



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