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Innovation and Operation with robotized systems

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Abstract: The presentation will summarized state of the art of underwater vehicles in the different domains of applications as, offshore, military and oceanographic business. The present paper is a focus which reports on the status of French Institute for Sea Exploitation (Ifremer) new Trends in underwater systems as an illustration of research in the underwater robotics domain applied to oceanographic applications. It will focus on recent innovations, improvements and operational references of the Remotely Operated Vehicle (ROV) *"Victor 6000"*, of the Autonomous Underwater Vehicles (AUV) *"Aster^X"* and *"Idef^X"* and some hints about RandD in the domain of Advanced Intervention AUVs and fleet coordination.

Keywords : autonomous vehicles, remotely operated vehicles, manned submersibles, underwater vehicles

1. INTRODUCTION

Underwater Vehicles are used in a wide range of applications and sectors offshore, military, oceanography, coastal works, in shallow water and deep sea. In term of "real applications" it is common to say that with more than 5000 operational systems, the underwater robots are the more developed "intervention and survey " robots for "real works".

The vehicles are dedicated to inspection, survey or intervention tasks with telemanipulators and tools. From manned submersibles to complete unmanned autonomous systems the panoply is large.

Remotely Operated System have been build during the Oil Boom last three decades, with very mature industrial applications and robust technologies, with an acceleration of the requests and technological offers, as the depth increase in offshore developments. From first small observation ROV initially built for diver assistance, to modern medium size and heavy work class ROVs equipped with manipulators and tool sleds all the components of such versatile systems are to day reliable and on the shelf components. The only problem remaining with ROVs is the fact that they are linked to ships, which are dimensioning in term of operation costs (much more than the ROV itself).

Since ten years, with a growing need of surveys (pipe line, sites, under ice investigation…), the optimization of the cost of at sea operation have pushed the research for new systems which are to day arising as "the solution", for rapid environmental assessment in the military sector, or economically very competitive (reduction of ship cost) for example for Pipe survey.

On the RandD size, the optimization of operational cost, and new requirements as under ice applications, or long term monitoring of sites and infrastructures on the seabed, push labs and industrial partners to investigate the new domain of Inspection and Intervention AUVs.

The presentation will integrate a state of the art and review of all this technologies, and will use reference to the fleet built and operated by Ifremer, in which all the systems are existing, Manned submersibles, ROVs, AUVs for survey, inspection and intervention.

For more details on the state of the art aspects readers can consult the professional reference review [Douglas Westwood 08].

Ifremer has been engaged in the development of underwater technologies since the beginning of the 1970s and in the operation al use of underwater systems within the European oceanographic fleets. Development of the deep sea ROV *Victor 6000* and a complete upgrade of the well-known manned submersible *Nautile* in 2000-2002 are some of the major activities undertaken recently by Ifremer, as well as numerous reference in the field of autonomous underwater vehicle for survey task but also for complex autonomous telemanipulation tasks.

Manned submersibles have been pioneers in the field of operational access to the deep sea for science for 20 years. Along with the *Shinkai 6500* from Jamtec in Japan and with the two *MIR* vehicles from Russsia, Ifremer's *Nautile* is capable of diving up to a depth of 6000 m. It was overhauled

in 2000-2002 and is currently available for science investigations with 1600 operational dives already conducted.

Nautile (see Figure 1) is mainly dedicated to oceanographic investigation but has also been used for archaeology, for example to dive on the wreck of the *Titanic*, and on oil spill reduction, for example on the wreck of the Prestige off the coast of Galicia. lt's a very flexible tool for complex unknown underwater environments. However, *Nautile* is not ideally suited for surveillance, especially when it is important to optimize the cost of collected data, or when the conditions are not consistent with the use of a heavy deep sea system. Ifremer has been developing a new generation of underwater vehicles with an emphasis on autonomous vehicles.

Figure 1 **:** *Nautile Manned Submersible © Ifremer*

ln the context of deep water technologies, numerous projects have been conducted recently with European partners for offshore applications. This effort started with the development of the supervised AUV *Sirene* [Rigaud, Semac, Drogou, Opderbecke & Marfia, 1999] that was designed for accurate launch and deployment of a benthic station. The prototype was built by Ifremer for depths up to 4000 m and has demonstrated progress in precise autonomous positioning and tracking using Kalman filter techniques, robust acoustic range-estimators, chirp communication and noise reduction technologies, as well as electro-acoustic-compa tibility. The technology developed in *Sirene* was applied to the *Swimmer* research and development project in collaboration with Cybernetix for the offshore industry [Chardard & Rigaud, 1998]. This hybrid AUV, which was based on the *Sirene* vehicle, carries a classical ROV and was designed to dock on a preinstalled bottom-station linked by a permanent umbilical to the surface. Once docked, the *Swimmer* "Shuttle AUV" deploys the ROV using the established link with the surface, through the permanent field umbilical. Over and above the spin-off of *Sirene* technologies, the autonomous docking concept was demonstrated using an innovative, integrated high precision positioning system (Figure 2).

Figure 2 **:** *Swimmer Hybrid AUV © Ifremer*

The successful development of Swimmer was followed by an ambitious prototype AUV that was built in collaboration with Cybernetix, Hitec-Horten, and Herriot Watt University. This is the Alive intervention AUV (Figure 3), the first AUV equipped with manipulators. The vehicle is able to dock with grabbers on a typical offshore ROV panel in an acoustically supervised mode. This project demonstrated innovative robust optical and acoustical dynamic positioning and sensor based docking, proven at sea in real conditions [Perrier & Brignone, 2004].

Beyond these technological advances, the need for a more classical survey AUV has arisen within Ifremer scientific programs, mainly dedicated to environmental survey, in the field of physics, chemical analysis, living resources survey, or risk assessments for geophysics (slope instabilities and seismic surveys). This has led to the establishment of an operational program based on a fleet of coastal survey AUVs. With respect to the ROV *Victor* 6000, the system has been in operation since 1997 and has been intensively used for multi-disciplinary science cruises all over the world. The vehicle is in permanent evolution. A new high resolution mapping module has been designed. This scientific tool skid is dedicated to "optical and acoustical mapping" at limited altitude for very high resolution "multi-modal" mapping.

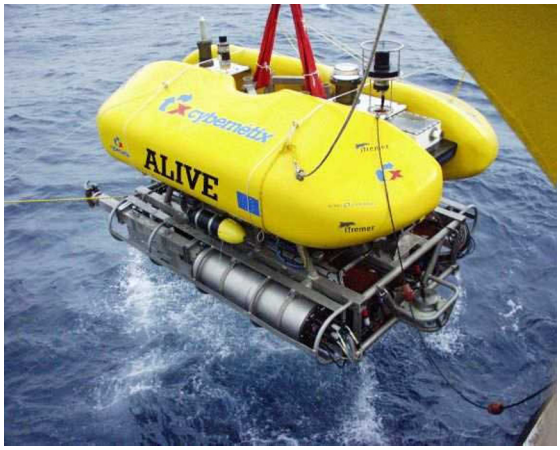

Figure 3 : *A/ive Intervention* AUV. © Ifremer