

A Low-Cost Autonomous Vehicles For Coastal Sea Monitoring

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1. Introduction

Coastal marine environment is an extremely complex system, characterised by strong links between its physical and chemical processes and biological population. Thus, the knowledge of the coastal marine environment needs interdisciplinary studies implying simultaneous sampling of physical, chemical and biological variables. Traditional methods such as oceanographic ships do not provide the necessary spatio-temporal measurement resolution because of its high operation cost, and moorings do not provide enough spatial data resolution. Recent alternatives to these platforms allowing oceanic observations with higher spatio-temporal resolution are the Autonomous Underwater Vehicles (AUVs) and Autonomous surface vehicles (ASVs), not very extended due to their high economic cost.

The objective of this project is to develop new concept of low cost ocean observing platform (called Autonomous Hybrid Vehicle, AHV), hybrid between AUVs and ASVs [1]. The vehicle should move on the sea surface and dive to make vertical profiles of the water column following a previously established plan. These two properties improves the ASVs performance, allowing to make deeper profiles, and reduces the cost of the vehicle, as it does not need expensive inertial navigation systems

In order to increase the performance and autonomy at sea, improvements like better hydrodynamic performance, propulsion and direction system, vehicle volume minimization, overall improvement of energetic performance, and better depth control have been considered. Concerning electronics and control, improvements include manual control via radio link, GPRS/GSM data transmission, improved GPS positioning, higher number of sensors and artificial intelligence for obstacle avoidance and trajectory optimization [2].

Finally, the data obtained from the platform will be assimilated into a numerical coastal model to build all together a coastal predictive system helpful for the management of the coastal marine environment.

2. Results and discussion

A first prototype vehicle has been developed with its basic electronics package and manual control system with radio link communication (Figure 1).

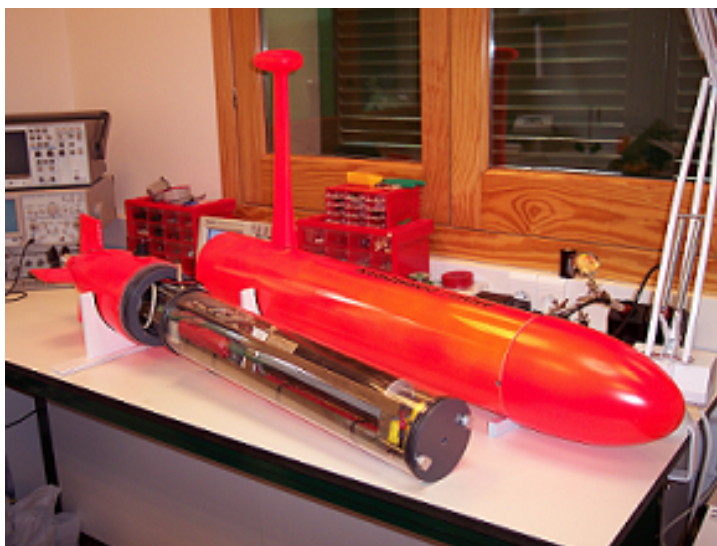


Figure 1. First prototype of AHV, Autonomous Hybrid Vehicle.

Mechanically, the vehicle has been designed with a double hull structure which can withstand pressures up to 100 meters depth, enough for coastal oceanography operation. The external hull is composed by four different parts assembled together. The fore section is built in GFRP (glass fibre reinforced polyester) 3.5mm thick. The GFRP stern is designed to avoid adverse pressure

gradients and boundary layer separation. It has an aluminium housing for the propeller shaft mechanical seal. The central aluminium tube 5mm thick is assembled on the aft and stern mounting ring, sealed with two o-rings. Eventually, a PVC antenna with a 40cm mast is mounted on the central tube completing the external hull. Sealing the passing-through elements is guaranteed by three means: A mechanical seal is mounted on the propeller shaft, o-rings and drive shaft gaskets for the direction rudders, and bonding adhesives for the fixed devices, connectors and sensors. The internal hull is designed to avoid accidental contact of water or humidity on the electronic devices and control systems. It is made of PMMA (Polymethyl methacrylate) tubes and PVC planar caps with o-ring sealing.

The direction system is based on 2 vertical rudders for the yaw control and 2 horizontal rudders for the pitch and roll control. The propulsion is based on an electric DC motor and a 3 blade propeller.

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The electronics of the navigation module is based on an ultra-high speed microcontroller circuit board. This circuit controls the angle of the rudders by means of servomotors, the speed of the propulsion motor with a PID control, and the position of the immersion piston.

The communication of the AHV with the central operation station is achieved by a main autonomous mode and a manual mode. The main system is based on mobile GPRS/GSM telecommunications, cheaper than satellite communications but with enough capabilities for coastal observation. GPRS/GSM (General Packet Radio Service/Global System for Mobile communications) allows a bandwidth of 14.4 Kbps and a usual coverage distance of more than 35 Km far away from the coast. The second system is a radio link based communication protocol that reaches 150 meters.

The data acquisition module is based on a multi microprocessor circuit boards that read the data of every sensor (GPS, temperature, depth, compass, sonar...) and will transform the information to the internal bus protocol (CAN) and send this data to a PC104 format double port memory card. The data will be previously filtered according to its correspondent filter design (Kalman, ...).

Experimental tests (Figure 2) have been conducted with the vehicle described on manual mode with positive results. Taking into account that the AHV moves based on a filtered GPS position system with about 5 meters error, manoeuvring behaviour is satisfactory, providing an approximate turning radius of 6 meters.

The maximum reached speed was around 1 meter per second. The actual battery pack installed in the vehicle gives an energy of 10A-hour at 12V DC. This means that the vehicle

has about 2 hours navigation autonomy, 15 hours immersion/measuring autonomy, or a combination of them.



Figure 2. Experimental test at sea.

3. Conclusions

This first prototype described has demonstrated the possibilities of this new concept of ocean observing platform. Future work will include the optimization of the hull shape, increasing of battery space, inclusion of all the sensing capabilities, modelling the dynamic vehicle control model, internal PC-104 control system, and the programming of the artificial memory routines.

4. References

[1] Alvarez et al, 2004, "Design and realization of a very low cost prototypal autonomous vehicle for coastal oceanographic missions", IFAC

Conference on Control Applications in Marine Systems, Ancona 2004.

[2] Garau B., Alvarez A., Oliver, G., 2005. Path planning of autonomous underwater vehicles in current fields with complex spatial variability: an A* approach. Proceedings of the 2005 IEEE International Conference on Robotics and Automation, 195-199.