Autonomous vehicle development for vertical submarine observation

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Abstract − *This work proposes the development of an ocean observation vehicle. This vehicle, a hybrid between Autonomous Underwater Vehicles (AUV) and Autonomous Surface Vehicles (ASV) moves on the surface of the sea and makes vertical immersions to obtain the profile of a water column according to a pre-established plan. Its design provides lower production cost and higher efficiency. GPS navigation allows the platform to move along the surface of the water while a radio-modem provides direct communication links and telemetry.*

Keyword − *Autonomous Underwater Vehicle, Vertical Profiler, Computer Embedded*

1. MECHANICAL DESIGN OF THE VEHICLE.

The vehicle has a double hull. The outside hull, made of fiberglass, is not watertight but it provides a good hydrodynamic characteristic. On this structure the steering and propulsion mechanisms are attached. A propulsion engine, of the company Seaeye, has been located on the stern of the vehicle and individual Seabotix(TM) engines are located on the sides of the hull. When these engines are used, the course of the vehicle can be altered [1] [2]. A watertight cylindrical module is located inside the outside hull. It houses the immersion actuator and the electronics control, as well as the power supply provided by the batteries.
Figure 1 shows the design of the vehicle.

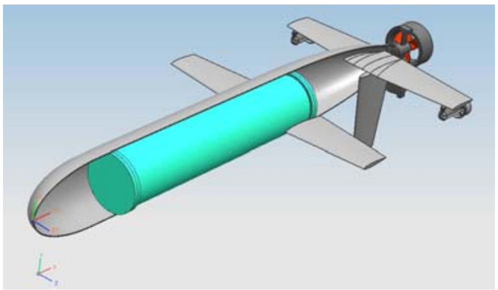

Fig.1. Design of the vehicle.

Outside Hull Design of the Vehicle.

The outside hull design is based on the Myring equations [3] that describe a body contour with a minimal drag coefficient for a given finesse ratio (body length/maximum diameter). Myring classifies body types by code of the form *a*/*b*/*n*/*θ*/0.5*d.* This vehicle has the code 15/55/2/0.4365/5. Figure 2 defines the parameters used to obtain the code and Table I shows the dimensional parameters used.

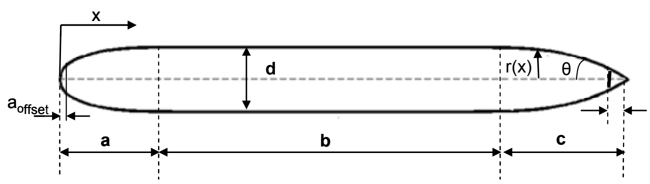

Fig. 2. Myring Profile: vehicle hull radius as a function of axial position

Parámetro	Valor	unidad
a	325	mm
a_{offset}	0	mm
b	1116	mm
c	924	mm
c_{offset}	70	mm
n	55	n/a
θ	2	radianes
d	326	mm
l_f	1441	mm
l	2365	mm

Table 1. Myring Parameters for the vehicle

The profiles of the hull of the vehicle to the bow and stern have been designed according to the following equations:
Bow:

$$r(x) = \frac{1}{2} d \left[1 - \left(\frac{x + a_{offset} - a}{a} \right)^2 \right]^{\frac{1}{n}} \tag{1}$$

Stern:

$$r(x) = \frac{1}{2} d - \left[\frac{3d}{2c^2} - \frac{\tan\theta}{c} \right] (x - l_f)^2 + \left[\frac{d}{c^3} - \frac{\tan\theta}{c^2} \right] (x - l_f)^3$$

$$l_f = a + b - a_{offset} \tag{2}$$

Finally, three stabilizers according to a NACA 63-012a profile have been designed on the proportions of the outside hull. Figure 3 shows the outside hull built.

Fig.3. Outside hull built

Inside Hull Design of the Vehicle.

The watertight module is a cylinder made in 6063 aluminium with hard anodized treatment and designed to withstand 30AT, although the nominal pressure is 3AT. The cylinder dimensions are 250mm diameter and 1100mm long, and is covered in aluminium. An o-ring guarantee watertightness.
The connection of the antennas and engines with the interior of the module is done through SubConn connectors. The watertight module houses the immersion actuator and the electronic control, as well as the power supply provided by the batteries. The design of the emersion and immersion equipment is composed of a commercial pneumatic stainless steel cylinder with a displacement of 1500cm3 and a linear electrical actuator which can cover a maximum distance of 200mm and a thrust force of 3KN. Figure 4 shows the layout of all the elements in the watertight module.

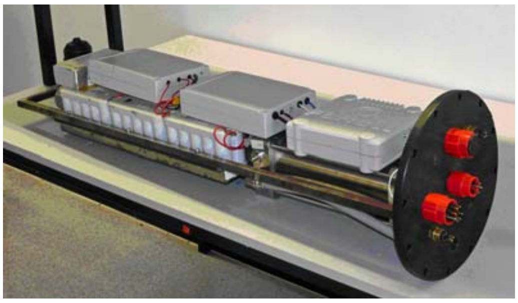

Fig. 4. Inside layout of the watertight module

2. ELECTRONIC DESIGN OF THE AUTONOMOUS NAVIGATION CONTROL SYTEM.

The autonomous navigation control system is made up of an embedded computer and the necessary elements for communication, navigation and propulsion and safety. In figure 5 the diagram for the autonomous control of the vehicle is described.Data acquisition system, composed of a CTD for the temperature acquisition, depth and conductivity of the water column, are also included [4].

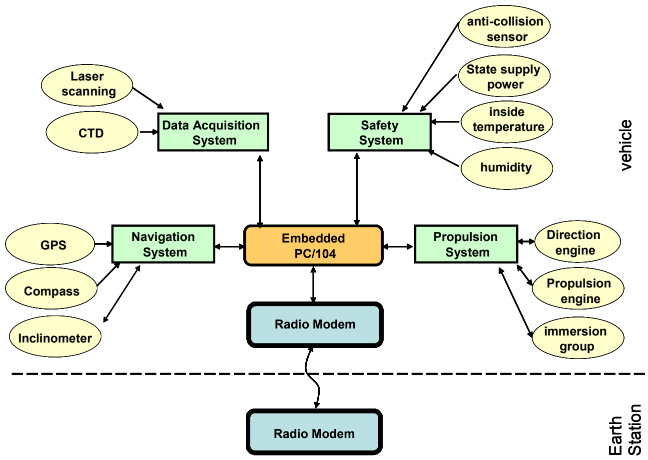

Fig. 5. Diagram of the autonomous control system

Communication between the vehicle and the station located on shore is bidirectional and a Farell Instruments(TM) industrial modem T-MODC48 has been used. Its features include a data rate of 4800 bps and a configurable carrier power of 100mW/5W that allows a maximum range of 10km.

A PC/104 embedded computer (PM-6100 AEWIN) makes up the central control of the vehicle. This is of limited size, weight and power consumption (max 12W). It is managed by a Windows XP operating system stored in a compact flash memory which provides good protection from vibration.

The propulsion control system is a SSC32 Lynxmotion driver that transforms the RS232 signal from the PC/104 in a modulated PWM signal that acts on the engine power drivers.

The navigation system is a digital compass and a three-axis inclinometer, PNI TCM-2.6, It is a 3-axis tilt-compensated compass-heading module with electronic gimballing to provide accurate heading, pitch, and roll measurements over a ±80° tilt range. The navigation system also has a global positioning system GPS, Magellan DG14^{TM}, which provides the precise location of the vehicle during a mission.

The safety system includes a pressure transducer HPS DS2806, which provides the measure of absolute pressure, from which is possible to know the depth of the AUV. The low cost sensor is resistant to corrosion, which allows a pressure variation from 0 to 10 bars. It also has a 4000 HIH sensor capable of detecting variations of 1% of relative humidity, which can detect a small flaw in the watertightness of the inside module

3. SOFTWARE DESIGN. TRACKING STATION

The vehicle needs user interaction in terms of control parameters, operational verification and data acquisition and downloading. A program has been designed which reads/writes the data received/sent by radio-modem, checks for transmission errors and represents the information graphically. Figure 5 shows the graphical user interface (GUI). The main page incorporates direction, roll and pitch angles indicators and also an artificial horizon to view the data transmitted by the compass / inclinometer. This page also includes a series of Scrollbars and buttons to control the vehicle's engine. The second page presents the user with each of the parameters that the GPS receiver provides using TextBox and a variety of geo-maps to locate the position of the vehicle.

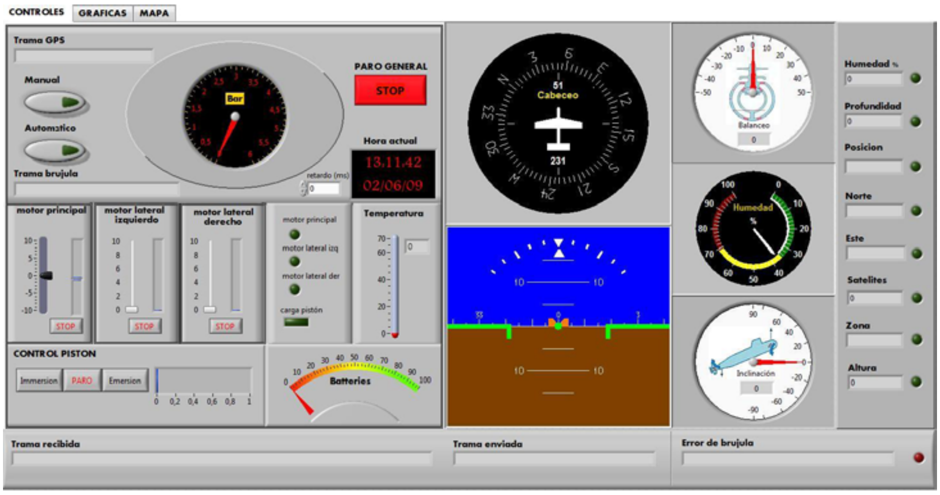

Fig. 6. Tracking Station

4. CONCLUSIONS.

An observation platform has been developed which is able to navigate on the surface of the sea making vertical immersions to obtain water column profiles. The vehicle has a double hull, a fiberglass exterior with a profile that provides a good hydrodynamic characteristic, and a watertight inner module built in aluminum. Also, an autonomous control system for the vehicle has been designed and implemented. Its proper operation has been tested in the laboratory. Now, all elements of the structure of the vehicles are being assembled and then a test of navigation at sea will be performed.

ACKNOWLEDGMENT

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