THE ICTINEU 3 PROJECT: A MODERN MANNED SUBMERSIBLE FOR SCIENTIFIC RESEARCH AND INTERVENTION

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Abstract - This paper describes the current state of Ictineu 3, the first project of Ictineu Submarins S.L., which aims at designing, building and operating a modern manned submersible for scientific research and intervention at a maximum depth of 1200m. This will be the first manned scientific submersible to be built and operated in the Iberian peninsula since the Ictíneo of Narcís Monturiol, and will help reduce the gap in our ocean exploration and intervention capabilities as well as pay a tribute to its old ancestor. This new submersible will employ state of the art technologies in areas such as material engineering, energy storage, navigation, control, and communication systems. Its main applications will range from deep seabed research, science dissemination, environmental protection, and archaeology to salvage operations and support to the offshore industry. The first sea trials are scheduled for the second half of 2010.

Keywords - Manned submersibles, Ictíneo, Monturiol, propulsion systems, navigation and control systems, sensor platforms, ocean exploration, structural design.

I. INTRODUCTION

In June 1859, Narcís Monturiol launched the Ictíneo submersible in Barcelona's harbour, the first operative civil submersible in history. The Ictíneo (7m long, 10 tons displacement) could fit up to six people and made 69 successful dives without incidents. Later in 1864 a second Ictíneo was built (17m long, 72 tons displacement) which employed an anaerobic engine able to produce heat for propulsion and breathable oxygen among other cutting edge technological solutions [1][2][4]. After 150 years, the company Ictineu Submarins S.L. is building the Ictineu 3, a modern scientific manned submersible which will help reduce the gap in our deep sea exploration and intervention capabilities as well as pay a tribute to Narcís Monturiol [6].

II. ICTINEU 3 DESIGN AND CAPABILITES

Ictineu 3 is conceived as a modern manned submersible which will incorporate innovative materials and advanced manufacturing techniques, efficient and environmentally friendly power systems, intelligent management and control systems and the most advanced technologies in safety, positioning, navigation, communication, sensing and data logging. It will be a highly versatile tool conceived to be adapted and modified for each specific customer mission needs and as newer technological solutions become available. A submersible that will play a central role in any scientific mission to be imagined under-seas. The first sea trials are scheduled for the second half of 2010.

The Ictineu 3 is a small and light weight manned submersible with high capabilities. Its main specifications are listed in Table 1, and a 3D model is shown in Fig.1. It will dive safely down to 1200 meters, making it one amongst the ten deepest submersibles in operation at present. It will be capable of carrying one pilot and two passengers, with an operative autonomy of 10 hours. Although a typical mission lasts between 3 and 6 hours, it will have reserve oxygen tanks and an emergency life support autonomy for 5 days. At the front, a big acrylic viewport (Ø1200 mm) will provide the crew with an exceptionally wide field of view, excellent for high quality photography and video capturing.

From the operational point of view several milestones have been fixed. The reduced size and a wide front viewport will provide easy and comfortable operation, as well as getting very close to the working area. The hydrodynamic shape has been designed for both optimal navigation and for safety reasons (e.g. avoiding stuck into nets). The capability to fully empty the diving tanks at surface will provide 600 mm between the design water line (dwl) and the entry hatch. This height together with the external shape design will allow passengers to get in and out the submersible once it is in the water, in good weather conditions.

General specifications	**Propulsion**		
Operating depth	1200 m	Main electric thrusters	4 x 2.7 kW
Weight in air	5.000 kg	Maneouvring thrusters	4 x 1.25 kW
Dimensions	4.8 x 1.9 x 2.8 m	Batteries	
Pressure hull diameter	1.7 m	Main battery group	Li-ion 4 x 70Ah 120V
Crew	1	Secondary group	Li-ion 160Ah 24V
Passengers	2	Safety	
Air and oxygen	Emergency life support	10 days	
Air	4 x 40 l (700 bar)	Jettisonable weight	500 kg
Oxygen	2 x 10 l (200 bar)	Total buoyancy capacity	1580 kg
Emergency oxygen	2 x 40 l (200 bar)	Emergency buoy	1800 m spectra rope
Dynamic characteristics	Equipment		
Cruising speed	1.5 knots	Sonar	Echosounder, Forward looking
Maximum speed	4.5 knots	Robotic manipulators	2 x 6 DoF
Range	10 NM	Lights	LED 1000 W
		DVL	RDI 300 kHz
		Acoustic Positioning	USBL

Table 1: Main specifications of Ictineu 3 submersible

The maximum dimensions (4,8 x 1.9 x 3 m) will allow to load the submersible in a standard open top container so that it will be possible to transport it on the road with a conventional truck, by train or by ship without requiring special transportation. The use of composite materials will allow to reduce the weight, still meeting the certification requirements: all the exterior hull, the water tanks and many supports/reinforcements will be carbon fibre/epoxy resin composites. Given its reduced weight (5 tonnes) it can be operated with standard launch and recovery systems on harbours and from most oceanographic vessels.

Thrusters / Batteries

The submersible will be equipped with brushless DC thrusters: four for propulsion and four for manoeuvring. The main propulsion power source is a set of high power Lithium ion polymer batteries which provide up to 34kWh. They will be hosted into the outer pads for safety reasons. These new generation batteries will also determine a weight reduction of around 85% compared to the standard lead acid batteries. The resulting power to weight ratio is highly favourable as compared to other submersibles of similar characteristics.

Navigation and control systems

Thanks to an advanced navigation system, the position and attitude of the sub will be known with high precision in real time which will allow for fine bathymetric surveying and scientific data georeferencing. The navigation system includes inertial, DVL, and acoustic positioning (USBL) together with state of the

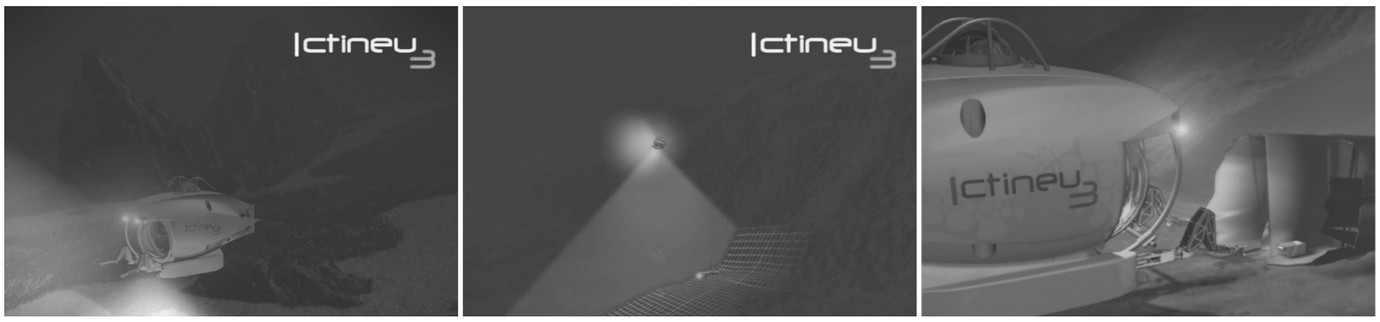

Fig.1: Ictineu 3 possible missions, from left to right: archaeological photo-mosaic, fine scale bathymetric surveying, and black box recovery.

art signal processing and state estimation techniques. An acoustic link will allow for simple data exchange and voice communications between the submersible and the surface. Advanced control systems will be designed to enhance the sub capabilities and free the crew from cumbersome tasks. State of the art robust, fault tolerant, and nonlinear control techniques will be implemented to perform station keeping, path following, heading, depth, and altitude control.

Safety

To achieve the highest safety warranties, the submersible design and construction process will be certified and classified by Germanischer Lloyd authority. To keep safety as high as possible and allow the submarine to escape from possible entanglement (nets, wrecks, remains), several redundant emergency systems will be implemented. The soft ballast (diving) tanks (600l) can be quickly emptied injecting pressurized air (700bar), determining a quick ascent. If this is not enough, a drop lead weight (500kg) can be gradually released to reduce the weight and increase buoyancy. A safety buoy can be manually released from inside the pressure hull, reaching the surface with a 1800m long, 3.5 tonne tensile strength, spectra rope. The two robotic manipulators will be ejectable in case they get stuck. Emergency oxygen tanks and carbon dioxide scrubbers will provide 5 days of emergency vital support.

III. CONCLUSIONS

In this paper, the main characteristics and current state of the Ictineu 3 project have been presented. The Ictineu 3 is being built in the Catalan Royal Shipyards, a XIV century building that hosts the Maritime Museum of Barcelona. The construction process started at the beginning of 2009 and the first sea trials are expected in the second half of 2010. More information can be found at www.ictineu.net

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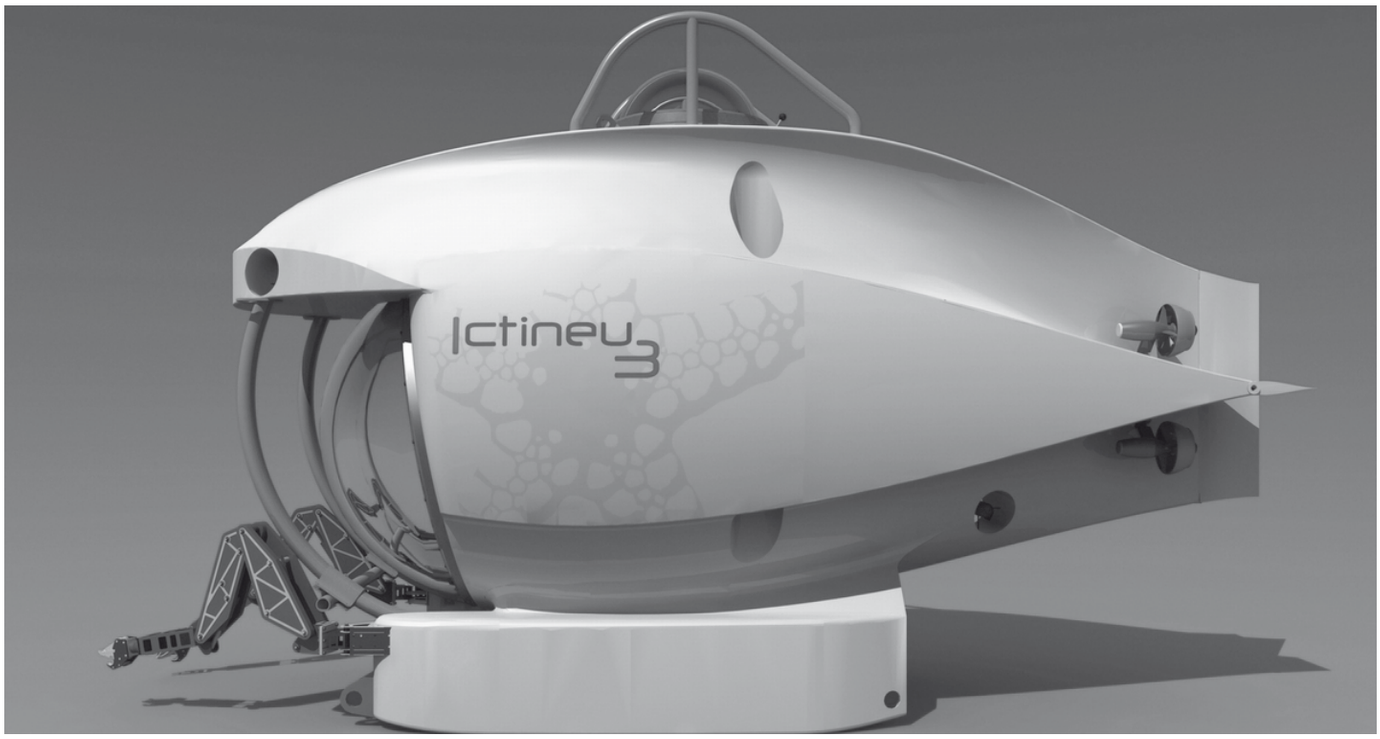

Fig.2: 3D representation of Ictineu 3 submersible