



# LONWORKS in the Yellow Submarine

An unmanned autonomous yellow submarine has just returned from a lonely mission to scour the ocean floor some 4800 meters below the surface for hazards due to giant landslides and earthquakes. The Autosub6000 developed by the Underwater Systems Laboratory at the National Oceanography Centre in Southampton, England, has just completed a cruise to the western European margin on the RRS James Cook, where it imaged the seafloor at a resolution 50 times better than is possible from surface ships.

The Autosub6000 (Autonomous Underwater Vehicle – AUV) carried out five missions between 8th August and 1st September, 2008 to investigate potential threats to coastal communities along the Western European margin from giant landslides, earthquakes, and tsunamis. “This new technology is allowing us to image the seafloor in unprecedented detail, and is providing valuable information about the huge scale and immense power of these giant underwater flows,” comments Dr. Russell Wynn, Chief Scientist on RRS James Cook Cruise 027.



Autosub6000 is 5.5 meters long, and weighs 1500 kg in air. It has a maximum depth rating of 6000 meters. The control software was perfected by three members of the five strong AUV development team. Each engineer had clear responsibility for a particular subsystem, e.g. mission control, navigation, depth control, position control, data logging.

## The Underwater Challenges

The reliability of all the systems is the single most important issue. “When an AUV is sent 30 km beneath an ice shelf, there is no hope of recovery if anything goes wrong. We tend to operate our AUVs in a totally autonomous mode.

Once launched from the ship, and dived, the AUV is very much expected to carry out the survey completely without any further intervention from the operators,”

explains Stephen McPhail, Head of Platforms Development at the Underwater Systems Laboratory.

Communication is also a problem. The only way of communicating with the AUV when underwater is by using sound waves. So-called acoustic modems have a range of up to 7 km at best, so the AUV is out of range for most of its mission. GPS does not work underwater, so navigation is another big problem. When dived, the AUV must “dead reckon” by measuring its velocity relative to the seafloor, using Doppler velocity measurements, and an Inertial Navigation system.

Naturally, the greatest engineering challenges are due to pressure, which is half a tonne per square meter at 5000 meters depth. Electronic systems must be housed in titanium pressure-resistant enclosures. A novel feature of the Autosub6000 is that these enclosures are not needed for the rechargeable lithium polymer batteries. The center has developed “pressure tolerant” batteries, able to withstand the pressure. This enables more batteries to be carried, allowing a greater operating range and with its current

sensors, it has an endurance of 36 hours, or 180 km at a speed of 3 knots.

## Solutions

LONWORKS, with its networked and completely distributed architecture, was chosen due to its modular approach. This meant that each engineer was able to independently develop individual devices and be assured that each device would be able to communicate with the others and function within the system when they were all finally installed in the submarine. Another major advantage is that the devices are “intelligent” and communicate with each other. This ensures that when the submarine is dived and out of contact with the topside (research ship), the research mission can be carried out autonomously. The AUV’s onboard mission control can, for example, receive information from the position control, velocity sensor and

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the collision avoidance sonar and pass on instructions to the motor control and depth control.

Simplicity is ensured because each node is not particularly complicated. The testability of the system is paramount and as each node has a built-in test routine, individual nodes can be easily located and tested. Extensibility is straightforward and new nodes, such as new sensors, can be added with ease.

Fourteen CNS DV03TPT modules were used for the AUV's sensing and control applications. These interface with the various sensors and actuators, which make up the robot submarine. The system is very distributed with all nodes doing an equal amount of work.

The functions of some the LONWORKS nodes in the system are:

- Depth Sensor
- Altimeter (SONAR) – measures height above the sea bed
- Depth Control – controls the depth and height off the seabed of the vehicle by moving the sternplane
- Doppler Velocity Sensor (SONAR) – measures speed of AUV relative to the seabed
- INS – Inertial Navigation System
- GPS – gets global position fixes when the AUV is floating on the surface
- Position Control – controls the horizontal position and heading of the vehicle by moving the rudder
- Emergency weight dropper – drops emergency ballast weight when fault detected
- Collision Avoidance Sonar
- Seawater Conductivity and Temperature Sensor
- Camera Controller
- Power Monitor – checks on power used and condition of the batteries
- Motor Control – controls the propulsion motor
- Mission Control – the boss, coordinates all the control, and stores the mission plan

A PC 104 based data logger uses a Gesytec EasyLON PC/104 Interface for accessing the LON WORKS

There is a WiFi link from the ship to the AUV, with a CNS eNode Bridge linking Ethernet and the LONWORKS twisted pair network. LonMaker, and NodeBuilder software were used for developing and configuring the system.

### Benefits

At the end of each of the five 24-hour missions, the processes were analyzed by the engineers. Scientific data obtained included water temperature, density, and chemical content. The seabed features of interest were seabed scours, hundreds of meters across and up to 100 meters deep, formed when giant submarine flows ripped out huge volumes of seafloor.

“Choosing LONWORKS made it possible for us to develop a very modular and functionally distributed approach to the development of the Autosub AUV systems. I think that this has been a key factor in the success of the program so far, making it possible to execute a wide variety of missions, with a great many different payload configurations. Our metric is science delivered,” concludes Stephen McPhail.

### About The National Oceanography Centre

The center is the country's focus for oceanography and represents an unparalleled investment in marine and earth sciences and technology in the UK. The center opened in 1995 in a purpose-built, £50 million waterfront campus on the city's Empress Dock. A collaboration between the Natural Environment Research Council and the University of Southampton, the center houses around 500 staff and 750 undergraduate and postgraduate students.

It has a remit to undertake research, development, demonstration and evaluation in technology to serve the needs of the NERC marine science community, stakeholders and project partners.

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