AUTONOMOUS UNDERWATER VEHICLE TECHNOLOGY

A SYMPOSIUM REPORT

BY

LIEUTENANT J. G. HAWLEY, B.SC., C.ENG., M.I.MAR.E., R.N.
(*R.N. Engineering College, Manadon*)

The first conference devoted to the technology of Autonomous Underwater Vehicles (AUVs) was held in Washington, D.C., on the 5 and 6 June 1990. The symposium focused on the technology issues associated with the development of long-range, fully autonomous undersea vehicles. Over 300 delegates were present to hear 43 technical papers under the headings of AUV Computer Architecture, AUV System Issues, AUV Control Systems, Energy Systems, Navigation and Path Planning, Collision Avoidance, Sensors, and Acoustic Communication.

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The opening address was given by Rear-Admiral Walker, U.S.N., on behalf of G.A. Cann, The Assistant Secretary of the Navy for Research, Development and Aquisition. Admiral Walker addressed the role of AUVs in naval warfare and detailed the joint Defense Advanced Research Project Agency (DARPA)/Navy Technology Programme on AUVs which has concluded that by the year 2000 such vessels will provide important adjunct support to submarines and surface vessels. Current technology is sufficiently advanced to support AUV prototype development and the four main mission-orientated programmes were detailed as:

- *Mine Search System (MSS).* This particular programme is intended to demonstrate autonomous mine detection and classification. The ever increasing global arsenal of sophisticated mines, particularly those held by third world countries, pose a severe threat to the U.S.N. tactical forces and DARPA consider the MSS to be the most important of its goals.
- *Remote Surveillance System (RSS).* The RSS is intended to support forward area ASW and special operations for Low Intensity Combat (LIC).
- *Tactical Acoustic System (TAS).* The TAS is deemed necessary for increased submarine survivability.
- *Development of Enabling Technologies.* Such technology would demonstrate a mission-capable AUV.

The prototype DARPA vehicle was delivered in March 1990 and a further vehicle is sheduled for delivery in September 1990. It uses silver-zinc batteries to demonstrate the propulsion, structures, electronics and the mission system of the AUV. The batteries provide 300 kWh of energy, the final vehicle energy density being 3360 kWh which represents a draw of 10 kW for 336 hours (2 weeks). It will be apparent that the development of high energy density sources is crucial to the success of the current programme.

The current DARPA vehicle design limits the energy subsection to 104 inches in length with a usable inner diameter of 39 inches. The vehicle has an overall diameter of 44 inches. DARPA has considered a variety of power sources that could meet this requirement; and subsequently, with the criteria of long endurance, low detectability and high reliability, electrochemical power sources have been chosen. Only two such power sources have been found to be compatible with the requirements of the AUV—the lithium/seawater semi-cell and the Advanced Proton Exchange Membrane (APEM) fuel cell. Efforts are under way to realize the potential of such power sources under the direction of the Charles Stark Draper Laboratory.

Although the symposium was intended to focus on the technological issues associated with long endurance AUV missions, only five papers sought to address the major subsystem—energy.

Rechargeable lithium and aluminium multi-mode batteries were detailed as possible replacements for silver-zinc cells in powering the next generation of naval underwater vessels. An evaluation methodology for AUV energy system analysis was presented by Arctic Energies Limited. The analysis was applied to heat engines, primary and secondary batteries and fuel cells, and sought to compare such systems using a figure-of-merit approach based on four weighted independent variables. The variables considered were fuel rate, convertor volume, installed costs, and navy-compatible fuel. While such analytical comparisons are useful as decision-making aids and for prioritizing options, they are subjective and open to interpretation. The analytical approach by Arctic Energies concluded that fuel cells are the only possible candidate energy system for use in long endurance AUVs. The study unfortunately did not consider reactor systems or include any reference to technical maturity and the problems of refuelling such vessels. Fuel cells are recognized as having the potential to provide efficient high energy storage but they are still technically immature for near-term AUV applications. The choice in the selection of an underwater power source will ultimately be mission-directed.

Garrett Fluid Systems, a division of the Allied-Signal Aerospace Company, presented a paper on heat source integration of Closed Cycle Brayton (CCB) powerplants for AUV missions. This particular system is a derivative of Garrett's Stored Chemical Energy Propulsion System (SCEPS) which is being developed for the U.S.N. Mk. 50 lightweight torpedo programme. For the AUV application, lithium reacts with sulphur hexafluoride in a 'pot-type' combustion chamber. Heat generated in the pot combustor is transferred to the heat engine working fluid via a heat source heat exchanger. Working from base line data, the heat release available from liquid metal systems is far superior to that which could be obtained from any other heat source and so such systems offer great potential for use in long range AUVs. A number of different vehicle configurations based on SCEPS were presented with diameters of 21 and 60 inches with energy storage capacities ranging from 60 kWh to 2500 kWh. Although Garretts have a great deal of experience in operating such systems for torpedo applications they are as yet without a customer for the AUV role.

Remarks

AUV development in North America is supported in the main through defence Agencies with clear goals in mind. Commercially, although their potential is realized, financial support has been modest and directed towards academic institutions. The technology to produce a long endurance AUV is currently revolving around advanced electro-chemical development under DARPA direction as part of a long-term programme (some estimates predict at least 10 years for technical maturity). The symposium (the first of its kind) will prove in future years to be a valuable platform at which to address AUV development issues.

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