Oceanic Engineering Society Technology Committee, Unmanned Underwater Vehicles: Where have we been the last 18 years, and Where are we going the next 18 years?

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Abstract: AUV's came into being in the late 80's. DARPA was the promoter of the technology. To expand their horizons, DARPA created the AUV Conference, a bi-annual two-day conference. This paper reviews the first 18 years of AUV technology conferences and workshops. The leader of this effort was the IEEE-Oceanic Engineering Society Technology Program Committee (TPC) Unmanned Underwater Vehicles (UUV) Group, headed by Claude P. Brancart. The paradigm is changing. Effective as of OCEANS'08 MTS/IEE Quebec, the new chair of the IEEE-OES TPC UUV will be Dr. Hanumant Singh.

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The First 18 Years of AUV Conferences and Workshops

by
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AUV '90 to AUV '96, the Conference Era

DARPA, Draper, and the UUV's

In the late 80's, the Defense Advance Research Project Agency (DARPA) was beginning to focus on unmanned underwater vehicles, UUV's. Draper Laboratory in Cambridge, Massachusetts, was selected to develop two UUV's with sufficient power and payload to accomplish three separate military missions. To promote the technology within the underwater technology community, DARPA decided to conduct conferences on UUV's. The name of the conference would be Autonomous Underwater Vehicle (AUV). Some UUV's could be considered as tethered for man-in-the-loop control and be supported with external power. AUV's are unmanned and untethered UUV's.

DARPA decided to conduct the conference in Washington, DC, at the Washington Dulles Airport Marriott, 5-6 June, 1990. The General Chair was Charles Stuart, of DARPA. Dr. Glen Williams, of Texas A&M, was Technical Chair. Support contractors were involved; namely, Gordon Raisbeck (Arthur D. Little), Joe Czika (Analytic Services Corp.) and Claude Brancart (Draper Laboratory).

The Foreword presented at the plenary identified the intent of the conference.

FOREWORD

As we enter the last decade of this century the realization of practical and economically feasible applications of Unmanned Undersea Vehicles (UUV) to both military and commercial activities seems more likely than ever before. Efforts are underway in both sectors to demonstrate such applications as deep ocean exploration, oceanographic data collection and offboard sensor adjuncts to submarines and surface ships. In fact not since the 60's and 70's has the investment been as great, and during the interim period our progress in computers and automation has begun to produce the technologies needed to implement fully autonomous systems.

However, robust, reliable autonomous systems that can operate over long periods unaided by human intervention remain to be demonstrated and the challenge falls to those of you attending this symposium to accomplish that goal. Developments that will pace that accomplishment include autonomous sensor systems and controllers, high density and efficient energy and propulsion systems and practical methods for communication where interaction with humans is necessary to meet mission goals or to improve system reliability.

This year we have decided to break the tradition of addressing both Remotely Operated Vehicles (ROV) and Autonomous Undersea Vehicles (AUV) issues within one program. This symposium has intentionally been focused on the technology issues associated with the development of *long range, fully autonomous*

undersea vehicles. I hope that you will find the program stimulating and that you will return to your workplace energized to continue the pursuit of that goal.

Charles E. Stuart
Arlington, VA
February 1990

The two-day conference was considered a success. Over 250 people attended. This is the only conference that had parallel sessions on day two.

AUV ’92 was a follow-up to the AUV ’90 conference, at the same venue, 2-3 June. General Chair was Captain Alan Beam of DARPA, and Technical Chair was Dan Steiger. The enthusiasm still existed.

AUV ’94 changed the organizational structure of the conference. DARPA felt it was time to pass on the responsibility to an IEEE Oceanic Engineering Society Technical Committee Group, The Unmanned Underwater Vehicle, headed by Claude Brancart. At that time the charter of the committee was as follows:

Technical Scope: Autonomous Underwater Vehicles (AUV) technology has progressed to the point that the vehicle as a transport medium is no longer the technical issue. Vehicles have been designed, built, and operated from the very small (micro) to the very large (20,000 lbs. displacement). Now, the technical area of emphasis is AUV capabilities: sensors, data processing and storage, communications, control, mission planning, and multiple AUV operations. These AUV capabilities are the main thrust of the AUV Committee’s activities. The OCEANS conference always has numerous AUV sessions. The AUV Workshop that takes place every even year focuses on one specific aspect of AUV technology and presents a forum for close technical interaction with the experts in the field. Most presenters are invited; the session is facilitated; and the last session attempts to look into the future, 10 to 20 years ahead.

The General Chair of AUV’94 was Mack O’Brien, the Vice Chair, Claude Brancart, both from Draper Laboratory. The Technology Program Chair was Dr. Anthony Healey of the US Naval Postgraduate School in Monterey, California. The venue was the Marriott Hotel, Cambridge, Massachusetts. The “Welcome to AUV ’94” discussed where AUV technology was and where it should be heading.

Welcome to AUV ‘94

AUV ’94 is the third Institute of Electrical and Electronics Engineers Ocean Engineering Society (IEEE/OES) AUV conference. The first conference was held in Washington, DC, in 1990. This was also the location for AUV ’92.

The technical autonomous undersea vehicle (AUV) community have concentrated their efforts and funds on perfecting the AUV. A reliable unmanned undersea vehicle is a readily achievable goal. This is exemplified by the large number of vehicles that have been and are in operation throughout the world. The technologists are now concentrating on the vehicle’s control system, sensors, and energy sources. The recent advances achieved are highlighted by the scope and depth and international source of the papers being presented at AUV ’94. Selecting the papers to be presented proved to be a very difficult task.

I compliment the AUV community for their achievements in perfecting AUV’s and their associated components. This progress can be compared to the computer industry, primarily because

computer technology is the major technological component in the AUV's. As we enter the mid 90's with a changed geo-political environment, I challenge the AUV community to search for non-military problems that can be solved with existing mature AUV technological solutions. New communities will have to be approached, educated, and convinced of the capabilities of AUV's. If successful, the AUV community will be given the opportunity to demonstrate the robustness of their hardware and, properly configured, the cost-effectiveness of AUV's. This is a nontechnical task that will be very difficult, but with or without expanding the AUV user community, we will continue to develop solutions for problems yet to be identified.

Mack D. O'Brien
General Chairman, AUV '94
Cambridge, Massachusetts
July 1994

AUV '96 continued with the conference format. It was held in Monterey, California, at the Hyatt Regency. The subjects continued to cover all aspects of AUV technology. There were even a few exhibitors. After the conference, during the hot wash-up, it was concluded that the presentations were becoming too diluted, and there was insufficient time to interact with fellow engineers (aka networking). The decision was made to work on this problem.

AUV '98 to AUV '06, the Workshop Era

A different approach was required in 1998. IEEE/OES sponsored UT '98 (Underwater Technology) in Tokyo, Japan, in April and OCEANS '98 in Nice, France, in October. There were numerous other oceans-related conferences before, between, and after the two IEEE ones. As a result of the multiplicity of general oceans conferences, it was decided to conduct AUV '98 as a workshop focused on a specific AUV technology thought to be in need of further development. Many topics were identified, but navigation for underwater vehicles was ultimately selected as the first AUV workshop topic. AUV '98 took place at Draper Laboratory, Cambridge, Massachusetts. The registrants and authors were very pleased with the workshop format. Unfortunately, for various reasons, there was no AUV 2000.

Certain ground rules were established for the newly formatted AUV gathering called a *workshop:*

- Focus on a specific AUV technology
- The best technologists selected to make presentations
- 4 to 5 presentations for each half-day session, with sufficient time for Questions and Answers (Q and A)
- A concluding session to extrapolate the technology 20 years ahead, with the same presenters undertaking this task
- A facilitator for each half-day session, who would summarize the presentations and Q and A

- A schedule to permit sufficient networking time via breaks and socials
- Total conference registration limited to 60 people to create the opportunity for beneficial networking (In the past this has been achievable because of the narrow scope of the subject matter.)
- Only one track and one presentation room, with each registrant having his/her own table space (classroom style)

As mentioned, AUV 2000 was cancelled for lack of proper support. C. Brancart was the Technical Chair for OCEANS 2000 Providence, RI, and could not devote sufficient time to make AUV 2000 a success. The next three AUV gatherings were conducted in the workshop format.

AUV '02 20-21 June 2002
Energy Systems for AUV's
Batteries
Fuel Cells
Other Energy Systems
A look ahead 20 years
Southwest Research Institute, San Antonio, Texas

AUV '04 17-18 June 2004
Multiple Cooperating AUV's
Navigation and Communications
Control
Sampling
A look into the future: Vision, Challenges, and Milestones.
Sebasco Harbor Resorts, Sebasco Estates, Maine

AUV '06 12-13 February 2007
AUV Navigation
Networks
Non-Acoustic Positioning Systems
Acoustic Positioning Systems
Prospects and Conclusion
Brest, France

AUV '06 tried a new approach to document the Workshop. The complete Workshop was video recorded from plenary to introduction to speakers and questions-and-answers. The results were encouraging. Most attendees felt they assimilated more of a presentation than they could have by reading a 6-to-8-page paper. The future will decide the success of this recording mode.

18 Years of AUV Technology

In the beginning, the major emphasis was on the vehicles as transport systems. It soon became very evident that the most significant technology in AUV's was in the realm of computer-based logic. Computers tend to take a generation jump every 18 months. Speed, power, and the resultant capacity are the variables of interest. The results in data acquisition, processing, and storage have been amazing.

There are two technology areas that still seek a break through: energy storage/density and an underwater "GPS." Lithium batteries have the best energy density. More advanced systems like fuel cells, nuclear and thermionic reactors are extremely costly and have reliability issues. Navigation systems are still improving, but nothing comparable to the GPS exists yet.

Multiple and cooperating AUV's and swarming technology are helping to augment the total AUV system capabilities. This technology will continue to improve. It is hoped that area coverage and position accuracy will improve for a lower equipment cost. The inertial systems were and are very useful; but cost and power consumption tend to reduce their affordability. In the end, man's creativity will solve all these problems for us. The past has proven that.

The Next 18 years of AUV Technology

The AUV biannual workshop will continue. It is an excellent venue to bring forward the latest technologies applicable to AUVs and to facilitate networking with fellow engineers and scientist. It would be audacious to try to identify "Vision, Challenges, and Milestones" for the future. The fact does exist that more emphasis is being placed on AUV missions. Functional hardware and sensors exists and are continually maturing.

To keep abreast of the future of AUV technology, consider the AUV Workshops. AUV 2008 will take place at Woods Hole 12-13 October. The theme will be AUVs in polar and other ice-covered applications. Additional papers on Unmanned Surface Vehicles (USV) and Unmanned Aerial Vehicles (UAV) will be considered. For details, visit website www.auv2000.org.