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OCEANS '98 CLEARLY A SUCCESS



OCEANS'98 in Nice was hosted in the huge and attractive Acropolis Convention Center. The celebration of the second venue of the Conference in Europe was clearly a success and OCEANS'98 is definitely a conference to be remembered. The organization ran smoothly and handled the 370 presentations

(oral and poster) with efficiency. Clearly the setting of the session rooms and the choice of the Poster area (nearby the coffee break tables) allowed the attendees to stay in touch longer and to pursue the exchange of ideas well after the end of the sessions.

Thirty countries were represented with a mere 20% from Northern America, while 2/3 of the attendees came from the European Union. A very few no-show were noted (less than 4%) during the conference making probably OCEANS'98 the most successful conference (in term of presented papers) since OCEANS'94 in Brest. It is worthwhile noting that the number of presented papers is increased by more than 25% when OCEANS is located in Europe. The conference registered 700 full attendees and more than a thousand people visited the Exhibit.

"Engineering for Sustainable Use of the Oceans", the theme of the conference, was at the heart of the presentations as well as in the booths of the Exhibition were about a hundred companies gathered their products. The fact that the Ex-

hibit space was on the way to the session rooms and located at the same level as the Author's breakfast and partly the coffee breaks made possible closer contacts with the session attendees.

The three days of the conference were opened by a plenary session where the different speakers presented a very large overview of the actual knowledge in the Oceanic Engineering domain, some of the break-through and the possible trails for the future. This session presented in the very comfortable Athena auditorium was attended by a very large audience and was a remarkable start-up of the conference. Some of the attendees (60) had already participated the previous day at one of the eight proposed Tutorials on state-of-the-art subjects. A very high level of interaction was obtained due to this large participation.

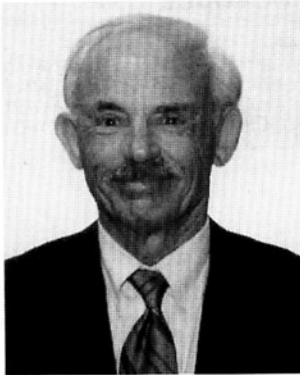
Other, maybe less scientific, great moments were also reached during the OES Awards luncheon, recognizing this year the involvement and achievement of Burton G. Hurdle, Norman D. Miller and Dan Alspach. The Gala Cocktail was also another great time of informal and friendly encounters. Organizing a conference in Europe on the theme of Oceanic Engineering is definitely a key to a large audience and the potentiality of a great success with an over increasing exchange of ideas.

René Garelo
Technical Committee Co-chair
President of the IEEE/OES French Chapter



370
 124
 1480

Expanded Web Version of the OES Newsletter



I want to thank all of you who have responded to the OES Newsletter survey of the web version which was conducted in the last issue. From those responses, we have determined that the

PDF format appeals to most who have responded so far. Some of you have also indicated you would like to have the option to view the newsletter in both HTML and PDF format. We will therefore be putting the newsletter online in both formats. We are also monitoring the number of visitors to the newsletter website. On average there are about twenty hits per week with one hundred thirty-eight over the last two months since the monitoring began. This helps us determine the value of this new service to the membership, but we would also like to hear from you directly.

You can now access the Spring, Summer, and Fall issues of the newslet-

ter by clicking on "Online Pubs" at the bottom of the IEEE home page with URL, <http://www.ieee.org> or link to it from the OES home page with URL, <http://auv.tamu.edu/oes/>, which now also carries current information on the upcoming Oceans '99 MTS/IEEE Conference and Exhibition. See the call for papers in this issue.

For those of you who haven't yet responded, and would like to let us know your opinions, I am running the survey form again. Let us hear from you.

Frederick Maltz,
OES Newsletter Editor

NEWSLETTER SURVEY

1. Have you accessed the trial web version of the OES Newsletter? _____
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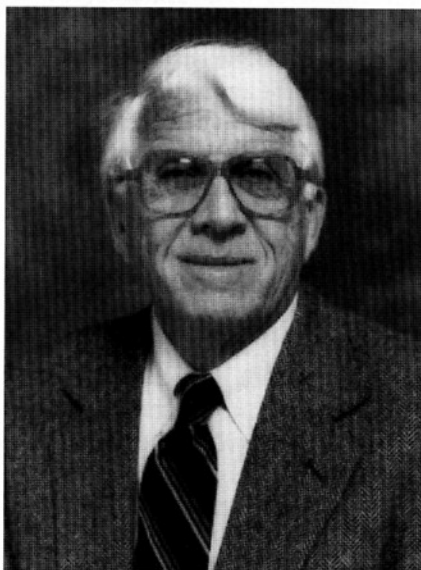
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AUV '98

By Claude P. Brancart



Claude P. Brancart
President
Oceanic Engineering Society

The Autonomous Undersea Vehicle (AUV) conference began in 1990 as a bi-annual conference. This was initiated by the focused interest in AUVs for military Applications. AUV '90 and '92 were held in Washington, DC, AUV '94 was in Cambridge, MA, and AUV '96 was in Monterey, CA. 1998 presented a different set of conditions. IEEE/OES is sponsoring Underwater Technology '98 (UT '98) in Tokyo, Japan (April), and OCEANS '98 in Nice, France (October). There are many other ocean-related conferences before, in-between, and after the two IEEE/OES conferences. Considering the above, it was decided to conduct AUV '98 as a focused workshop to address a specific AUV technology considered to be in need of further development. Many topics were identified, and navigation for underwater vehicles was selected as the first candidate workshop topic.

AUV '98 was a two day workshop that took place 20 and 21 August 1998 in the Draper Laboratory auditorium in Cambridge, MA. The agenda included presentations on current practice, hardware trends, and non-traditional approaches to AUV navigation.

There were four half-day sessions, each moderated by a facilitator. Each facilitator summarized their session, and their summaries are presented below. They represent an excellent overview of the conference.

Session I: Current Practice

*Prof. Anthony Healey, Director,
Center for Autonomous Underwater
Research, Naval Postgraduate School*

Five papers were given in the first session of the Workshop. The first paper, by Keith Vickery of Sonardyne, Inc., presented a comprehensive overview of acoustic positioning systems, their configurations, and operational considerations. In general terms, it is found that absolute accuracy of deep water systems can be within 5m and relative position accuracy within 2m. Ultrashort, Short, and Long Baseline Systems refer to the baseline length being respectively less than 10cm, 50m, and 6000m.

The author defined absolute accuracy, relative accuracy, resolution, and precision. Absolute accuracy is affected by the acoustic frequency used, and for LBL systems, ranges from 10 cm to 5m, for frequencies ranging from 300 KHz down to 8 KHz. Naturally, the range - of the order of magnitude of the baseline - is inversely dependent on the frequency. Several common configurations were discussed.

Considerations are made concerning the errors caused by bad configuration design (ray path tracing can help understand this in designing transponder positions, shadow zone effects for operation near bottom, and multipath problems due to improper mounting locations on the vehicles). Acoustic noise effects were reviewed - generally using the well known so-

nar equations and spherical spreading laws, with background noise levels from vehicle self noise and environmental background noise. Specific details of shallow water operations, however, were not given.

The second paper addressed the problem of finding the best possible heading and position for the HUGIN UUV using sensor measurements and Kalman filtering. The vehicle uses the HiPAP ultrashort baseline system (with accuracy 5m) and DGPS (2 - 4m accuracy), an inertial unit (0.07° roll and pitch, 5°/hr angular velocity error), a doppler log (0.015m/s), a magnetic compass (2° - 3° accuracy), and a depth sensor (0.1m accuracy). The paper discusses the results from simulated trajectories using white and colored noise models for sensor errors. It is stated that the use of an extended Kalman filter having 3 motion model states (X, Y, psi) and 4 measurement error states associated with the noise coloration provides position estimates that are less accurate than those obtained using a Kalman smoother in post-processed data. Typical accuracies are given for the simulated results. It is not surprising that the smoother gives better position esti-



Facilitator Christopher V. Trainor moderating the debate at AUV'98.

mates from prior data - that is well known. Experimentally obtained results, however, showed that accuracies obtained in fact were not as simulated. The major source of positioning error was felt to be the heading reference, which was a compass. Compass errors in the experimental data showed several degrees of error between the measured heading, the computed heading, the real time (filter) estimate, and the smoothed (post-processed) results. The major problem was felt to lie in the calibration of the compass, which was stated to be an important consideration for all vehicle operations.

The third paper, by G. Trimble, concerned a 'Doppler Inertial Acoustic System For Littoral Navigation (DIAS)'. DIAS was to be verified using a long baseline acoustic system for comparison. The navigation, relocation, and 'precise' positioning work was in support of mine/ordnance survey and inspection from the surf-zone to 200 meter depths. Static testing in 1993 determined the acoustic positioning reference accuracy in the 3-5 meter range (using DGPS transponder placement, post-processed data from a stationary transducer). This was acceptable for basic navigation of the ROV test-bed but not for reacquisition and closed-loop servoing to a target. The relative positioning approach required that the vehicle maintain positioning accuracy of approximately 2 meters and hover versus the target, closing the positioning loop around the navigation sensors. A 1995 Lake Powell deployment exposed many shortcomings of the LBL/inertial approach, such as environmental considerations (multi-path, occlusion) and the time required to set up the transponders (unacceptable for dynamic "in-stride" search/evaluation). So far, no definitive performance results for the Doppler inertial system have been obtained.

The fourth paper, by Healey, An, and Marco, provided a detailed study of data obtained from runs with the FAU OEX vehicles. Navigation was accomplished using acoustic Doppler and an inertial (Watson) unit (yaw rate gyro), with a TCM2 Precision Navigation Inc. magnetic compass. A filter was developed for the fusion of sensor data arriving from sources at arbitrary times. In par-

ticular, the filter was used to estimate the errors in the Doppler/compass/rate gyro dead reckoning system. Based on the growth of errors, a system was used to incorporate a single DGPS fix that simultaneously corrected the position estimate and estimated the bias on the compass. Compass residual errors were found to be still not less than 2 degrees after careful prior calibration. The methodology of compass calibration was discussed by An, and results comparing the integration of a fiber optic rate gyro to the data from the TCM2 compass were analyzed to show that the deviation table of the compass is significant, and must be calibrated very carefully prior to use. The analysis of the filter results illustrated that compass errors were increased during turns. The test runs were made on the surface so that DGPS data was available for use if necessary, but that meant that the vehicle wave-induced motion was significant. It is generally concluded that the TCM2 compass is not sufficient for a 1% navigation system, even though the Doppler ground speed errors were less than 1%.

The final paper, given by Hernandez, was a multi-author paper illustrating the results of a small package INS suite for navigation as tested to date on a land vehicle. Speed reference was obtained using a following wheel. The MotionPak IMU was used for inertial measurements, and the long period accelerometer data was used with the TCM2 compass for angle measurement. Heading was thus dependent on the compass - its deviation table accuracy, yaw rate integration, and the use of DGPS for final position correction. The accuracy of the system without DGPS correction was about 1% - velocity error is bounded by the following wheel.

Session II: Hardware Trends

*Dr. William W. McFarland,
Draper Laboratory, Inc.*

The afternoon session of the first day of the Workshop was devoted to invited presentations that were intended to present the attendees with informed opinion as to where the major navigation hardware technology is headed in the next several years.

The session led off with a paper on inertial sensor technology trends, as projected by the Draper Laboratory. This was followed by presentations by representatives from Litton Guidance & Control Systems, Inc., and Honeywell, Inc., arguably the principal providers of inertial navigation systems today, on their expectations for this technology and its application to AUVs. These in turn were followed by a presentation from RD Instruments, Inc., a major provider of acoustic velocity logs to the AUV community, on where they see this important technology heading. The final presentation, by Sonardyne, Inc., reported on several new approaches to acoustic positioning that are starting to find application in the offshore community.

The first paper, given by Dr. Christopher Trainor of the Draper Laboratory, presented a comprehensive overview of developments in modern gyro and accelerometer technology. The principal technologies that are under development were discussed and related to end uses in the current, near, and far terms. The relative maturities and prospects of the individual technologies were discussed. The paper concluded with a projection of IMU cost as a function of instrument technology and desired performance, conditioned by the size of the likely markets.

The second paper, given by Dr. James Huddle of Litton, argued that inertial navigators are becoming increasingly attractive for small autonomous submersibles because of dramatic reductions in their physical "footprint" and cost. The use of zero-velocity updates was suggested, and tutorial material presented, to show it as a means of achieving extremely low position error growth from otherwise medium-accuracy inertial navigators. He pointed out that this technique has been thoroughly validated for land survey, and discussed how it could be extended to AUVs with appropriate sensors.

The third paper, given by Daniel Murphy of Honeywell, described in some detail Honeywell's small HG1700 inertial measurement unit, which uses miniature ring laser gyros and linear accelerometers and was developed specifically for the tactical navigation market.

He discussed its use in a wide variety of DoD programs, its current production status, and its cost targets as a function of production. Its necessarily flexible I/O software was also described in some detail. A video of its actual use in precision guided munitions concluded the presentation.

The fourth paper, given by Francis Rowe, the president of RD Instruments, Inc., identified and elaborated on trends that have and will continue to guide the development of acoustic velocity log technology. The issues discussed included factors that have led to the reduced size, weight, and cost of RD Instruments' current Doppler Velocity Logs, measures that will lead to further reductions in these factors, the use of phased array technology to further reduce transducer size, and an update on progress made in Correlation Velocity Logs as a deep-water alternative to DVLs.

The session concluded with a paper by Keith Vickery, president of Sonardyne, Inc., on new concepts and trends in the use of acoustic positioning technology that are starting to find application in the commercial world. This paper was the complement to the paper he gave in the morning session and described system-wide trends (such as the "inverting" trend) as well as incremental technology trends that are taking place or that need investment. A highlight of the talk was his engagement of the attendees in an effort to quantify the AUV market across customer (commercial, academic, and military) and zone of operation in the water column (<100 m, <1000 m, <3000 m, 6000+ m), along with estimates of the positioning accuracy required, average AUV cost, and number of AUVs by the year 2008.

Session III: Non-Traditional Approaches – Exploitation of Natural Phenomena

Seamus T. Tuohy Ph.D., Director, Engineering and Computational Facility, Draper Laboratory, Inc.

The term "non-traditional" is something of a misnomer, since the topics covered here are an application of navigation techniques that humans have always used to navigate long before the advent of inertial or GPS systems. In

fact, my grandfather, a river pilot for over 50 years, used all senses - touch (bathymetry), sound, sight, smell, and even taste (freshwater vs. salt) of the surrounding environment - to navigate before the exploitation of acoustics, microwaves, etc., was even an option. What is new here is the replacement of human reasoning with computational methods (that is, computers reasoning about the world by gathering all available information and not being limited to engineered portions of the environment or specializing in a particular sensor). This data is then combined into a hypothesis about the position, to borrow a term from one of the papers, and, to a greater benefit, the surrounding world of the vehicle. As computers increase in processing speed and sensors increase in usability, the future, I believe, lies in capitalizing on information that has always been available, to as much an extent as possible.

Overview

The following papers pursue two fundamental directions of research:

1. Efficiently exploiting the information contained in data collected by a sensor
2. Combining (or fusing) disparate data into a single, coherent, and complementary state of the vehicle and model of the world

The first paper presents the application of a concurrent mapping and localization algorithm to long-range/long-duration missions. This algorithm uses forward-look sonar data to construct a feature-based model of the bathymetric environment.

The second paper (by the same group) presents an overall framework for combining data derived from the world around the vehicle and, in addition, creating a model of the world (i.e., a map). This framework relies on promulgating multiple hypotheses about the construction of the environment (and the vehicle's location in it) and making reasoned decisions as to which hypothesis is true.

The third paper extends and applies this notion to a fieldable system and is impressive in its application of signal processing techniques to extract as

much usable information as possible from a high-end forward-look sonar.

The fourth paper presents results of experiments using scanline analysis of returns from a readily available mechanically-indexed forward look sonar, in progressively complex but static in-water environments, to extract useful information on target range, bearing, and approximate size.

The final paper demonstrates that not all exploitable natural phenomena need be acoustically measureable, relying instead on measurement of the earth's gravity gradient tensor using inertial instrumentation. It explores an application of gravity gradiometer technology to AUV-sized vehicles and points the way to completely self-contained operation (no radiation of energy whatsoever) using gravity-based measurements.

Major Findings, Conclusions, and Recommendations

A fundamental concern with the exploitation of natural phenomena is what to do in the absence of measurable quantities - that is, when the character of what one is measuring is less than the accuracy of the sensing device. An example might be when the vehicle is over a seemingly featureless, flat sandy bottom. The papers presented all assume that features are indeed present and can be observed. Whereas this may detract from the usefulness of some of the approaches, it enhances the approach taken by the first paper.

In addition, as with all *non-traditional* approaches, there will be confusion as to whether an approach has been tried before. This is especially true of the use of forward-look sonar in which the approach is one dependent on sensor and algorithm, not so much the higher-level goal of using forward-look sonar for navigation. Until some convergence (through successful application) is reached, great care must be taken so that an idea is not discounted outright.

As a final thought, we may be witnessing with these papers the beginning of a new paradigm for AUV navigation. Current systems are built for the purpose of positioning and do not play a significant role in the higher-level con-

trol (so-called mission planning) of the vehicle. They are primarily concerned with "tell me where I am" and "point me to where I need to go." We may see in the future, as systems become more complex, more of a concern with determining the best route to accomplish a mission, with, for example, navigation accuracy being just another parameter in the decision making process of the vehicle controller. It will be put alongside survivability, power consumption, etc., so that accuracy may be sacrificed (or increased) in order that the highest probability can be reached for accomplishment of a mission goal.

Because of its importance to overall mission success, much effort has gone into making navigation a decoupled *black-box*. We may find, however, that it is too important to be independent, and that it needs to be tightly integrated into the overall vehicle control architecture. There is much work to be done!

Session IV: Underwater GPS and Vision-Based Approaches

James W. Youngberg, Senior Member IEEE, Draper Laboratory, Inc.

Sessions I through III of AUV-98 provided exposition of current practice and the sensor technology available upon which to evolve practice. Session IV turned to address emerging technologies.

Hubert Thomas, Managing Director of the French company Advanced Concepts and System Architecture (ACSA), has published numerous articles recently in the industry press regarding GPS Intelligent Buoys. Rather than reiterating the GIB description as might have been expected, Mr. Thomas' presentation highlighted the technology introduction and systems architecture issues encountered in fielding an underwater navigation capability.

Hubert noted that successful innovation results when new technology and requirements coincide producing "the right product at the right time." He said that technologies arrive via an incremental (continuous) path or as a rupture discontinuity. Acceptance of technology is easiest for incremental change. Rupture technologies, on the

other hand, can "render possible what was not possible" or "change the way things are done."

Hubert then used a case study in system architecture to introduce what he terms Supervised Underwater Vehicles. His SUV architecture responds to a number of self-imposed design rules including reducing data flow, keeping man in the loop, and minimizing cost.

While there may have been early concern that the two vision-based papers would address overlapping topics, this turned out not to be the case. Mosaicking was the projects' common enabler but their mosaicking techniques differed and their resulting systems were quite different.

Dr. Steven Rock, an Associate Professor at Stanford University and research engineer at Monterey Bay Aquarium Research Institute, briefed the Workshop on research that his team is doing on vision-based sensing and interpretation. Vision-based dead reckoning is an extension of their previous work on stationkeeping and real-time mosaicking. Transit is the dominant capability of the system that Dr Rock's paper describes.

Rather than accumulating a mosaicked map incrementally, Steve's image processor correlates current images to a reference that changes only when the vehicle moves out of the field of view of the current reference image. This approach provides error bounding consistent with the needs of moderately long distance point-to-point navigation. It also provides, as he points out, a capability to accumulate maplike images of larger regions than would otherwise have been possible in a sight-limited environment.

Steve further described an enabling technology for natural language command of AUVs, that is, commands such as "Return to the wellhead," rather than "Go left-straight-right-down-left." The interface for natural language commands requires only a low bandwidth connection to the vehicle and is very tolerant of communications delays. While a natural language command system is a reasonable adjunct to a vision-based navigation sensor, it itself promises to be an enabling technology. The vehicle that Steve's work

has been applied to is untethered and semi-autonomous: by implementing a measure of on-board intelligence the system can increasingly approach full autonomy.

Dr. Shahriar Negahdaripour, an Associate Professor at the University of Miami, presented his researchers' recent work on a vision-based system with a robust stationkeeping capability. Dr Negahdaripour's system has evolved from computer vision research he first undertook in 1984.

Shahriar's mosaicking is incremental but it accounts for image warping as well as the shading and artifacts induced by moving illumination sources. Its susceptibility to error growth is low enough that point-to-point navigation well beyond the boundaries of the starting image frame has been demonstrated as reliable.

Shahriar's work on 3-D shape and motion recovery is most exciting. By treating objects as having dimension, rather than just as flat images on a map plane, he not only establishes a means to help determine vehicle motion information but also enables extracting shape and texture information on the object itself.

Zubair Awan, who worked in Shahriar's lab as an eleventh grade student, provided an independent briefing on his participation in the research. Zubair's presentation was a serendipitous cap to the afternoon's session, dramatically complementing the university-level student participation described in the lunchtime report on the recent International Autonomous Underwater Vehicle Competition at the Naval Coastal Systems Station, Panama City, FL.

Facilitator's Comments

Consider three views of the underwater navigation problem: tracking, navigation, and situation awareness. The views are based on the location of primary information.

In tracking the underwater vehicle's position is sensed and known by others, *i.e.*, first-order knowledge is acquired off-vehicle. In this context, LBL or USBL acoustic systems are examples of tracking systems, as is Hubert's GIB. If

this tracking data is communicated to the vehicle an on-board navigation capability can be instantiated which will provide it useful position – velocity – acceleration information. Vehicle position can be tied to either an arbitrary (local) or a geodetic reference frame. Additionally, tracking plus communications provides a capability to control the vehicle from the surface. The vehicle is always under surveillance, though. It is supervised at best and can hardly be termed “autonomous.”

In navigation the vehicle is the both the sensor and the primary repository of its own position knowledge. It can therefore conduct truly autonomous operations. By using a communications channel it can report position information elsewhere, but it need not do so. By reporting its own position the vehicle is participating in what the aviation and shipping communities are calling “dependent surveillance.” Interestingly, the *surveillor* is dependent on the *surveillee* in these systems. Inertial measurement units, compasses, Doppler velocity logs, and an (as yet unimplemented) underwater extension of GPS are examples of navigation sensors in this context. Depending on such factors as point of origin, calibration, error growth, and the particular sensor system employed, position may be logged in either an arbitrary or a geodetic reference frame.

In situation awareness the vehicle accumulates knowledge of its local environment. Sonar and vision-based sensors are examples of situation awareness systems. Perception provides position in an arbitrary local reference frame. Perception plus *a priori* information, e.g., a map or the results of a previous survey, can provide position in a non-arbitrary reference frame. Situation awareness can help provide some measure of autonomy to the vehicle.

When Hubert Thomas submitted his paper how could he have known that a comment early in his text would presage a comment made in the Workshop’s first session? To the owner, the concept of

“autonomy” currently only goes so far. When dealing with an expensive, one-of-a-kind asset, today’s surface crew doesn’t want not to know where their underwater vehicle is. Hubert argues that a mixture of tracking and communication is the most practical system architecture. In today’s “sparse inventory” context this is true, even if it makes the term AUV somewhat of an oxymoron.

During discussions throughout the Workshop, Keith Vickers tried to get participants to grapple with the character of the future underwater vehicle marketplace by presenting his “AUV Applications with Associated Water Depths and Market Size” spreadsheet. Notwithstanding the usual utility of such a Delphi technique, we spent our time merely juggling the last few percentage points on the sheet to satisfy the representational interests of various existing Operational Roles. There was no futurist discussion regarding the possible existence of markets other than those on the worksheet. A few of Keith’s Operational Role entries were split, but we generally reached the unvoiced conclusion that tomorrow will be a linear extrapolation of today.

Technology provides new opportunity to the mission manager and expanded implementation choice to the system designer. Sensors, or combinations thereof, plus on-board intelligence can permit true “autonomy” in AUVs. Navigation systems are already being introduced which provide ties through to the Global Positioning System to a single geodetic reference frame. Natural language commands will enable more independence of vehicle activity. Shape and motion recovery will enable more complete on-board situation awareness and appropriate response to ambiguities in the environment. With entrepreneurial foresight, perhaps we can “render possible what was not possible” or “change the way things are done.”

But discontinuous growth in markets or mission requirements may bring

about a situation where underwater vehicles no longer perform alone, inevitably placing severe demands on communications channel use. Today’s mission market can tolerate dedicating one or more channels to tracking plus one or more channels to communications for each underwater vehicle. A dramatically expanded underwater vehicle population—“schools” of inexpensive UVs replacing fewer expensive assets—will require rethinking the paradigm that currently prefers tracking over the navigation or situation awareness alternatives. An expanded population will also lead to rethinking the topology of the communications network as well as the message content carried. The more autonomy each vehicle is trusted to have, the more autonomy all will need in order to contend with burgeoning communications channel occupancy.

Conclusions and Recommendations

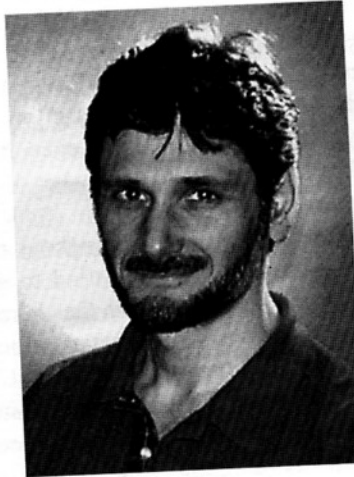
One of the goals of the Workshop’s agenda was to quantify “where we are now,” then to address the topics of “where we can be” leading to a discussion of concepts that could be available in the next 10 to 25 years. The quantification proceeded well and provided ample contextual entry into the final session. Frankly, however, visionary projections did not emerge. We would be well advised to use enabling technologies not merely as a way of doing today’s mission better, more accurately, or more economically but as a means of engendering missions and customer bases that are more than just extrapolations of today’s industry.

Looking back, I considered AUV ’98 to have been a successful workshop. It did identify to the participants that AUV navigation is still a field presenting opportunities that will require creative thinking. There will be an AUV 2000, please participate.

Note: For those interested, copies of the AUV ’98 Proceedings are available. Contact cmckee@draper.com for details.

Who's Who in the OES

CHRISTIAN DE MOUSTIER (M'86) received his Diploma of Engineer from the Ecole Supérieure d'Ingenieurs de Marseille, France, in 1979, his M.Sc. and Ph.D. degrees in Oceanography (Applied Ocean Science) at the University of California, San Diego (UCSD) in 1981 and 1985, respectively. He is with UCSD's Scripps Institution of Oceanography (SIO), where he is an Associate Research Oceanographer at the Marine Physical Laboratory, conducting research in signal and image processing techniques applied to swath bathymetry sonar data, and in underwater acoustics with emphasis on physics of bottom-interacting sound and sound reverberation in the ocean. He is also an Academic Administrator for SIO's Ship Operations and Marine Technical Support, providing scientific direction and specifying engineering solutions for shipboard instrumentation needs (computers, sonars, underway sensors) and software programming requirements. He serves as a Lecturer in UCSD's Electrical and Computer Engineering Department



in which he supervises graduate students working towards the PhD degree. In 1993, he was a Visiting Scientist in the Marine Physics Branch of the Naval Research Laboratory, Washington, DC.

He was Guest Editor of the October 1989 special issue of the IEEE Journal of Oceanic Engineering devoted to bathymetry and seafloor acoustic remote sensing and co-editor of the January 1997 special issue on image processing for oceanic applications. He has been serving as Associate Editor for the Journal since 1990, for topics related to seafloor acoustic remote sensing, bathymetry mapping and

surveying, and sonar image and signal processing applications.

He served on the Administrative Committee of the Oceanic Engineering Society for 1990-1993 and 1995-1997 and has been reelected in 1998 to serve until 2001. He is a member of the IEEE OES, and the American Geophysical Union. He is a Fellow of the Acoustical Society of America.

A TRIBUTE TO ROSS E. WILLIAMS

**Pioneering Underwater Acoustician, Founder of Ocean and Atmospheric Science, Inc.
1922-1997**

Fred H. Fisher
Marine Physical Laboratory
Scripps Institution of Oceanography
University of California, San Diego
La Jolla, CA 92093-0701

Ross Williams, a Fellow of the Acoustical Society, friend of many, noted for major contributions to the knowledge and applications of underwater sound, has passed on, November 8, 1997 at the age of 75.

His publications in JASA, with colleagues, in the 70's on the pioneering research accomplished in the magnificent ARTEMIS project (see footnote) during the 60's made clear the minimal effects of the medium on long-range propaga-

tion (600 miles) on single paths of low frequency pulses (400 Hz) from a megawatt sound source. Conclusion (3) per Williams and Wei (1972) stated:

"The standard deviations measured of spatial fluctuations show that wavefront distortions are quite small, with the former being dominant. Typical values of relative displacement range from 5 to 15 feet over the vertical aperture of 2000 feet."

Thousands of hydrophones consisting of vertical stacks of 32 elements were placed on sloping banks off Bermuda. Using a line of these vertical arrays aligned in the direction of propagation, a synthesized vertical aperture of 2000 feet was used to study a single path.

The project Artemis [see footnote] was created about 1957 or 1958 at the Navy's request to see FM long range active sonar system was possible, exploiting the observed stability and coherence at low frequency. Under Director Bob Frosch and Associate Director Alan Berman the project was well under way when, in 1960, Dr. Ross Williams joined the Laboratories.

As the project expanded, Ross joined the Hudson Laboratory of Columbia University in 1960 as a senior research associate, becoming Project Director for Artemis later on and Associate Director in 1966. The massive data streams from the hydrophones were processed by him using an optical correlator. He worked

on the theory, the actual data processing and the interpretation of the results along with his colleagues.

In the words of Bob Frosch: "Boldness and accomplishment were the hallmarks of his contributions to Project ARTEMIS".

After Hudson Laboratories were closed in 1968, Ross became a professor of Engineering and Applied Science and Director of the Ocean Engineering Program and served in that capacity until 1974. It was during this period he and his co-authors worked on publishing in the unclassified literature the results of Project ARTEMIS from the sixties.

The impact of the ARTEMIS PROJECT, a magnificent technical achievement in long range acoustic propagation, on understanding the ocean as a coherent medium for single path propagation and communication was spelled out (over 60 pages) in the following papers published in the Journal of the Acoustical Society of America:

Coherent Recombination of Acoustic Multipath Signals Propagated in the Deep Ocean, Williams and Battestin, JASA, 50, 1433-42 (1971);

Time coherence of acoustic signals transmitted over resolved paths in the deep ocean, Williams and Battestin, JASA, 59, 312-328 (1976);

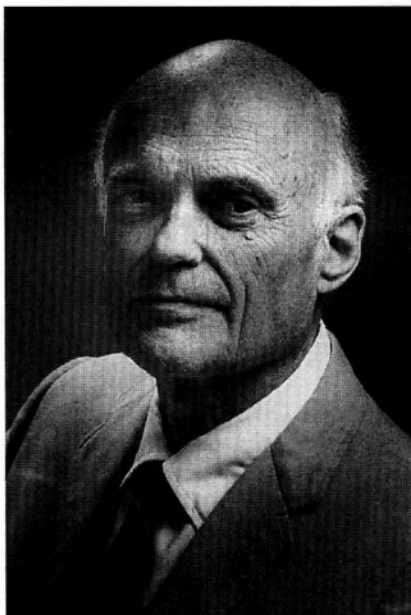
Spatial and temporal fluctuations of acoustic signals propagated over long ocean paths, Williams and Wei, JASA, 59, 1299-1309 (1976);

Creating an acoustic synthetic aperture in the ocean, Williams, JASA, 60, 60-73 (1976);

Array processors for simultaneous noise and interference suppression or simultaneous signal-to-noise and resolution enhancement, Glaser and Williams. 60. 1319-30 (1976).

Because of security considerations, none of the early results from Project ARTEMIS made it into the open literature until later.

In 1969, he helped to found Ocean and Atmospheric Science, Inc., which, in its early days did research in underwater acoustics as well as in various commercial engineering projects. He began to take a more active role in OAS when he became Chairman of the Board in 1972. Although OAS broadened its interests into other fields under his lead-



Ross E. Williams

ership, Ross continued his consulting work in underwater sound. In 1977 he became President of OAS and its CEO in 1995. His abiding interest in acoustics remained throughout his life and he and Bernard Harris published an invited paper in the IEEE Journal of Oceanic Engineering in 1992, entitled Passive Acoustic Synthetic Aperture Processing Techniques.

It was in the course of reading some of his papers about this work and talking to him at various meetings over lunch or dinner that I came to know Ross. My admiration for his genial, friendly and quiet competence grew to where he became a hero to me not only for his prowess in pioneering research in underwater acoustics, but also, for his kindness and friendship.

For whatever reasons, perhaps just plain oversight, he had been overlooked as a candidate for Fellowship in the Acoustical Society. Belated recognition of the pioneering research he did in Project Artemis came to him when he became a Fellow in 1994.

Ross Williams should be remembered as one of the key people who helped Columbia's Hudson Laboratories bring it to fruition and making its results on sound propagation in the ocean ultimately known in the unclassified literature.

Bob Frosch wrote this beautiful tribute to Ross Williams: "I want to empha-

size what a sweet, competent, audaciously intelligent man Ross was. Perhaps because he was quietly humorous as well as serious, he did not get the recognition he deserved."

Personal notes on his life from various sources follow: some from Jim Jenkins and Julius Bowen in Echoes, May, 1998, and some from the obituary by Fredrick W. Cotton in Physics Today.

He married Madeline Dunning on Sept. 21, 1996, in Hastings-on-Hudson. Throughout his life, he loved the New Hampshire woods and wildlife, and moved to Hollis, N.H., a little over a year ago after living in Yonkers, N.Y., for 38 years. In New Hampshire, he bought tracts of land to preserve them as national forest. He also loved collecting and driving antique cars and jogging..

Survivors besides his wife Madeline in Hollis, include a son, Ross E. Williams of Darien, Conn.; his daughter, Katherine J. Williams of North Hampton, N.H.; a sister, Beverly Whitehead of Rockford, Ill.; and four grandchildren.

His first wife, Carol L. Williams of Corrales, N.M., also survives.

Ross was an active member of the Asbury United Methodist Church in Crestwood, serving as layleader and trustee. He was a member of the church's stewardship, finance, and grounds committee, in addition to Monks in the Marketplace, a charitable church organization. He was interred in the North Pembroke Cemetery in Pembroke, N.H.

Friends and family are making donations in his memory to Asbury United Methodist Church, 167 Scarsdale Road, Tuckahoe, N.Y., 10707.

Historical footnote: PROJECT ARTEMIS arose when Harvard Professor F.V. (Ted) Hunt suggested the feasibility of an audacious active sonar concept, namely, to search an ocean an hour for submarines. The Hudson Laboratory was created by the Navy in the fifties to explore this concept with Robert A. Frosch as Director and Alan Berman as Associate Director. In the words of Bob Frosch: "We (Frosch and Berman) named it ARTEMIS, the Roman name for the Goddess of the Hunt, to honor Ted Hunt, who inspired us with Greek name was already in use for another

project - I think the one to get a radar echo off the moon."

I am grateful to C.S. Clay for the following history of the research which led to the ARTEMIS PROJECT.

"Scientists live and work in the context of their times. Robert Frosch and Alan Berman were the director and associate director of the Hudson Laboratories of Columbia University. They and other Hudson Laboratory physicists believed that fluctuations of sound transmissions would not limit what one could do in using sound to locate and track submarines. They thought there was no obvious mechanism for fast enough motion at large scale to make low frequencies incoherent. Their early results bore out their expectations and were much smaller than expected from theories of Chernov, etc.

"For a crucial test in 1957, Frosch, Berman, Clay, Guthrie, and Sherry and

made low frequency (10 - 30 Hz) CW transmissions across the Hatteras Abyssal Plain to several bottomed hydrophones on the Bahama banks. The hydrophone separations were more than 100 nm. They were able to track the moving source by measuring the Doppler phase differences."

[From Bob Frosch: "These experiments demonstrated that long range sound transmissions in the ocean were stable, as expected, and reproducible. We actually did an experiment in which we beat sound signals from receivers as far apart as Eleuthra and Sable Island and got the ship's differential doppler, from which we could deduce its position, and whether the helmsman was steady or not."]

Again from Clay: "By 1960, the Hudson Laboratory physicists had experimental evidence that internal waves in the ocean would have negligible ef-

fects on the reproducibility of sound transmissions.

"The concepts were huge and increased the size and complexity of active sonar systems more than two orders of magnitude. Ross was the pioneer on the signal processing techniques and later on, he became the project leader after Bob Frosch and Alan Berman moved on. Among other things, he invented state of the art advances in complex underwater receiving systems and in multi-channel processing. When he started, the most complex sonars and signal processors used Vic Anderson's one-bit DIMUS delay lines. Incidentally, the existence of an Apple II computer would have been a breakthrough. With primitive hardware, Ross invented new ways to process huge numbers of signals in real time."

NEWS FROM HALIFAX, N.S., CANADA

IEEE/OES Canadian Atlantic Chapter

Prepared by
Dr. Ferial El-Hawary,
P.Eng., F.MTS, F. EIC.
Chairman, IEEE/OES Canadian
Atlantic Chapter

The Oceanic Engineering Chapter of the Canadian Atlantic Region of IEEE, the first OES Chapter in Canada, was established in 1985. It was founded as part of the preparations made by the Oceanic Engineering community of the Capital of the Canadian Province of Nova Scotia, "Halifax" to make it the host city for OCEANS'87.

Population-wise, the Canadian Atlantic Region is relatively small in comparison with other geographical areas around the world. This is more than compensated for by being home to a significant infrastructure that serves engineering and technology for the marine environment. The Greater Halifax area is home to organizations such as the De-

fence Research Establishment Atlantic, the Bedford Institute of Oceanography, Federal Oceans and Fisheries Department, and related Fishery Industry. In addition, the off shore oil and gas sector includes companies involved in the Sable Island Oil and Gas activities. Academic Institutions such as Dalhousie University and DalTech are heavily involved in oceans related engineering activities. The Chapter has started by a team of well motivated volunteers who are members of the staff at many of these organizations.

The current officers of the chapter are:

Dr. Ferial El-Hawary,
B.H.E.S. L. - Chairman
Dr. Brian Maranda,
DREA - Secretary
Dr. Anthony Ashley,
DREA - Member at Large
Mr. Fred Guptill,
Consultant- Publicity



Dr. Ferial El-Hawary

We are proud that the volunteers from our Chapter have been able to contribute to the success of two great Oceans' conferences in our city, OCEANS'87 and ten years later, OCEANS'97. Our volunteer efforts were instrumental in assisting the creation of the French Chapter in 1993 and the Norwegian Chapter in 1996. Indeed,

the encouragement of the Executive of the Oceanic Engineering Society along with Dr. Ferial El-Hawary's work with the French and Norwegian groups have led to the extremely successful International Oceans conferences in Europe, OCEANS'94, which was held in Brest, France and again this year OCEANS'98, which was held in Nice, France. We believe that these efforts are significant since there is evidence, that expanding the geographical area of conference offering around the world would further promote the goals of the society by making it accessible to a greater number of our membership.

The remaining part of the Chapter's calendar events for 1998 is a busy one, since everyone is trying to do their best in

order to celebrate "THE YEAR OF THE OCEAN" before the end of the year. Most recently the Chapter co-hosted a Luncheon/Harbour Cruise on June 8, 1998, in conjunction with the Conference LESCOPE'98 held at the Sheraton Hotel in Halifax. This was followed by a Technical Tour to the "Funday Tidal Power Generating Plant", on June 10/98. A series of Invited Speakers has been scheduled with a variety of topics that can serve the local membership.

On August 21, 1998 the Chapter hosted Dr. David Weissman as a guest speaker. The topic was "SATELLITE SCATTEROMETER (NSCAT) STUDIES OF OCEAN SURFACE STRESS AND DRAG COEFFICIENTS USING A DIRECT MODEL"

On October 22, 1998 the Chapter is hosting Dr. Meyer Nahon to speak on "RESEARCH ACTIVITIES IN UNDERSEA SYSTEMS AT THE UNIVERSITY OF VICTORIA"

These events were well attended and provided benefit to students and participants from the marine industry in the local area .

We are looking forward to hosting the 1999 Large Engineering Systems Conference On Electrical and Computer Engineering "LESCOECE'99". We expect to see many of you attending the Oceans Related Sessions at the Conference. Let me hear from you.

UPCOMING CONFERENCES

The 1999 Large Engineering Systems Conference on Electrical & Computer Engineering "LESCOECE '99"

The Halifax World Trade Convention Center
Halifax, Nova Scotia, Canada

June 20-22, 1999

Dr. Ferial El-Hawary, P. Eng.,
F.EIC, F.MTS

BH Engineering Systems Limited
P.O. Box 25041,
Halifax, NS, B3M 4H4, Canada
Tel: 902-443-2400
Fax 902-445-5110
Email "FERIAL" *elhawary@dal.ca*

Ultrasonics International '99 joint with Technical University of Denmark

Copenhagen, Denmark

June 29 - July 1, 1999

1999 IEEE Pacific Rim Conference on Communications, Computers and Signal Processing (PACRIM '99)

August 23-25, 1999

Victoria, B.C., Canada

Second International Conference

Shallow Water Fisheries Sonar
Seattle, Washington

September 7-9, 1999

OCEANS '99 MTS/IEEE Conference & Exhibition

September 13-16, 1999

Seattle, Washington

Underwater Technology 2000 UT '00

The New Sanno Hotel
Tokyo, Japan

May 23-26, 2000

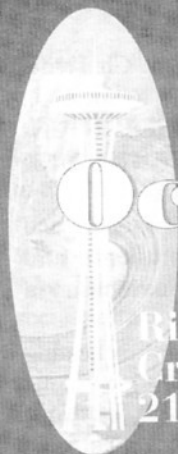
5TH European Conference on Underwater Acoustics ESCPE

Lyon, France

July 10-13, 2000

OCEANS 2000 MTS/IEEE Conference & Exhibition

Providence, Rhode Island
September 11-14, 2000



Oceans '99

Riding the Crest into the 21st Century

OCEANS '99 MTS/IEEE

CONFERENCE & EXHIBITION

13-16 September 1999

Seattle, Washington

Call for Papers



IEEE

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Prospective authors are solicited for papers dealing with new technology concepts, developments and applications which describe advances in science and engineering in the ocean environment.

Proposed technical sessions at the Conference will focus on the following technical topic areas:

Theme Related Topics

Data Visualization
Defining New Horizons
Environmental Challenges
Future Science and Technology
Global Changes
Global Ocean Observation
Internet Information
Planned Ocean Programs
Satellite Communications
The America's Cup 2000
Virtual Ocean Data Systems

Advanced Marine Technology

Advanced Measurement Systems
Autonomous Unmanned Vehicles
Manned Submersibles
Ocean Energy
Oceanographic Instrumentation
Optics and Imaging
Real Time Measurement Systems
Remotely Operated Vehicles
Ships/Technology

Communication & Navigation

Acoustic Communication
Fiber Optic Communication
Intelligent Dynamics
Mission Control
Positioning/Navigation
Underwater Robotics
Underwater Telemetry/Modems

Ocean Monitoring Systems

Air/Sea Interaction
Autonomous Benthic Sensing
Climatology
Coastal Ocean Nowcasting
Ocean Science Forecast
Polar & Severe Environments
Real Time Measurements
Remote Sensing
Water Current Measurements
Water Level Monitoring
Waves & Sea Level

Marine Policy & Education

Coastal Zone Management
Marine Law & Policy
Marine Recreation
Marine Safety/Security
Marine Science Education
Merchant Marine
Ocean Economic Potential
Ocean Policy

Marine Resources

Marine Geodesy
Marine Living Resources
Marine Mineral Resources
Oceanographic Ships
Ocean Pollution
Physical Oceanography/Meteorology

Underwater Acoustics

Acoustic Detection
Boundary Interaction
Classification
Localization & Tracking
Matched Field
Polar Operations
Process/Tomography
Sonar Signal Processing
Transducers & Arrays

Signal & Information Processing

Data Access/Retrieval/Display
Database Compression
Geographic Information Systems
Metrology & Calibration
Modeling/Simulation & Databases
Non-Acoustic Imaging
Oceanic Neural Networks
Super Computers

Ocean & Coastal Engineering

Buoy/Moorings Technology Diving
Electro/Optical Cables & Connectors
Marine Materials
Marine Salvage & Towing
Offshore Structures
Ropes & Tension Members
Seafloor Properties/Engineering

The technical program will include a Student Poster Competition and Tutorial sessions for which prospective authors will be solicited. A large State of the Art Exhibition in the field of Marine Technology will be held in the Washington Convention Center.

Information for Authors

Prospective authors should submit a single page (300 to 500 words) abstract in the technical topic areas. There should be no equations or figures in the abstract. The official language of the **OCEANS '99** Conference will be English.

The abstract must show the following information:

Paper Title _____

Authors, co-authors and affiliation _____

Preferred topic area (indicate a second choice) _____

Paper previously published (if yes, indicate place and date) _____

Oral/Poster session (indicate preference) _____

Corresponding author: _____

Last Name _____

First Name _____

Company _____

Mailing address _____

Telephone _____

Fax _____

E-mail _____

In the abstract, authors should describe the problem that is addressed, indicate its importance and describe how the work contributes to the field. The **OCEANS '99** Technical Program Committee will evaluate papers only on the information supplied in the abstract. The Committee will select papers for presentation and organize the Advance Program following receipt of abstracts. We strongly encourage sending the abstract via e-mail, with no attachments, to the addresses shown at the bottom of the page. If e-mail is not accessible, send via fax or mail four (4) typed copies of your abstract to one of the addresses below.

To ensure that authors are in attendance at the Conference to present their papers, a non-refundable **\$100** Deposit or a Discounted Early Registration Fee will be required for authors whose abstracts have been accepted. This Deposit will be applied towards the Early Registration Fee upon receipt of the Notification of Acceptance and prior to inclusion of their paper in the Advance Program. The remainder of the Early Registration Fee must be submitted with the Camera-Ready Manuscript for the paper to be included in the Final Program and Proceedings.

SEND ABSTRACTS TO:

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IMPORTANT DEADLINES

Abstract Deadline: 6 February, 1999
Notification of Acceptance: 10 April, 1999
Camera-Ready Paper: 19 June, 1999

IEEE OCEANS '99

445 Hoes Lane, Piscataway, NJ 08855, USA



Networking the World™



Call for Exhibits

The Conference invites manufacturers of ocean engineering products and organizations offering related services to exhibit at **OCEANS '99**. The conference schedule will include ample time for participants to visit the Exhibit Hall. Conference participants will include national and international representatives of marine-related industries, academic institutions and government agencies who buy, recommend or specify new products and technologies.

This is the original "CORE" exhibition of the world's ocean research industry. Now celebrating its 10th anniversary. Don't miss it!!!! For further information contact: Danielle Catapano at IEEE Travel and Conference Management Service; 445 Hoes Lane, Piscataway, New Jersey 08855 USA, within the United States at 800.810.4333, outside the United States at 732.562.5599, Fax 732.981.1203 or email: exhibits@ieee.org.

Call for Tutorials

As part of the **OCEANS '99** focus on advanced technology concepts, developments, and applications, the Conference Committee is soliciting proposals for half day tutorials, in technology areas related to those highlighted in the Call for Papers. Interested individuals must submit a 500 word abstract on tutorial utility, focus and intended audience, a 200 word biography of the instructor and an outline of material to be presented. Instructors will be compensated in accordance with tutorials registration. Tutorials must be received by 6 February, 1999 to be considered for acceptance.

For further information contact:

Tutorials:

Frank Hughes Co-Chair
8918 45th Ave NE
Seattle, WA 98115
Fax +1.425.237.5517
Email: frank.w.hughes@boeing.com

Frederick H. Maltz Co-Chair
1760 Larkellen Lane
Los Altos, CA 94024
Fax: +1.650.969.9390
Email: 75674.611@compuserve.com

Call for Student Posters

OCEANS '99 will sponsor a Student Poster Session. Full time undergraduate and graduate students in engineering and sciences at accredited universities are invited to submit a 500 to 800 word abstract describing their work in the technical topic areas, their method of solution, the results/conclusions and a discussion of their work.

Selected students will be invited to attend **OCEANS '99** and present their poster as guests of the Conference.

For further information contact:

Student Posters:

Norman D. Miller, 2644 NW Esplanade Dr.
Seattle, WA 98117
Fax: +1.206.784.0478
Email: n.miller@ieee.org

US Liaison:

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Piscataway, NJ 08855 USA
Phone: +1.732.562.6826
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Email: oceans99@ieee.org

Poll Shows Engineering Remains U.S. 'Stealth Profession'

by Chris Currie, IEEE-USA staff

Amid concerns that not enough of America's brightest students are pursuing technical careers, a new Harris Poll survey shows that the U.S. public feels uninformed about the engineering enterprise and betrays a startling lack of knowledge about engineers' involvement in key areas of American endeavor.

Louis Harris and Associates conducted the telephone survey in late July. The American Association of Engineering Societies (AAES) commissioned the study, with additional funding provided by The Institute of Electrical and Electronics Engineers - USA (IEEE-USA) and other societies. An objective of the study is to determine the impact of public awareness of engineering upon the size and quality of the U.S. engineering workforce, particularly given the changing demographics of the overall domestic workforce.

Although the survey of "American Perspectives on Engineers and Engineering" found that Americans believe that engineers are to be credited with creating economic growth and preserving national security, the general public is less clear on how and why that is so. The survey revealed that 45 percent of Americans believe that they are "not very well informed about engineering and engineers" while another 16 percent stated that they are "not at all well informed about engineering and engineers." Among women, however, the percentages increased to 55 percent and 23 percent, respectively. Even a majority of college graduates (53 percent) reported that they are "not very well informed or not at all well informed" about engineering and engineers.

The responses to other questions demonstrated that the respondents were not guilty of false modesty. On one question that asked which professionals — scientists, technicians, or engineers — respondents "mostly associated" with various technical activities, engineers were frequently underestimated in their roles. In areas where there exists a strong or dominant engineering element such as "working in space," "developing new forms of energy" and "creating new materials," scientists were cited more than engineers.

"The poll manifests both a subjective and objective American ignorance about the work of engineers," said IEEE-USA President John R. Reinert. "Observers have often pointed to engineers' allegedly 'nerdy' image as a turn-off to students considering engineering careers. However, these results may have identified the stealth character of our profession as the real challenge in attracting the nation's best and brightest young people — including women and minorities — to technical fields."

A more encouraging result for engineers is that ignorance apparently doesn't translate into bad feelings toward the profession. Many parents suggested they would encourage their children to pursue careers in engineering. When asked the question, "Using a scale of 1 to 10 with 1 being extremely displeased to 10 being extremely

pleased, if your son or daughter or other family member said they wanted to be an engineer, how pleased would you be?" the mean response was 9.

Furthermore, an earlier Harris Poll conducted in June revealed that engineers hold relatively high prestige com-

pared to other professions — although they fall considerably below scientists, teachers and physicians. And a Gallup poll last November found that engineers ranked seventh among surveyed professions in honesty and ethics.

Americans may be laying the blame for their own lack of engineering awareness at the feet of the news media. When asked to rate the quality of media coverage of science, technology, engineering, and medical discoveries, more than 69 percent of the survey respondents assigned "fair" or "poor" grades to engineering reporting while less than 3 percent gave the media an "excellent" score. Among college graduates and those with incomes of \$75,000 or more, 85 percent and 80 percent of the respondents respectively assigned scores of "fair" and "poor" to the media's job in covering engineering.

"Other professionals — such as doctors, lawyers and teachers — can inform the public more easily because they work directly with the public," said Reinert. "We speak mostly through our products, and even those are increasingly difficult to understand. So it's imperative that we do a better job of speaking directly to the public through the media and our professional societies in order to bridge the awareness gap. The health of the engineering workforce and, ultimately, the American quality of life may be at stake."

In addition to IEEE-USA, survey sponsors included The American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME), the American Society of Civil Engineers (ASCE), the American Society of Mechanical Engineers (ASME), SPIE, the International Society for Optical Engineering, and the United Engineering Foundation.

(Reprinted from Spearhead Online Directories christine.rose@spearhead.co.uk)

CALL FOR PAPERS - OCEANOLOGY INTERNATIONAL 99 PACIFIC RIM

Extended deadline 15 November 1998

Oceanology International 99 Pacific Rim 27-29 April 1999, a marine science and ocean technology exhibition and conference focusing on the Indo and Pacific Regions, returns to Singapore with its theme "Enabling Technology for a Sustainable Environment."

'We are glad to host Oceanology International 99 Pacific Rim in Singapore and certainly extend a warm welcome to all intending participants and exhibitors' says Dr Elizabeth Taylor, Deputy Director, Tropical Marine Science Initiative & Associate Professor, School of Biological Sciences and Chairman of the Oceanology International 99 Pacific

Rim Conference Committee. The ocean environment has tremendous potential that can be harnessed to benefit mankind in almost limitless ways. Oceanology International 99 Pacific Rim will provide full opportunities for researchers from different disciplines, managers, decision-makers and providers of state-of-the-art services and products to come together, share and exchange information, and to plot the future course of research and development for the seas and oceans.'

The Conference Committee invites speakers to present abstracts on Marine Environmental Management, Marine

Information Technology, Marine Biology/Biotechnology, Acoustics, Operational Modelling and Integrated Coastal Zone Management. The topics are intended as a guide and are not exclusive. Copies of the call for papers are available from Spearhead Exhibitions Ltd, owners and organisers of the OI series of events. For more information email christine.rose@spearhead.co.uk or visit our website <http://www.spearhead.co.uk>.

The extended deadline for the receipt of abstracts is 15 November 1998.

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