IEEE

OES

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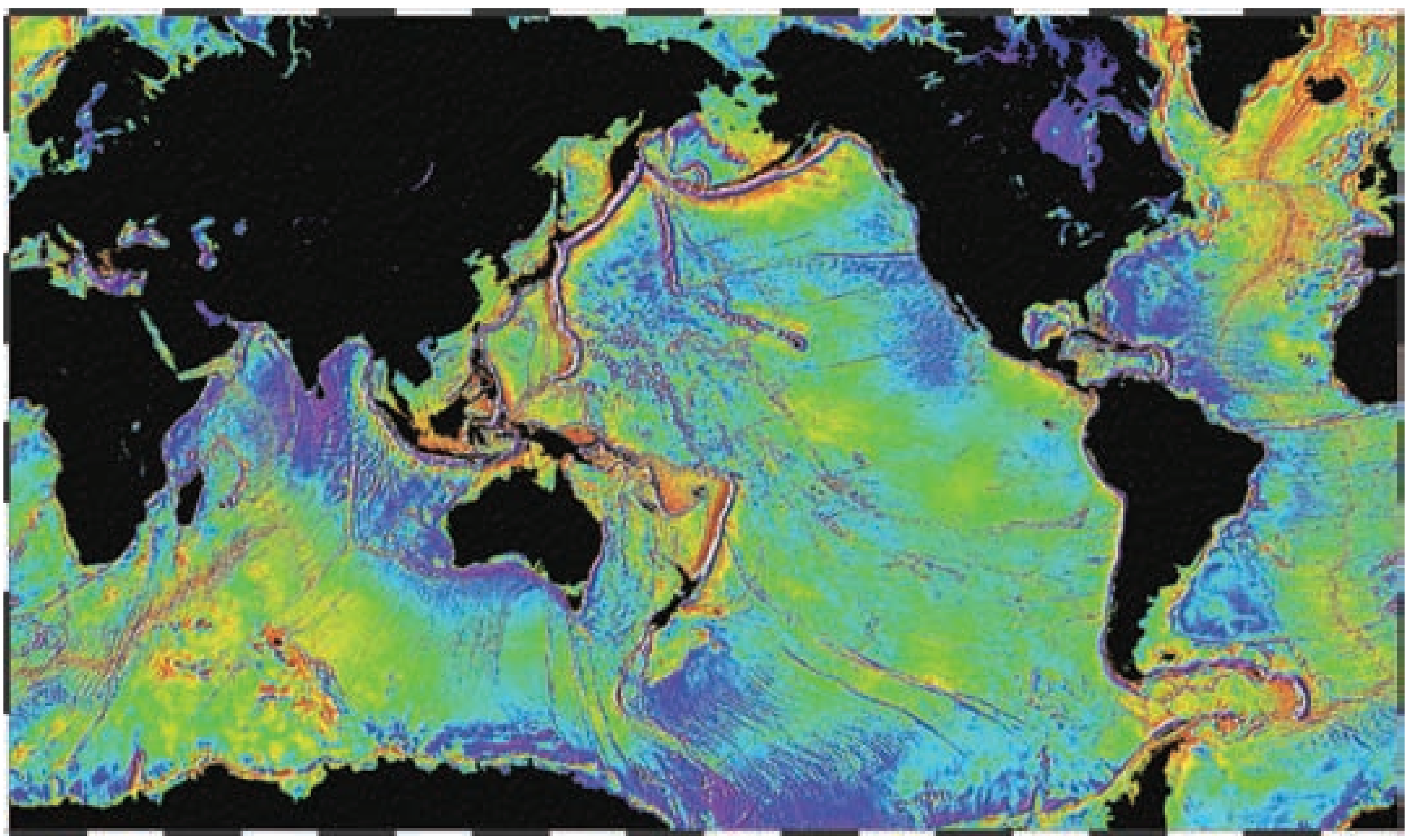

Ocean surface topography from satellite altimetry,
David T. Sandwell – Scripps Institution of Oceanography and
Walter H. F. Smith – Geosciences Laboratory, NOAA

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President's Corner

Every five years each of the IEEE Societies undergoes an extensive review by the Society Review Committee (SRC). The Oceanic Engineering Society completed its last review in 2005 and has just completed its current review in February of 2010. The SRC reported in February to the Technical Activities Board with the following Executive Summary:

OES is a relatively small society with only 1,600 members but is very active for its size. In contrast to most societies, its membership has been gradually increasing over the last several years, with commendable global presence. The society is well managed with an ADCOM comprising a diversity of volunteers (affiliation, region, etc.). The society regularly provides officers for the Councils it is a member of. OES has an active program of technical activities, successful conferences and publications, and is financially sound.

The SRC further commented that the Society has an excellent Conference Operational Manual which provides continuity from one conference to the next. The Society has a streamlined web-based conference management process for paper submission, review, filtering, and submission to Xplore. IEEE has looked at this system and is considering adopting some of this process for general use. The SRC did note that our distinguished lecturer program has been relatively weak and the Society explained that the VP Technical Activities has been given responsibility for revitalizing the program. The SRC did take note of all our activities aimed at younger students, including middle school, high school and undergraduates and commented on our excellent Student Poster Contest associated with the OCEANS Conferences. They also noted a lack of members in Region 9. We noted that we conducted a workshop in Chile in 2008 and are holding a symposium in Buenos Aires in April of 2010 which we hope will lead to an OES Chapter. We also have plans for activities in Brazil. They also consider as a best practice having a Vice President for Conference development that carries out our strategic plan and a Vice President for conference operations.

This very favorable review we received is based on all the hard work that our volunteers are doing. Rene Garelo and the JOAB committee are to be commended for their development of the OCEANS Operations Conference Manual. Todd Morrison, along with Sandy Williams, and the Veraprise crew are to be commended for our Conference web based tools which have streamlined our operations. I appreciate the help of all of you in preparing for the Review. Christian de Moustier conducted a separate review with the Publications Committee on the Journal that was also very successful and did much to establish an understanding of the operations of the Oceanic Engineering Society.

I just completed a RECON trip with Robert Wernli, Vice President for Conference Development, to Korea to revitalize the plans for OCEANS 2012 in Yeosi and to prepare a venue for OCEANS 2014 in Taipei, Taiwan. Both of these conferences should be very exciting with the 2012 conference associated

(continued on page 4)

OES Newsletter Editorial

The front cover has a terrific image of ocean surface topography derived from satellite altimeter data. You can find this image and many others at http://www.ngdc.noaa.gov. Besides being of interest in its own right, it reminds me how OES is an international society, spanning many countries and cultures. This is quite evident when you look at the list of new members; I count 24 different countries that are represented in the new membership and the diversity is increasing. Further evidence of this is provided in this issue in the reports from different chapters around the globe. OES is an active society, facilitating vigorous dialogue in many branches of science and engineering relevant to all bodies of water. There are several conferences advertised in this issue that are soliciting papers; an opportunity to share and learn from one another.

In this issue we feature a website that is rich in educational content concerning acoustics. We also feature a website from IEEE that will benefit us all. I'd like to invite more submissions like this. The internet is such a fundamental part of how we work these days and knowledge of particularly useful sites is of great value. Perhaps you know of a site that has great utility to you and could share that with the rest of us.

I hope to see many of you at the next OCEANS conference in Sydney, Australia in May; another opportunity to hear the latest developments and network with a great group of professionals.

Please send me your ideas, comments, or suggestions; I'm always looking for new material to publish. E-mail me at j.gant@ieee.org.

Jim Gant
OES Newsletter Editor

New Chair – Ocean Modeling Technology Committee

Frederick H. Maltz, Sr. Life Member

On the retirement of Warren L. J. Fox, former chair of the Modeling, Simulation and Visualization Technology Committee, it is with great pleasure and a sense of pride that I accept this new position. I believe that this particular Technology Committee is a crucial element in the future development of the OES during this time of pressing global ocean challenges. As the new chair, I hope to help our society in meeting these new challenges.

In the current Statement of Technical Scope for this committee, the technology focus is on "computer oriented modeling, simulation and databases within ocean engineering and science." The current mandate concerns three major issues:

1) Improved quality control in existing and developing databases and their user interfaces.
2) Expanded description of models, including a "sunset law" for associated computer codes.
3) Attainment of greater interdisciplinary interaction with workers in the other technical fields under OES cognizance.

The activities of the committee are deemed to serve as a bridge – in an advisory capacity – between application needs and solution means. In this sense the committee interacts with all of the other technology committees. In some cases there may be an overlap, since modeling in a general sense is an activity of it's own within the other technology committees. In a future issue of the OES Newsletter, I will address this point and describe a redirection of the committee to better fill the requirement for "many verified, validated, correct models of the ocean to meet not only our own needs as we design and analyze systems for the ocean, but also high quality models and simulations to support serious policy questions", as stated by the technology committee's founding chair in the Summer 1999 Issue of the OES Newsletter, "Modeling and Simulating the Influence of the Ocean: A Role for the Oceanic Engineering Society" by Edward C. Gough, Jr.

President's Corner *(continued from page 3)*

with EXPO 2012 in Korea. Both Local Organizing Committees were very enthusiastic about conducting the OCEANS Conference. A representative from the Marine Technology Society accompanied us on the visit and MTS may be a co-sponsor for these events.

The next couple of months will be very busy for OES with our IEEE/OES South America International Symposium in Buenos Aires, Argentina, 12–14 April; the Offshore Technology Conference in Houston, 3–7 May; and our spring OCEANS Conference in Sydney. Australia, 24–27 May. Our new Vice President for Technical Activities Liz Creed is working with our OES Chapters to help them increase their activities. Planning for the OCEANS Conference in Seattle is well under way with a very competent and active Local Organizing Committee.

Jerry Carroll
OES President

Welcome New Members

Fares Abda	France	Carroll K. Gordon	USA
Zulkifli Bin Zainal Abidin	Malaysia	Brandon Groff	USA
Mazin R. Alalusi	USA	Herve Gueguen	France
Saul A. G. Alonso	USA	Huaihai Guo	USA
Malarkodi Amirthalingam	India	Sara Haines	USA
Stuart D. Anstee	Australia	David Hammond	USA
Mohd R. Arshad	Malaysia	Mohd S. Hamzah	Malaysia
Stephen A. Barkby	Australia	Valerie A. Hartmann	USA
Becky Baxter	USA	B. J. Harker	UK
Landry J. Bernard	USA	Cathy E. Henderson	USA
Massimo Bertacca	Italy	Gail Henry	USA
Samuel A. Bingham	USA	Lori E. Hogan	Canada
Austin M. Blackert	USA	Geoffrey K. Holden	Canada
Jerry B. Boatman	USA	Voon Ee Bernard How	Singapore
Kenneth D. Brewer	USA	Kenneth T. Hunter	USA
Steven F. Browdy	USA	Nur Afande Ali Hussain	Malaysia
Hannuman Bull	USA	Gerry W. Irvine	UK
Igor N. Burdinsky	Russia	Sungho Jin	South Korea
Luke Cawley	Australia	Gerald B. Johnson	USA
Jessica L. Chepp	USA	Ali B. Kadafur	UK
Heeseob Cho	South Korea	Yilmaz Kalkan	Turkey
Sungrae Cho	South Korea	Girges F. Gad El Karim	USA
Timothy Cook	USA	Savvas A. Karvounis	Cyprus
Cameron Craig	USA	Richard A. Katz	USA
Peter N. Crocker	Canada	Benjamin W. Kelleher	USA
Rongxin Cui	Singapore	Kevin A. P. Kirchman	Monaco
Nayden D. Danchev	Bulgaria	Nicholas Krouglicof	Canada
Donald F. Dinn	Canada	Christophe Laot	France
Michael Dix	USA	Ricky Leavell	USA
Michael G. Edds	USA	Eun Seok Lee	South Korea
Timothy A. Ellis	USA	Michael Lewis	UK
Eric L. Ferguson	Australia	Tony Lin	Taiwan
Bruno M. Ferreira	Portugal	Ying-Tsong Lin	USA
Aaron D. Fisher	USA	Lance D. Linton	Australia
Nancho Foo	Singapore	David Luberger	USA
Rosaire Francoeur	Canada	Deepikarani M	India
Thomas C. Furfaro	USA	Austin R. Mack	USA
Jason T. Galary	USA	Brian Tabor Maguire	USA
Natalia Galin	USA	Amaresh Mahapatra	USA
John T. Gebbie	USA	Muhammad N. Mahyuddin	Malaysia
Matthew L. Gochnour	USA	Virgilio J. Maisonet	USA
K. G. Gopinath	India	Meyer Marks	USA

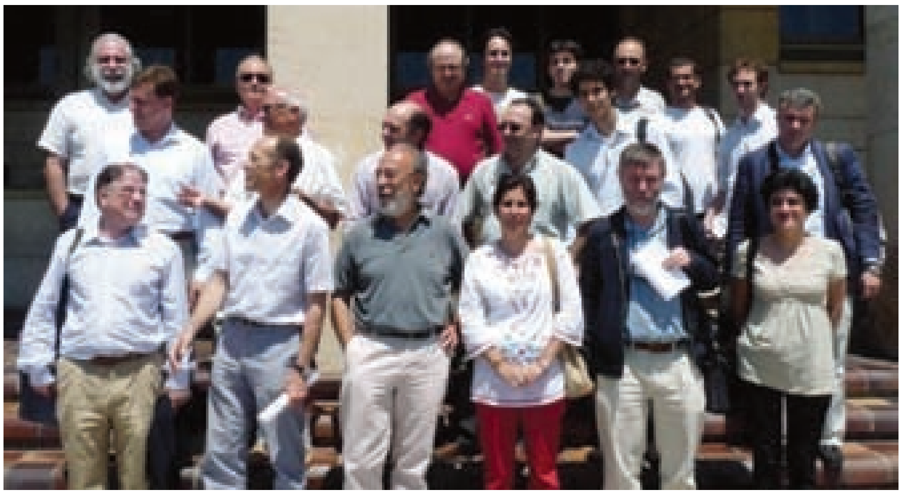
M. Mathiyaparanam	UAE	Muataz Hameed Salih	Malaysia
Michael W. Mccann	USA	Alexander Scherbatyuk	Russia
Scott D. Mclean	Canada	Apoorva Sharma	India
Zachary T. Miller	USA	Khaja Mohammad Shazzad	Canada
Rosmiwati Mohd Mokhtar	Malaysia	S. K. Shivarudrappa	USA
Carlos W. Morato	USA	Connie Elise Solberg	Norway
Ruth L. Mullins	USA	Randall J. Snoeyink	USA
Rajesh R. Nadakuditi	USA	Michael H. Snow	Canada
Arthur E. Newhall	USA	Steven C. Spencer	USA
Ana M. De Oliveira	Brazil	Nina Stark	Germany
Robin R. Padden	USA	Maria Stefanovich	USA
Anthony Paul	Canada	Hiroyuki Suzuki	Japan
Peter D. Pearl	Canada	Tawfiq Taher	Singapore
Dennis K. Peters	Canada	A. M. R. K. Talukder	Bangladesh
Craig A. Peterson	USA	Ching S. Tan	Malaysia
Miguel A. Pinto	Portugal	Wenxia Tan	Canada
Andrew J. Poulsen	USA	Kevin J. Taylor	USA
James L. Prater	USA	Aaron M. Thode	USA
Plamen Qnkov	Bulgaria	Lachlan Thomson	Australia
Edward J. Quinlan	Canada	J. P. Thorburn	Canada
Khairul Izman Abdul Rahim	Malaysia	Beatrice Tomasi	Italy
Charles J. Randell	Canada	Ray M. Tumi	USA
Ralph F. Rayner	UK	Lauren K. Tuthill	USA
Brian Rehmer	USA	Furong Wang	China
Shanshan Ren	USA	P. J. Welton	USA
Michael J. Robinson	UK	Brooks B. Wood	USA
Craig R. Rodine	USA	Ikhwan Hadi Yaacob	Malaysia
John Roeder	USA	Tim O. Yeider	USA
Maria L. P. Romero	Columbia	Yaakob Yusof	Malaysia
Steven Ruberg	USA	Muzammer Zakaria	Malaysia
Jason Rudzinsky	USA	Adam Zatik	Hungary
Michael Rufo	USA	Mike Zerkus	USA
Patrick F. Rynne	USA	Lijie Zhang	China
Lluis-Ramon Sales	Spain	Qinqing Zhang	USA

Chapter News

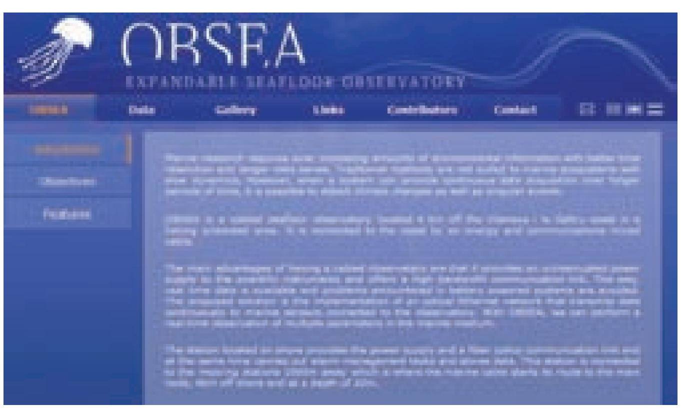
[Editor's Note: We'd like to make this column a regular feature. Please send news items from your chapter with pictures whenever possible. Send it to me at j.gant@ieee.org.]

Spain – *reported by Gabriel Oliver Codina*
In June 2009, the universities of Cantabria, Complutense de Madrid and UNED organized a workshop on Marine Robotics in Santander. Part of the audience appears in the picture below.

On November 19–20, the third edition of the Martech workshop took place in Vilanova i la Beltran (close to Barcelona).



Martech is a scientific and technical biannual meeting for researchers in marine technology. You can see a video of the workshop at: http://www.cdsarti.org/martech09.wmvMartech09-Video. One of the topics presented at the workshop was the undersea observatory OBSE, a cabled seafloor observatory located 4 km off the Vilanova i la Geltru coast in a fishing protected area. It is connected to the coast by a cable providing energy and communications. For further information about OBSEA visit: http://www.upc.edu/cdsarti/OBSEA/info/intro/intro_eng.html or contact Prof. Antoni Manuel, from the Technical University of Catalonia at antoni.manuel@upc.edu.



There will be a meeting next June in Santander (as you know, Santander will host the next OCEANS conference in 2011). Thus, on June 24th some of the members of the OES Spanish chapter will visit the conference facilities and will have a meeting with the local committee members. The next day, we will have a technical meeting of the Automar network. Automar is a research network that gets in contact all the Spanish research groups that work in automation in the marine environment.

San Diego, USA – *reported by Kevin J. Delaney*
The San Diego chapter of the IEEE Oceanic Engineering Society participated in a local high school's Engineering, Math and Science Career Exploration Fair on March 3, 2010. The Engineering Academy at Patrick Henry High School invited a variety of universities, research organizations and professional societies to present career information to about 400 interested students during the half-day event.

Japan – *reported by Kenichi Asakawa, Hitoshi Mikada and Harumi Sugimatsu*
Japan chapter was organized in August 1995 by Prof. Tamaki Ura. Since then, it has been vigorously active. Now the membership of Japan Chapter is eighty-four strong (as of October 2009). The conferences and workshops it organized or co-sponsored include OCEANS'04 MTS/IEEE / TECHNO-OCEAN'04, OCEANS'08 MTS/IEEE KOBE-TECHNO-OCEAN'08, a series of workshops "Underwater Technology" and "Scientific Use of Submarine Cables and Related Technologies". Recently it has organized or sponsored a memorial workshop "Frontier of Geoscience and Ocean Observation Technology," "'10 Underwater Robot Convention in JAMSTEC," the "Workshop for Asian and Pacific Universities' Underwater

San Diego IEEE/OES chapter president Kevin J. Delaney discusses the role of a professional society in career development with high school students at Patrick Henry High School Career Day, March 3, 2010.

Roboticians APuuRobo 2010", and "Forum for Underwater and Seafloor Engineers" (domestic forum in Japanese). It is now preparing to be a technical co-sponsor of "Techno-Ocean 2010" and to co-sponsor "International Symposium on Underwater Technology 2011 & International Workshop on Scientific Use of Submarine Cables and Related Technologies 2011 (UT11 & SSC11)". Some of the recent activities of Japan Chapter are highlighted below.

'10 Underwater Robot Convention in JAMSTEC

The '10 Underwater Robot Convention in JAMSTEC was successfully held in Japan Agency of Marine Science and Technology on March 13–14. Twenty-five robots including ten AUVs, one UROV, one bio-mimetic robot and radio-controlled robots participated to the convention. Among the ten AUVs, one came from National Taiwan University and another one came from Korea Advanced Institute of Science and Technology. About 200 people including those from high schools, universities and the general public participated. (Photo 1). A delegation from Shanghai Jiao Tong University also participated in the convention. People with various backgrounds gathered together and communicated with each other.

The convention was held for two days. On the first day, the participants set up and tuned their own robots. Experts from JAMSTEC helped those who had little experience. It should be one of merits for them to be able to get contact with technical experts and get advice.

After supper, participants had a workshop (Photo 2). Every team except radio-controlled robots had presented their robots. They were followed by useful discussion. Some participants showed very artistic and attractive presentation, drawing close attention.

On the second day, they competed with each other. There were four courses prepared for competition: (1) to touch a ball, (2) to pass a gate, (3) to follow a line on the poor's floor, and (4) free demonstration. Every team can select any courses, and has ten minutes for the competition. The rating was made in three categories; (1) number of courses they achieved, (2) technical performance, and (3) weight. Lighter vehicles had advantages. The winner was 'HAL urabo' team from the University of Tokyo. Other awards including the best presentation award, the best effort award, the best performance award and the young robotician award were presented. The results of the competition will soon be posted on the homepage.

The competition is not the sole aim of the convention. It also provided a good opportunity for engineers, young engineers in particular, who engage in or have interest in underwater robots to gather together and exchange their experience and knowledge.

The first underwater robot festival in Japan was held in October 2006, in conjunction with the international conference "Techno-Ocean 2006/19th JAMSNAO Ocean Engineering Symposium" in Kobe. Since then three underwater robot festivals, three underwater robot conventions and one underwater robot competition had been held in Japan. That is almost two a year. All these events, except the first, were planned by the Underwater Vehicle Competitions Forum chaired by Prof. Tamaki Ura, the founder of Japan chapter. The next Aqua Robot Competition will be held in Kobe on October 16, 2010, in coordination with Techno-Ocean2010.

Enthusiastic presentation and discussion continued until midnight of the first day.

The competition was held in an indoor swimming pool of JAMSTEC.

International Workshop APuuRobo 2010

Following "'10 Underwater Robot Convention in JAMSTEC," an international workshop "APuuRobo 2010" was held at the

Participants to APuuRobo 2010.

Institute of Industrial Science (IIS), the University of Tokyo, on March 15–16; 46 researchers took part in the workshop and thirteen papers and one keynote talk were presented at the workshop. http://underwater.iis.u-tokyo.ac.jp/top/apuu/APuuRobo2010.html

This is the tenth in a series of workshops initiated by Prof. Ura. The first one "TruuRobo" was held in 2001 in cooperation with IIS, the University of Tokyo, the University of Tokyo, Seoul National University, and National Taiwan University in order to facilitate academic research and development of autonomous underwater vehicles in Asia, and to deepen mutual exchange and communication. In 2005, it was enlarged to cover Asia-Pacific as a Workshop for Asian and Pacific Universities' Underwater Roboticians (APuuRobo), adding Hawaii University as a member. Moreover, Shanghai Jiao Tong University joined this year. Kyushu institute of Technology, Tokyo University of Marine Science and Technology, Osaka Prefecture University, University of Science and Technology in Republic of Korea, National Cheng Kung University and National Sun Yat-sen University in Taiwan joined this year as friend universities. Being held in Hawaii University last year, it again returned to IIS, the University of Tokyo this year.

Frontier of Geoscience and Ocean Observation Technology

Celebrating the elevation of Prof. Junzo Kasahara, Professor Emeritus of the University of Tokyo, to IEEE Fellow, the Chapter has organized an academic meeting jointly with the Japanese Coast Guard on the recent advancement of solid earth geosciences and the latest oceanic observation technologies with emphasis on the mutual relationship on March 18, 2009. The number of participants was 125, which was an astonishing number for the number of researchers involved in oceanic engineering in Japan (the IEEE Oceanic Engineering Society members are fewer than 100 in Japan). For this day-long meeting, we were able to review how the latest achievements in solid earth geosciences were brought about by the advancement of oceanic observation technologies, how technological development had been realized in daunting and difficult processes, and what kind of technological development is necessary to proceed further for research objectives in geosciences. At that meeting, we strove to introduce IEEE and the IEEE Oceanic Engineering Society to the audience and succeeded in inviting one professor to become a member of the IEEE Oceanic Engineering Society. Following this small success, we shall work to keep inviting non-IEEE members to become IEEE members at future IEEE-organized or IEEE co-sponsored meetings.

Upcoming Conference, Symposium and Workshop

The Japan Chapter will be a technical co-sponsor of Techno-Ocean2010 (http://www.techno-ocean2010.com/) on October 14–16, 2010, in Kobe and will co-organize UT11 & SSC11 (http://seasat.iis.u-tokyo.ac.jp/UT11_SSC11/) on April 5–8, 2011 in Tokyo.

A series of International Conferences "Techno-Ocean" have been held in Kobe biennially since 1986. In 2004 and 2008, Techno-Ocean had been held jointly with OCEANS conference. The next one will be the thirteenth. The theme in 2010 will be "A New Era of the OCEAN."

The first International Symposium "Underwater Technology" was held in 1998 celebrating the establishment of IEEE OES Tokyo Chapter (now called Japan Chapter) in 1995. Since then UT symposiums have been held biennially in Tokyo and Asia.

SSC11 will be the sixth workshop, among which three workshops were or will be co-sponsored by Japan Chapter. The next UT and SSC will be held jointly again as UT & SSC 07.

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Techno-Ocean 2010
A New Era of the Ocean
October 14-16, 2010, Kobe, Japan
Organizer
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Techno-Ocean Network
Techno-Ocean Network (TON)
Co-Organizers
KOBE UNIVERSITY
La mer
·Kobe University, Graduate School of Maritime Sciences
·Japanese-French Oceanographic Society
Sponsors
JAMSTEC
IEEE
OES
marine technology
·Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
·City of Kobe
·Kobe Convention and Visitors Association (KCVA)
·IEEE/OES Japan Chapter
·MTS Japan Section
Call for Papers
www.techno-ocean2010.com

Techno-Ocean 2010

D a t e ; October 14 Thu. -16 Sat., 2010
Venue ; Kobe International Exhibition Hall (Kobe, Japan)

A New Era of the Ocean

As new global trends have become evident, a new era of the ocean has begun. Attempts to characterize these trends have already been made in many subdisciplines of maritime science, including marine engineering, resource development, ecology, policy, education, and so on. An international symposium and exhibition, Techno-Ocean 2010, will offer opportunities for fruitful exchange of ocean science and technology across subdisciplines and across generations. Let's start what we can do now to convey our understanding of the wonderful ocean to the next generation.

Special Session Topics

◎**Marine Education & ESD (Education for Sustainable Development)**
◎**Towards Sustainable Use and Management of the Oceans**

One of the special topics of Techno-Ocean 2010 is "Marine Education and ESD (Education for Sustainable Development)". Japanese-French Oceanographic Society will also organize another special session, "Towards Sustainable Use and Management of the Oceans". These topics are the most important subjects to preserve the ocean for the next generation.

General Topics for Call for Papers

Techno-Ocean 2010 calls for papers in the following general topics other than the special session ones, and expects many paper submissions to arrange sessions with wide variety.

Aquaculture/Artificial Upwelling/Fishery Engineering
Artificial Reef/Lagoon/Tidal Flat
Carbon Dioxide Capture & Sequestration
Coastal & Estuary Monitoring/Modeling
Corals/Mangroves/Tropical Ecosystems
Current/Tide/Wave/Tsunami
Data Collection/Processing & Management
Deep Ocean Water Application
Environmental Impact Assessment
Environmental Risk Assessment/Management
Geo-technology/Soil Technology
Global Warming/Climate Change/Sea Level Rise
Maneuvering/Navigation/Control
Marine Biology/Biotechnology/Biodiversity
Marine Engine/Propulsion/Ship Hydrodynamics
Marine Environment Science/Technology/Management
Marine Logistics/Port Management
Marine Policy/Law/Economics
Marine Resource/Management/Ocean Drilling
Marine Safety/Defense/Security
Marine Sports/Tourism
New Ship Concept/Design
Ocean Archaeology/Maritime History
Ocean Circulation/Ocean Flux/Sea-Air Interaction
Renewable Energy
Sensing/Monitoring/Acoustic Technology
Structure/Material/Welding
Underwater Robotics/AUV/ROV
VLFS/Floating Platform/Buoy
Watershed & Coastal Zone Management

Procedure of Paper Submission

Firstly, you will submit an abstract. For the paper accepted by the abstract review, you will write a manuscript within four pages for publication in the symposium proceedings. The contents of the manuscript will be free for paper submission to any journals published by societies, which are cooperative members of Techno-Ocean 2010. The submission system is now open on Techno-Ocean 2010 website.

Important Dates

◆ Abstract
- Deadline: May 31, 2010, approximately 400 words with no figure or table.
- Language: English (Japanese is acceptable for the Marine Education & ESD.)
- Method of submission: Online through the website at www.techno-ocean2010.com
- Notification of acceptance : June 30, 2010, after reviewing.

◆ Proceedings Paper
- Deadline: August 31, 2010
- Language: English (Japanese is acceptable for the Marine Education & ESD.)
- Instructions for preparation of manuscript will be informed on the website.

www.techno-ocean2010.com

Discovery of Sound in the Sea Website

Kathleen J. Vigness-Raposa, Gail Scowcroft, Christopher Knowlton and Holly Morin

Oceanographers, submariners, whales, dolphins, seals, in short, all working or living in the ocean use underwater sound to sense their surroundings, to communicate, and to navigate. The scientific community and the public have become increasingly aware of, and concerned about, underwater sound. There is interest in learning about sources and uses of sound, and potential effects of sound on the environment. Underlying this interest, however, is a need to provide scientific information at a level appropriate for the general public and for educational and media professionals. The "Discovery of Sound in the Sea" website (http://www.dosits.org) provides scientific content introducing the physical science of underwater sound and how people and animals use sound to accomplish various tasks. We are excited to announce the launch of a significantly redesigned website that takes advantage of the advances in web technology since the website was originally launched in November 2002. The look and feel of the website has been refreshed without losing functionality or content. The redesigned DOSITS site offers a much more interactive learning environment. The front page uses a Flash-based interactive that allow users to quickly immerse themselves in exciting content, from the songs of humpback whales to interviews with cutting-edge scientists to the science used to measure waves.

Figure 1. Front page of the Discovery of Sound in the Sea website (http://www.dosits.org).

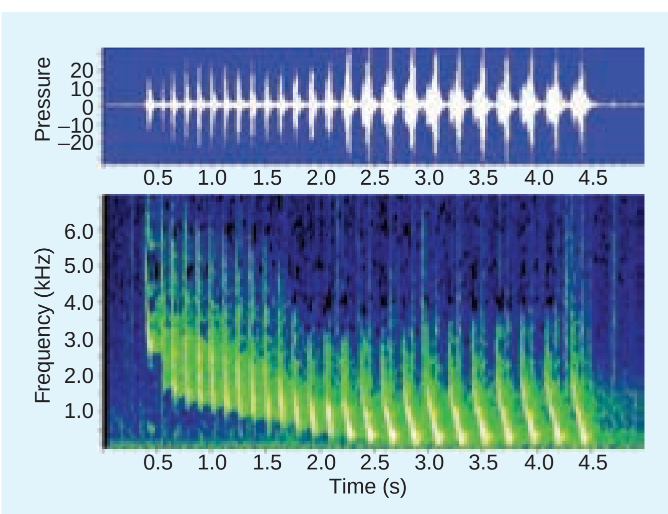

Figure 2. Visualization of a Weddell Seal call from the DOSITS Audio Gallery.

Interactives have also been created for the Audio Gallery and the Scientist Gallery, two areas with an extraordinary amount of multimedia resources. The Audio Gallery includes over 65 examples of sound sources found in the oceans, from the unique underwater sounds of a lightning strike or ice cracking to the haunting sounds of the Weddell seal.

Each Audio Gallery page includes images and sounds of the highlighted sound source, as well as descriptive material to inform the reader. We are continuously working with researchers to expand the Audio Gallery and have recently added underwater video clips to several Audio Gallery pages. The Scientist Gallery includes in-depth interviews of five scientists conducting cutting-edge acoustics research. The interactive allows the user to select a scientist by name or their research field. The interviews can be viewed as videos and transcripts of the interviews can be seen simultaneously while watching the videos or downloaded to read later. There are also images of their research and a brief summary of their recent results.

In addition to the scientific content and specialty galleries, the DOSITS website also includes three major resource sections. The Media Resources include a Facts & Myths quiz, Frequently Asked Questions, and a backgrounder on how animals hear under water. In addition, PDF reprints of a tri-fold pamphlet and a 12-page educational brochure are available. The 12-page booklet specifically addresses stakeholders' questions regarding sound in the oceans. Background scientific content written for the lay person and highlighted issues related to the use of sound in the sea by animals and humans provides the reader with a clear picture of what is currently understood about this important topic. The booklet text relies exclusively on peer-reviewed literature and has also been reviewed by the DOSITS external scientific advisory team. Over 3,000 booklets have been distributed since publication, including distribution to the United States Senate and House of Representatives. In addition, a tri-fold brochure has been published that highlights the content on the DOSITS web site and promotes its use. Over 5,000 of these have also been distributed. These resources are specifically targeted for media individuals, providing clear, concise descriptions of the most interesting aspects of underwater sound. The Teacher and Student Resources include structured tutorials and educational games. DOSITS provides easy, efficient access to timely information on the science of underwater sound and the current state of knowledge of the effects of underwater sound on marine mammals and fishes.

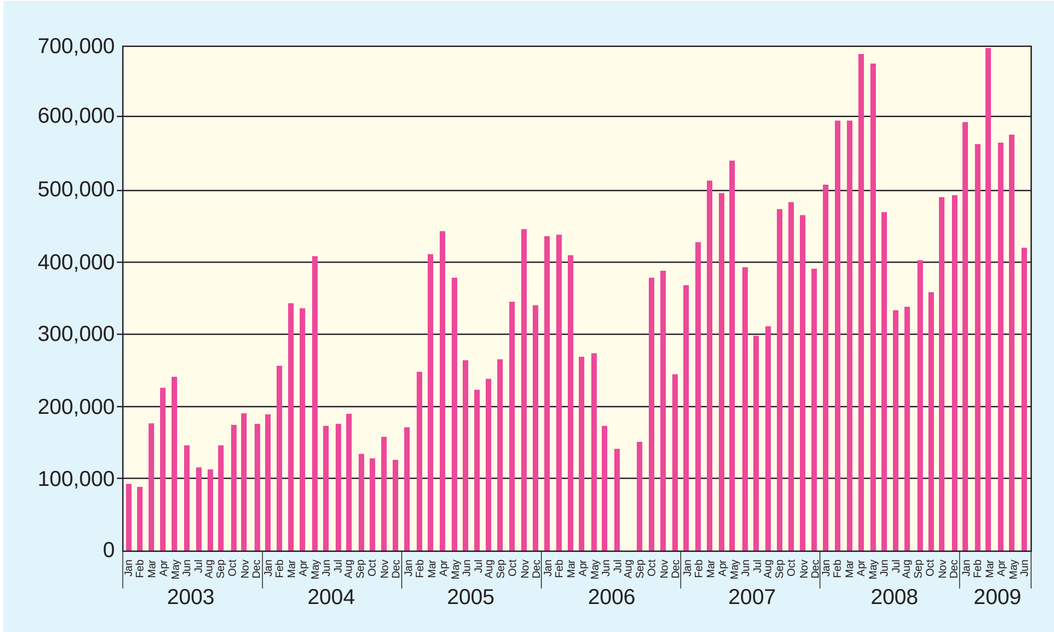

Figure 3. Bar chart of monthly hits on DOSITS from 2003 to 2009.

Since its original launch in November 2002, DOSITS has experienced tremendous popularity. During 2009, DOSITS recorded more than 6.4 million hits; this is an extraordinary amount for an educational website. The February to May time period is typically strong for DOSITS due to wide exposure at meetings and workshops for K-12 teachers in the US. The overall pattern of traffic tracks strongly with the US academic schedule. This level of traffic is outstanding and exemplifies the public and academic need for the information on the DOSITS site. In addition, during the DOSITS project, over 32,000 CD-ROMS, containing the DOSITS web site, educational PowerPoint presentations, and classroom activities, have been distributed.

The U.S. Office of Naval Research (ONR), National Science Foundation (NSF), and National Oceanic and Atmospheric Administration (NOAA) have provided funding for the DOSITS project.

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For those of you coming to OCEANS'10 IEEE Sydney, welcome to Sydney! Everything is in readiness for you to come and take part in an informative, enjoyable and unforgettable event!

Maximize The Value of Your IEEE Membership

Dr. Ferial El-Hawary

Recently while attending the IEEE Board Series meetings in Atlanta GA, in February of this year, I was alerted to some wonderful news for IEEE members. IEEE launched a major initiative to enhance benefits to you the IEEE members. This is in response to 2008 Section Congress Recommendations, the IEEE is offering E-Books and Webinars free to all IEEE members. Over 200 books are now available to download free of charge, all you have to do is to go to IEEE XPLORE:

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You will need your IEEE Web account credentials: user name and password. In case you don't have a web account, now is your opportunity to maximize your benefits by signing up for one using your membership number. Once you enter the XPLORE WEB site you can look at the right hand side welcome panel to check what your membership entitles to access. On the left hand side panel you can browse various categories including books. The neat thing is that each book is divided into downloadable chapters so, you can save time and focus on your needs.

All IEEE Press Books which were published 3 years or earlier are available for IEEE members free of charge.

I decided to look at the available titles to search for areas that may be of interest to OES members. While I know that there is no IEEE specific series in Oceanic Engineering, I found many gems in Signal Processing and Communications and Power Systems that would interest many of our members. What I find exciting is that every year new titles related to emerging technologies are added and these are highly recommended.

Now for free Webinars head to the IEEE USA Web site:

http://www.ieeeusa.org/careers/gpa/

There you will find a treasure trove of Webinars such as: Mentoring, Your Career's Competitive Advantage, Discovering and Using Your Innovation Style, Career Management: Maximizing Your Employability and Enhance Your Career With Online Networking. This is part of IEEE's response to Section Congress Recommendations as well.

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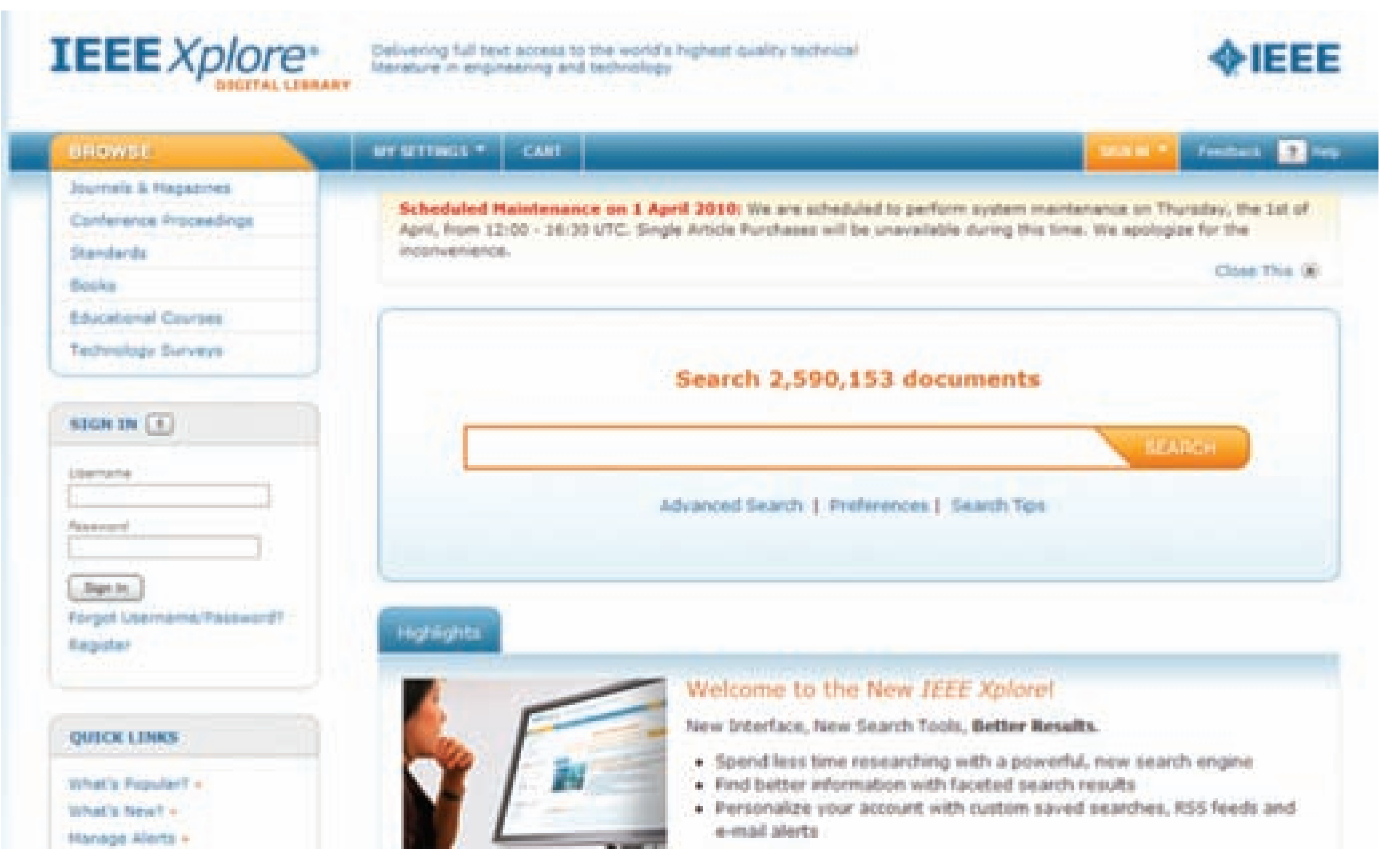
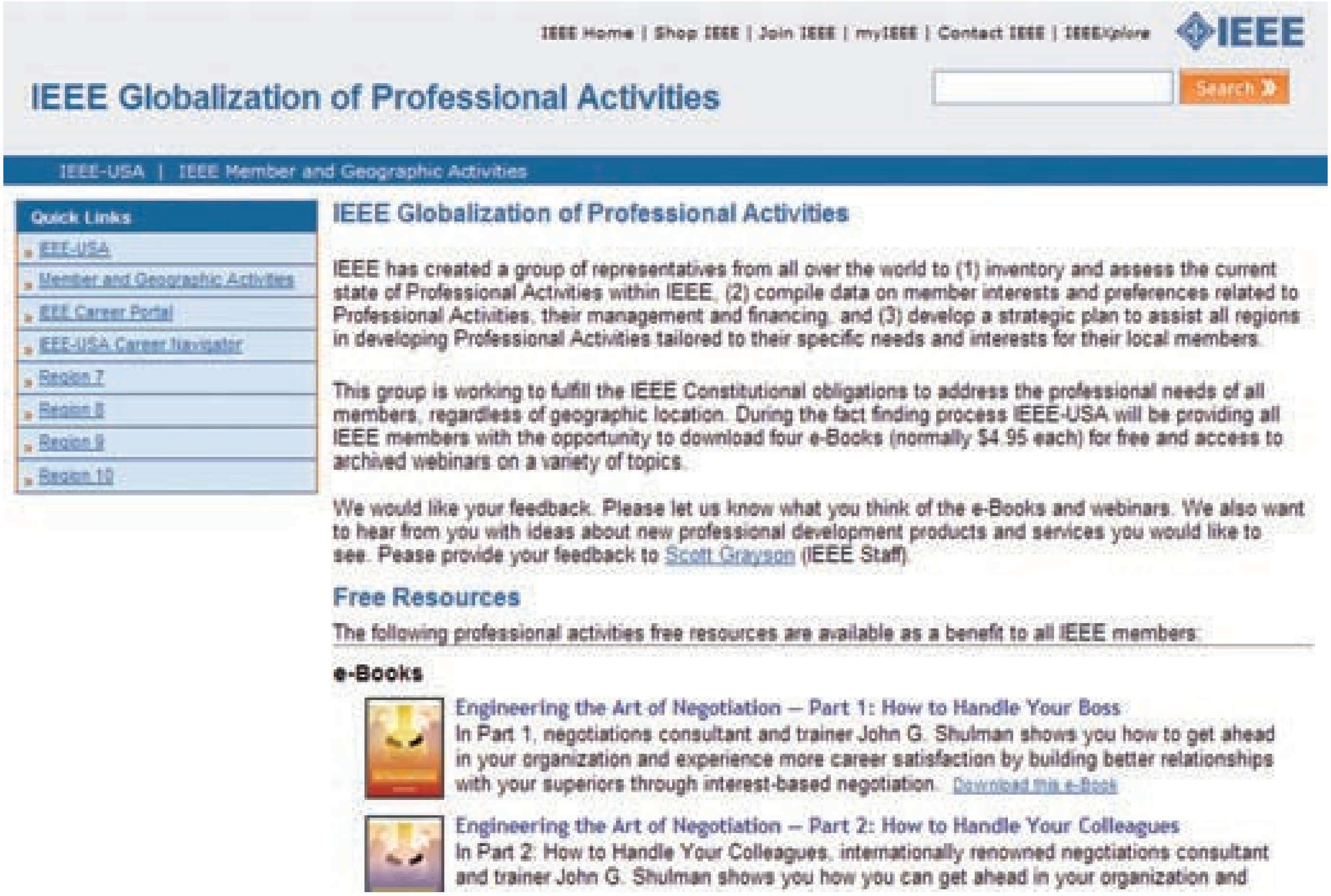
Part 1: How to Handle Your Boss, and

Part 2: How to Handle Your Colleagues

IEEE, as part of its globalization efforts, has opened up access to these resources to all members throughout the world. IEEE has also created a group of representatives from all over the world to:

1) inventory and assess the current state of professional activities within IEEE,





2) compile data on member interests and preferences related to professional activities, their management and financing, and
3) develop a strategic plan to assist all regions in developing professional activities tailored to their specific needs and interests for their local members. This group is working to fulfill the IEEE Constitutional obligations to address the professional needs of all members, regardless of geographic location.

I hope that you will take advantage of these opportunities and maximize the benefits of being part of the wonderful IEEE Network.

Dr. Ferial El-Hawary,
P. Eng., F. IEEE, F. EIC, F. MTS
President of IEEE - Canada (2008–2009)
Director of Region - 7 (2008–2009)
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New IEEE Xplore Released

Pedro Ray, IEEE President

As 2010 IEEE President, I am pleased to announce the launch of the enhanced IEEE Xplore® digital library, providing a smarter and more productive research experience for all IEEE members.

IEEE Xplore is a trusted repository of more than two million IEEE journal articles, conference papers, standards, eLearning tools, and eBooks. I'm sure you're already aware of the significance of IEEE Xplore for the most exacting research. This new release – the latest realization in added value to our membership – has been completely redesigned with a faster search engine, a more efficient interface that makes it easier to browse and search, new ways to personalize and save your searches, and more.

This greatly enhanced digital library is the result of collaboration between IEEE and hundreds of librarians, faculty, scientists and engineers, as well as IEEE members, volunteers, and students around the globe. It exemplifies the commitment of IEEE to foster technological innovation and excellence for the benefit of humanity.

I invite you to take a look. An overview video, together with a comprehensive summary of the new features of IEEE Xplore, and access to free training are available at http://www.ieee.org/newieeexplore. Or you can log in directly to IEEE Xplore with your IEEE Web account at http://www.ieee.org/ieeexplore to experience the new features first hand. I am confident you will be as impressed as I am and will agree that searching the wealth of IEEE content has never been easier or more fruitful!

UT11+SSC11

Symposium on Underwater Technology 2011
and
Workshop on Scientific Use of Submarine Cables & Related Technologies 2011
April 5 - 8, 2011
IIS Conference Hall "Haricot", Tokyo, Japan

The Magnificence of Tokyo will again greet international experts as they attend the 7th Underwater Technology Symposium in April 2011 with the 6th Workshop on Scientific Use of Submarine Cables & Related Technologies. One of the most pleasant months in Japan will host the highly successful symposium, which is organized by the IEEE OES Japan Chapter, the University of Tokyo's Institute of Industrial Science (IIS), Earthquake Research Institute (ERI) and Japan Agency for Marine-Earth Science and Technology (JAMSTEC). This symposium will provide you with a thematic umbrella under which attendees will discuss the problems and potential long term solutions that concern not only the Pacific Rim countries, but the world in general.

IMPORTANT DATES

Deadline for Abstract Submission: December 15, 2010
Deadline for Notification of Acceptance: January 15, 2011
Deadline for Paper Submission: Feb. 25, 2011
Deadline for Early Registration: March 11, 2011
Symposium Dates: April 5-8, 2011

TOPICS

The symposium consists of keynote talks, double-track technical sessions, a poster session and a technical tour in the first day. It will feature advanced underwater technology and scientific use of submarine cables & related technologies. Suggested topics for oral and poster presentation are listed below.

Advanced Technology for Ocean Resources and Energy
Underwater Vehicles and Robotics
Underwater Acoustics and Bio-Sonar
Underwater Observation Systems
Underwater Sensors
Submarine Cables and Connected Observatories
Signal and Information Processing
Underwater Construction

ABSTRACT SUBMISSION

On line Registration through the website at http://seasat.iis.u-tokyo.ac.jp/ut11_ssc11/
For more information, contact the Technical Co-Chairs Prof. Akira Asada at **asada@iis.u-tokyo.ac.jp**, or Prof. Shinichi Takagawa at **takagawa@iis.u-tokyo.ac.jp**

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POST-SYMPOSIUM WORKSHOP

Post-Symposium Workshop will be held from April 11-12, hosted by MOERI (Maritime & Ocean Engineering Research Institute), KORDI, Korea.

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Washington State Convention and Trade Center
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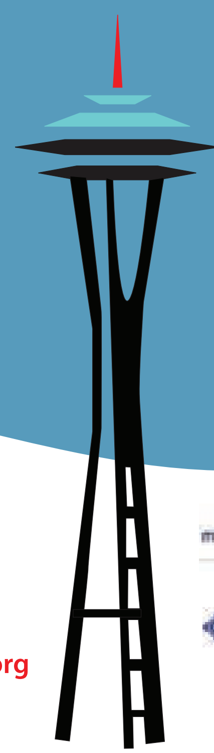
- Sonar signal / image processing and communication
- Ocean observing platforms, systems, and instrumentation
- Remote sensing
- Ocean data visualization, modeling, and information management
- Marine environment, oceanography, and meteorology
- Optics, imaging, vision, and E–M systems
- Marine law, policy, management, and education
- Offshore structures and technology
- Ocean vehicles and floating structures



Critical Dates

Abstract submission opened 15 March 2010
Abstract submission closed 15 May 2010
Notification to authors 15 June 2010
Final paper submission 1 August 2010

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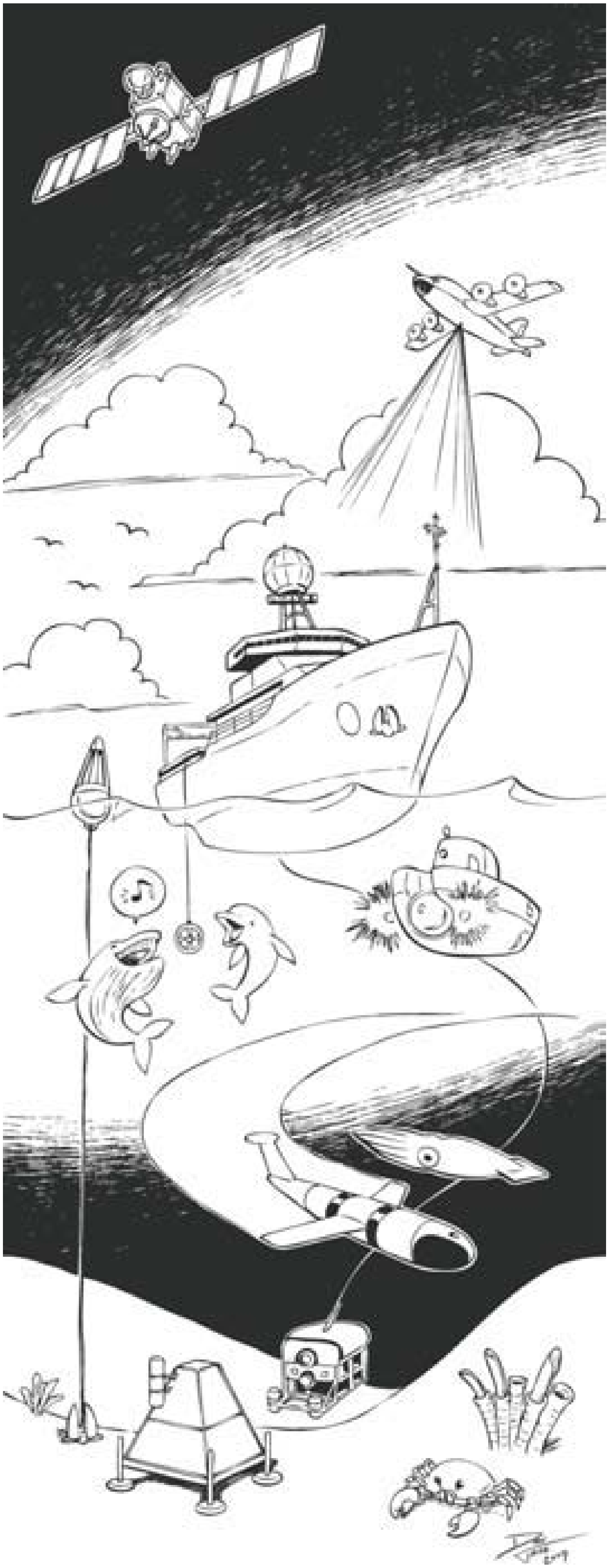

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Funding - Multiple undergraduate and graduate scholarships of $2,000.00 are available yearly.

Eligibility - Students must be enrolled full-time in an accredited college or university in a field of study that will lead to a career in ocean engineering or a related ocean science field.

Undergraduate Eligibility -

a. Must submit a scholarship application outlining his/her field of study and plans for a career in ocean engineering or a related ocean science field.
b. Must have completed (at least) the second year of study.
c. Must submit an academic transcript.
d. Application must be accompanied by written recommendations from two faculty members.
e. Must have been a student or regular member of the IEEE Oceanic Engineering Society at least six months prior to the beginning of the requested scholarship year.

Graduate Eligibility -

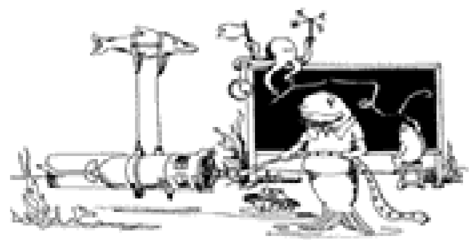
a. Must submit a scholarship application outlining his/her field of study and plans for a career in ocean engineering or a related ocean science field.
b. Must be currently enrolled, or have been accepted, in a graduate program of ocean engineering or a related ocean science field.
c. Must have demonstrated excellence in academics and the ability to perform independent research, through professional and/or academic recognition programs.
d. Application must be accompanied by a written recommendation by an academic advisor.
e. Must have been a student or regular member of the IEEE Oceanic Engineering Society at least six months prior to the beginning of the requested scholarship year.

Application Deadlines:

a. There are two award cycles each year. Completed applications must be postmarked by 1 April for scholarship award in September of that year, or 1 September for an award in the following January. References and recommendations must accompany the application.
b. Official transcripts, mailed by the academic institutions, must be received by April 15th for September awards and September 15th for January awards.
c. Scholarships will be awarded during the spring and fall meetings of the OES Executive or Administrative Committee. Recipients of the awards will be invited to attend the following OCEANS Conference to be recognized at the OES Awards Luncheon.

To find out about OES membership and get your form, go online to www.ieeeoes.org.

The CWTM 2011 website is now under construction



CALL FOR PAPERS

THE 2011 IEEE/OES TENTH CURRENT, WAVES AND TURBULENCE MEASUREMENT WORKSHOP (CWTM)

will be held March 20-23, 2011
at The Monterey Plaza Hotel, Monterey, California

Abstracts are due on October 15, 2010
Early deadlines: Exhibits January 17, 2011 --- Registration February 11, 2011

With a new name, we will be celebrating our 33st year. For the past 32 years, our workshops were known as "The Current Measurement Technology Conference (CMTC)". Due to the many changes in the science and technology of current, waves and turbulence measurement, it is fitting that we change the workshop title to incorporate them. The theme of this conference is

"Advances in Lagrangian and Eulerian Measurement Techniques and Observations of Currents, Waves and Turbulence"

Workshop objectives are to provide the ocean community with a forum for technical information exchange and to promote coordination among those concerned with measuring current, waves and turbulence.

The 2011 CWTM Workshop Team:
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Technical Chairs: Sandy Williams awilliams@whoi.edu Mal Heron mal.heron@jcu.edu.au
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European Coordinators: Gwyn Griffith gxg@noc.soton.ac.uk
Local Contact: Laura Pederson laura@codar.com

Sponsored by the Current Measurement Technology Committee of The IEEE Oceanic Engineering Society

Underwater Imaging and Optics: Recent Advances

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***Abstract* – Obtaining satisfactory visibility of undersea objects has been historically difficult due to the absorptive and scattering properties of seawater. Mitigating these effects has been a long term research focus, but recent advancements in hardware, software, and algorithmic methods have led to noticeable improvement in system operational range. This paper is intended to provide a summary of recently reported research in the area of Underwater Optics and Vision and briefly covers advances in the following areas: 1) Image formation and image processing methods; 2) Extended range imaging techniques; 3) Imaging using spatial coherency (e.g. holography); and 4) Multiple-dimensional image acquisition and image processing.**

I. INTRODUCTION

Recent advancements in the field of Ocean Optics are, at least, partially attributable to the following developments:

- Affordable, high quality cameras that support a suite of fast, inexpensive specialized image processing software and hardware add-ons;
- Digital holographic cameras that record interference fringes directly onto solid state sensors (i.e., mega pixel charge coupled devices) to produce time resolved, 3-D movies;
- High repetition rate, moderate power lasers and advanced detector designs which enhance performance of two-dimensional (2-D) and three-dimensional (3-D) imaging systems;
- Compact, efficient and easy to program digital signal processors that can execute algorithms once too computationally expensive for real-time applications;
- Modeling and simulation programs that more accurately predict the effects that physical ocean parameters have on the performance of imaging systems under different geometric configurations;
- Image processing algorithms that handle data from multiple synchronous sources and that can extract and match feature points from each such source derive accurate 3-D scene information; and
- Digital compression schemes provide high-quality standardizations for increased data transfer rates (i.e. streaming video) and reduced storage requirements.

The applicability of each of these is unique to general topical areas in undersea imaging covered in the following sections. A more thorough discussion of these topics is found in [1].

II. CONVENTIONAL IMAGE ACQUISITION FOR SURVEY AND MONITORING

Many recent applications are aimed at deploying conventional cameras for long-term monitoring and observation where collection of video imagery and subsequent processing can be used to provide image scaling and measurements, identification and assessment, 3-D reconstructions, and analysis [2-5]. These systems benefit from cameras capable of operating continuously for long, unattended durations with ample resolution and high bandwidth data links. One recent example is a high-speed megapixel benthic imaging system designed to operate from a towed platform for scallop stock assessments [6]. The system features a commercial GigE Vision™ camera (1360 x 1024 pixels), strobe light, and tow vessel that streams images at 4/s for near real-time monitoring. Tow speeds of 5 – 8.5 km/h provide 58 – 27% overlap between successive images with a resolution of greater than 1 pixel per mm, enabling identification of objects less than 50 mm in diameter in most water conditions. The system is also useful for fine-scale habitat mapping, ground-truthing acoustic data, benthic ecology research and fishing damage assessment.

Higher accuracy imaging equates to increased pixel resolution requiring much greater bandwidth and storage capability. High definition (HD) and ultra high definition video (UHD or super hi-vision) produce images having 1920 x 1080 and 7,680 x 4,320 pixels, respectively. Image compression formats such as HDV, MPEG-4 AVC/H.264 and VC-1 reduce data rate and memory demands by up to a factor of nearly 50 [7, 8]. Although these reductions help make requirements more manageable, users are often not in favor of "losing" data. Table 1 provides approximate upper bound bandwidth requirements for various types of cameras, including some with image compression.

TABLE 1
BANDWIDTH REQUIREMENTS FOR CAMERA SYSTEMS [9, 10]

Camera Type	Max Resolution	Compression Codec	Data Rate (Mbps)
SD	704 x 480	None	244
D9-HD	1280 x 1080	DCT	100
HDV	1440 x 1080	MPEG-2	25
XDCAM HD	1440 x 1080	MPEG-2 (VBR)	50
HDCAM	1440 x 1080	DCT	144
DVCPRO HD	1440 x 1080	DCT	100
HDTV (broadcast)	1920 x 1080	MPEG-2	19
AVC HD	1920 x 1080	MPEG-4 AVC/H.264	24
XDCAM EX	1920 x 1080	MPEG-2	35
XDCAM HD422	1920 x 1080	MPEG-2 HD422	50
D5-HD	1920 x 1080	DCT	323
HDCAM SR	1920 x 1080	DPCM / DCT / MPEG-4	440
HD	1920 x 1080	None	1,493
Digital Cinema (RED 4K)	4096 x 2160	Redcode RAW wavelet	288
UHD	4096 x 2304	None	26,000

III. EXTENDED RANGE IMAGING

A primary goal of extended range underwater imaging is to improve image contrast and resolution at greater distances than what is possible with a conventional camera and underwater lighting. Schemes implemented include:

- Time discrimination / range-gated methods;
- Spatial discrimination / laser line scan (LLS) methods;
- Scattered light rejection using modulation / demodulation techniques;
- Imaging using structured lighting;
- Polarization discrimination; and
- Multiple perspective image construction.

Current emphasis has been to develop wide swath imagers with the potential to be implemented on the common classes of autonomous underwater vehicles (AUVs). Previously demonstrated imaging system architectures include : i) synchronously scanned continuous wave (CW) beam with photomultiplier tube (PMT) detection (Raytheon LS4096 and the Northrop Grumman LLS systems); ii) scanned laser beam and high speed linear CCD camera (LBath system [11]); iii) pulsed fan beam with time-resolved signal detection using streak tube (Arete STIL system); and iv) CW fan beam structured lighting system with a CCD camera (University of South Florida and SRI International Bluefin2).

All approaches provide intensity reflectance maps, while the latter three also provide 3-D topographic information, either via time-of-flight or triangulation. Each system has limitations or operational challenges that result from the design choices, i.e. limited depth of field, leading to difficulty in 'focusing' the system variable terrain; large size; high input power requirement; and limited operational range versatility. The operational community however requires reduced operational complexity (size, power, etc.) and enhanced performance.

A. Time Discrimination / Range-Gated Methods

Range-gated systems have traditionally used low repetition rate (< ~100 Hz) green pulsed laser sources to improve image contrast by rejecting backscattered light between the source and target. Previous and recent implemented bench top configurations [12-14] use a spatially broadened laser pulse as the illuminator and a non-scanning gated intensified camera as the detector allowing for the acquisition of a thin temporal slice of the entire (global) scene, over up to 40 degree field of view (FOV). Utilizing suitably high sampling rates, these systems can also allow for 3-D image reconstruction from many short time slices [15].

More recently, an evolved implementation of this variety of system, the LUCIE2 (Laser Underwater Camera Imaging Enhancer) [16], has been packaged and deployed onboard an ROV for propeller blade inspection at 5 attenuation lengths. Optical polarization differencing is used to further enhance target contrast. A compact third generation diver-held version is also under development. Other techniques to extend the performance range and retrieve optical properties of the environment are described in [17].

B. Spatial Discrimination / Laser Line Scan (LLS) Methods

Laser Line Scan (LLS) systems optically scan a narrow instantaneous FOV (IFOV) receiver synchronously with a highly collimated laser source linearly over a large angle. It has been shown that the optical transfer function of such systems can be near the diffraction limit [18].

Although effective at spatially rejecting scattered light, LLS systems can be limited by receiver shot noise resulting from the temporal overlap between the target return and that of the scattering volume, from both laser and solar illumination. To maximize operational range, CW LLS systems use increased source-receiver separation that reduces the detrimental effect of near field multiple scattered light reducing their potential for use aboard small unmanned underwater vehicles (UUVs). Computer models of such systems have been studied [19, 20] indicating that images can be obtained at up to 6 attenuation lengths as has been verified in both field and lab-based demonstrators. Employing high repetition rate pulsed lasers with receiver gating (the Pulsed Laser Line Scan or PLLS imager) reduces the effects of beam overlap and has recently been shown to be effective at over 7 attenuation lengths. This method also offers a reduced form factor for payload operation on small UUVs.

Computer model developers have been concentrating on synoptic model development for LLS and PLLS systems to avert the computational burden of Monte-Carlo ray trace methods and to allow system designers to consider the trade-off of system parameters [21]. Recent studies indicate that the PLLS approach allows temporal separation of the volume scatter and target signals improving the image contrast and the operational range of the system [22, 23]. Electronic gating is particularly advantageous at a smaller source receiver separation [24].

Examples of the improvement possible using the PLLS system has been demonstrated at HBOI/FAU using a custom high repetition rate (357 kHz), high power green pulsed laser (6-7 ns full width at half maximum). Test tank reflectance image comparisons are shown in Fig. 1 indicating improved signal-to-noise ratio (SNR) and contrast of the time-gated PLLS over CW LLS in under near-identical system and operational conditions.

At the limit of detection of the time-gated PLLS, several possibilities exist to extend the performance. The integration of multiple pulses will increase the SNR, albeit with a sacrifice to the achievable image resolution. Physically increasing the size of the receiver aperture can also increase the SNR; likewise the use of coded pulses and coherent detection has also been shown to potentially further extend imaging capabilities [25, 26].

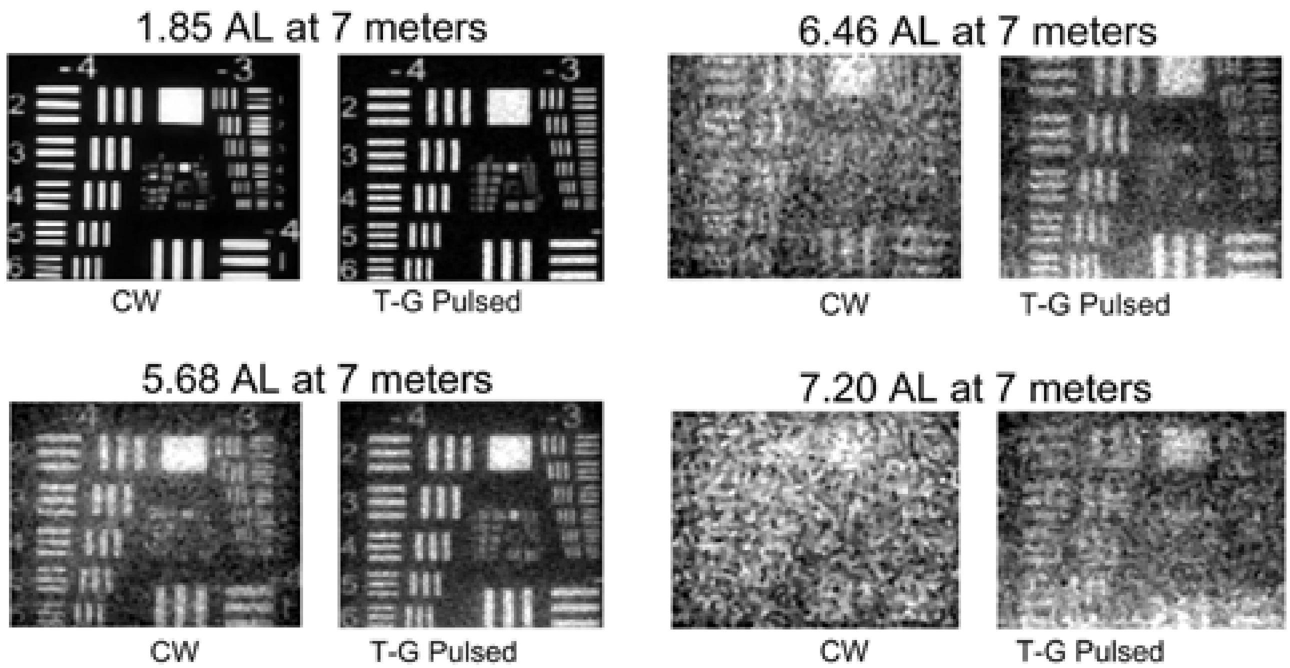


Figure 1. Test tank acquired reflectance image portions taken at 7m stand-off distance.
Left side images of each column: CW LLS image using 1.5W CW laser; Right side: Time-gated PLLS image using 1.5W average power pulsed laser at 357 KHz. For both sets of tests, the scan speed was 100 lines per second, source receiver separation was 23.4cm, instantaneous FOV of the receiver was 15mrad and seabed velocity was 1.5ms-1. Laser divergence for both lasers was 2-3 mrad. Note that all images have been histogram equalized and median filtered (3x3).

C. Scattered Light Rejection using Modulation / Demodulation Techniques

It is well known that coherent modulation/demodulation methods can offer improvement in signal detection for communications systems, but at optical frequencies these schemes are not useful over large distances due to the dispersive nature of seawater [27]. Consequently, coding of modulated waveforms is a more practical scheme to achieve improved S/N at the detector. As an example, earlier underwater coherent detection demonstrations have used a CW laser radiating an amplitude modulated beam of light illuminating an underwater target from an airborne platform or underwater vehicle. A PMT then integrates the backscatter and the target photons together, and by demodulating the AM signal, partially rejects the scattered light signal enabling ranging ultimately limited by receiver shot noise. It has also been recognized by the authors and others, that the non-coherent signal detection methods used by earlier LLS systems might also be improved by using sub-carrier coherent detection at the receiver to separate the temporally dispersive scattered light from the target return and to produce target profile or range information. One such system has been developed by NAVAIR to image targets underwater from an airborne platform or underwater vehicle [28, 29]. This system uses a 3W CW laser sinusoid modulated at up to 100 MHz, with complex (IQ) demodulation to recover magnitude and phase information for enhanced contrast and range imaging capabilities. The system has also been demonstrated as having the potential for hybrid imaging/communications capabilities [30]. Other recent modulated CW imaging demonstrations [31] utilized a 20 mW single mode laser at 405 nm amplitude modulated at 36.7 MHz via control of the current, and scanned in steps by a miniaturized piezoactuator. In laboratory tests at ENEA Research Center, submillimeter range accuracy was reported at a 1.5 meter stand-off distance in clear water. The diode laser wavelength matches the minimum of the pure water absorption spectrum, and hence this system has been designed for (eventual) long range 3-D imaging in relatively clear water.

The goal for any operational imaging system is a full-up demonstration, and progress is being made currently. In 2007, the NAVAIR system was tested with the HBOI bench top LLS system [32]. The results, which demonstrated a noticeable reduction in backscatter and hence improvement in image contrast when compared to CW LLS in turbid water (shown in Fig. 2), were reported in a recent poster [33].

It has been proven in simulation that the use of modulated-pulses, described by [25], as the hybrid LIDAR-radar technique has the potential to further extend the operational range of LLS systems. The simplest method is to impress a high frequency sinusoidal amplitude modulation on the laser pulse. This in turn makes it possible to reject the lower frequency components of backscatter and ambient light, further increasing the range capability of the system. This type of system has previously been investigated by various research laboratories [25, 34] and has been the subject of recent simulations using Metron's radiative transfer solver [21] and other radiative transfer codes developed specifically for pulsed underwater laser imaging systems [35]. Sub-systems hardware development (lasers and detection means) and verification of simulation codes continue to remain a primary activity for these systems.

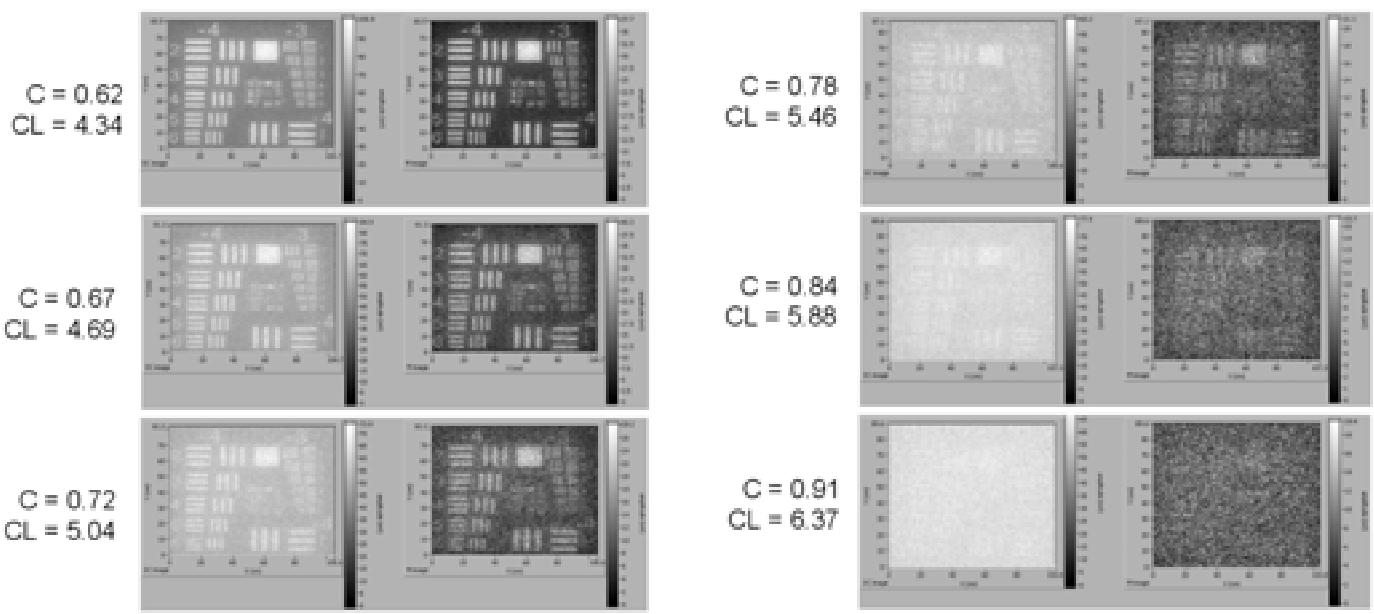


Figure 2. Raw image comparison from HBOI test tank at 7 meters stand-off distance (contrast stretched between min to max) between CW LLS (left side images on each column) versus modulated-CW LLS (right side images on each column).

Note: C = beam attenuation coefficient in inverse meters. CL = number of attenuation lengths.

D. Imaging using Structured Lighting

When using structured light, a narrow laser beam or plane is typically projected onto the scene off the center axis of a standard 1-D or 2-D camera to reduce backscatter and enable recovery of the scene's 3-D structure by means of triangulation. One method commonly used with structured lighting is a distance-compensated technique. Fig. 3 shows an example of a distance-compensated structured light system that uses a projector to create structured light patterns, providing improved contrast over wide field illumination [36]. Post-processing compensates for the water attenuation based on recovery of the object distance map.

A second method commonly used with structure lighting is synthetic aperture illumination. While most methods of structured light are based on illumination from a single direction, methods such as that devised by [37] (shown in Fig. 4) use a constellation of illumination sources, each illuminating the scene from a unique position and direction. Multiple frames are acquired while different sets of illumination sources are active, where each combination produces a different illumination pattern. The acquired frames contain backscatter similar to that obtained by floodlighting. When the data are post-processed, the backscatter field is estimated based on the set of frames and then the backscatter component is compensated for to enhance the image quality.

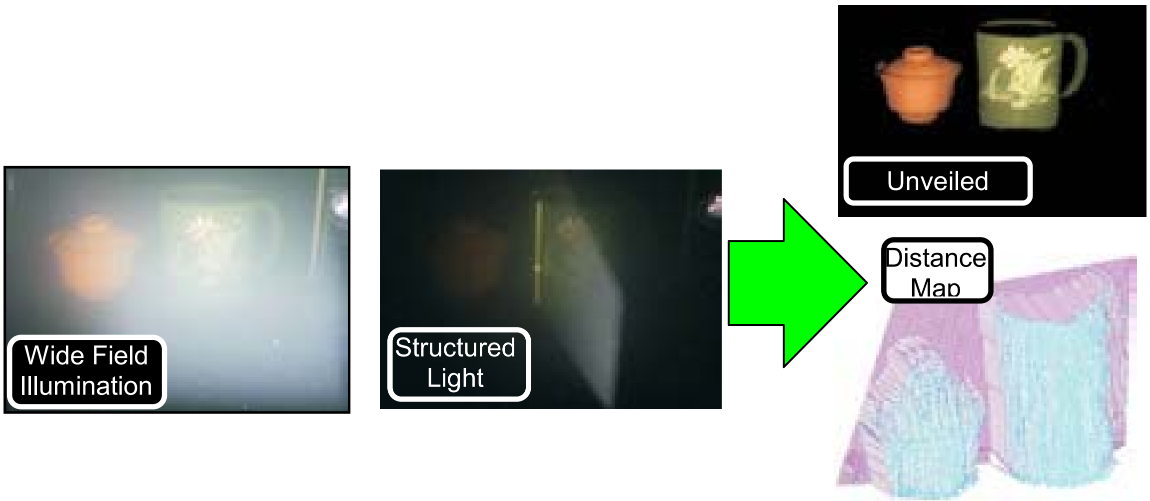


Figure 3. Example of a distance-compensated structured light system.

Figure 4. Experimental setup using multiple illumination sources.

Other methods relying on spatial coherence, such as those conceived by [38, 39] using structured illumination for object shape recovery and distance imaging are limited by practical size of the required optics and have not been investigated due to practical implementation problems for scenes of any reasonable size.

E. Polarization Discrimination

An image enhancement technique demonstrated most recently in [40] combines an optical step during image acquisition along with digital post-processing. The optical step uses wide-field polarized light to irradiate the scene, while viewing the scene via an additional polarizer. Two wide-field frames are taken in mutually orthogonal polarization states. Backscatter exists in both polarization states (frames) but in different amounts; hence the optical step modulates the backscatter. A mathematical process is applied using the two raw frames as input, extracts the backscatter field, and then estimates the background free of backscatter.

F. Multiple Perspective Image Construction

Imagery of a scene collected from different locations is commonly used to derive size and depth measurements, photo-mosaics, and 3-D reconstructions. This can be accomplished by performing high resolution optical reconnaissance sweeps of a desired area using a single imaging system, or using multiple imaging systems that perform the sweeps in a fraction of the time. When a multiple system technique is employed that separates the illumination from the image formation process, images can be captured at greater distances due to a reduction of the backscatter component. Examples of different configurations of illumination and cameras, such as those shown in Fig. 5, have been simulated by [41].

Woods Hole Oceanographic Institution researchers are implementing a slightly different technique using two AUV's to cooperatively characterize the Arctic seafloor [42]. Unlike the approach in [41], two AUV's are launched sequentially with different objectives. The first AUV, Puma or "plume mapper," is launched to localize chemical and temperature signals given off by hydrothermal vents; while the second AUV, Jaguar, is sent to those locations to use high-resolution cameras and bottom-mapping sonar to image the seafloor.

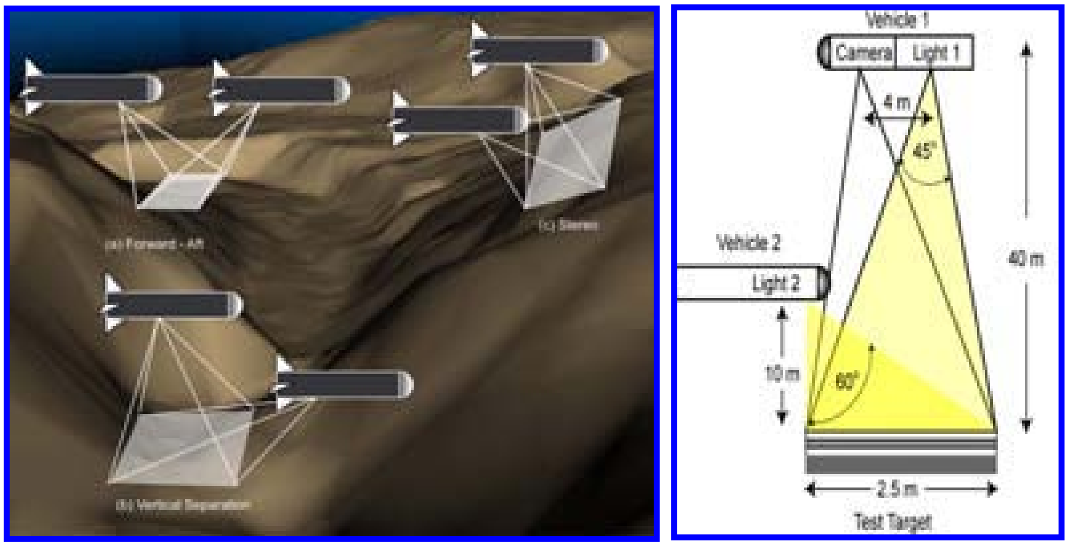
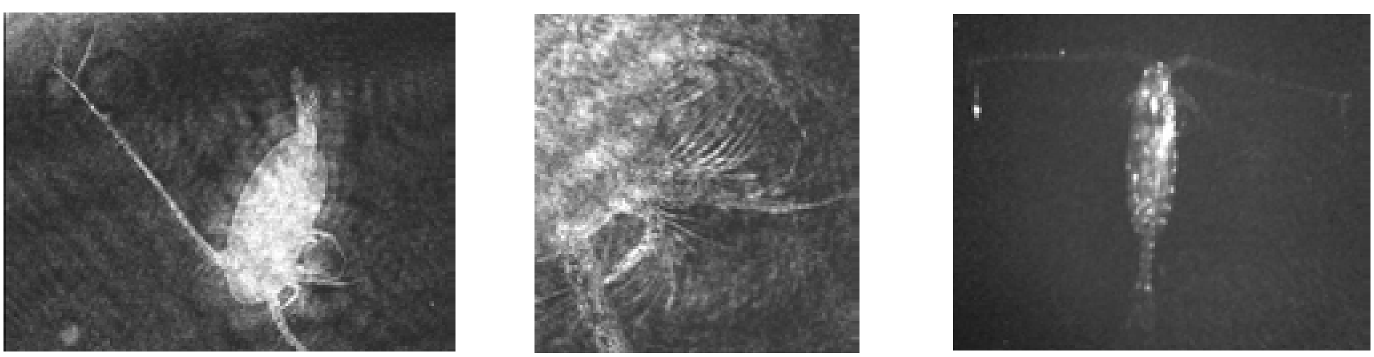


Figure 5. Multiple perspective imaging concepts (left) and an example showing one camera with two different lighting positions (right).

Finally, worth mentioning here are software techniques employed real-time to enhance video quality such as LYYN Visible Enhancement Technology (www.lyyn.com/) and tools made available in several image processing software development kits [43].

IV. Spatial Coherency Methods

Holography is a technique utilizing the spatial coherency of wavefronts to record 3-D information by forming the interference pattern between waves propagating from an object and a reference wave – usually at optical frequencies. Conventionally, the interference pattern modulus is recorded and played back on film, but today reconstruction can be done digitally by mathematically applying the rules of diffraction on the hologram input data. An electronic hologram can be recorded directly onto a CCD camera and then numerically reconstructed. As a result, 3-D information can be recorded in real-time producing 3-D videos of living organisms and particles in their natural environment.



(a) In-line recoding at 70m (2.2 x 0.7 mm).

(b) An enlarged detail of (a).

(c) Off-axis recording at 60m (~ 6mm long).

Figure 6. Hologram images of calanoid copepods.

Holography is possible over short distances in seawater and is used by submersible digital holographic systems, as described in [44-47], to record plankton [48] and other millimeter-sized marine organisms. Examples are shown in Fig. 6. Demonstrated systems operate at stand-off distances of 0.1 mm to several millimeters, are not plagued by backscatter or attenuation effects, and offer considerably greater depth of field than possible with conventional microscopy – allowing a single hologram to provide instantaneous volumetric information.

V. Multi-Dimensional Methods in Image Space

Methods that combine Dual frequency IDentification SONar (DIDSON) and stereo imagery are being investigated for multiple-view 3-D reconstruction of scenes [49, 50]. The intent is to use the sonar to enhance reconstruction in poor visibility conditions, where visual cues become less informative. DIDSON uses high-frequency sonar (1-2 MHz) to produce range and azimuth 2-D measurements that are acquired in a polar coordinate system at operational ranges of 10 to 20 meters in turbid water. Since the geometry of "acoustic imagers" differs drastically from those of "optical lensless pinhole imagers," the greatest challenge in combining sonar and stereo images is calibrating the system to ensure data model consistency [51, 52]. Not only do the sensors have different areas of coverage, but a pixel in polar coordinates maps to a collection of pixels in the Cartesian coordinate system, further complicating the process of searching and matching feature points in successive images. Other challenges specific to DIDSON include limited resolution, low SNR, and limited range of sight. Ref. [53] developed an algorithm to enhance sonar video sequences by incorporating knowledge of the target object obtained in previously observed frames. This approach involves inter-frame registration, linearization of image intensity, identification of a target object, and determining the "maximum posteriori fusion of images" in the video sequence.

DIDSON as a stand-alone sensor offers numerous advantages and commercial software packages are becoming more available to process this data (e.g., Acoustic View for mosaics, www.acousticview.com). In high-frequency mode, images from the sound beams can show the outline, shape and features of a target object. A common application is fisheries management and assessment, where fish behaviors such as spawning, feeding and migration can be non-invasively monitored and recorded even in low visibility conditions [54-56]. However, there still can be conditions that limit the capability of acoustic sensing [57] so a better solution may be a hybrid – combining DIDSON and a video camera [58, 59], stereo camera system [60] or other optical imaging system.

VI. Future Trends

Several areas of technology development are particularly notable when anticipating future advancements in underwater imaging technology. Compact high power light sources, data compression and management, energy storage, and realistic recreation of the image space continue to be areas where major strides are being made.

A. LED Technology

White light and single wavelength light emitting diodes (LEDs) have made rapid advancements in the past few years with respect to electrical to optical conversion efficacy and wattage. Single package units are available that can produce output of several hundred lumens – equivalent to 60-watt incandescent sources, but at a fraction of the power. A measure of the output normalized to the wattage is the "luminous efficacy". This can range from 50 lumens per watt to 70 lumens per watt for fluorescent lamps, and as much as 50 and 150 lumens per watt for arc light and HMI sources, respectively. White light LEDs promise efficiencies of 150 lumens per watt (or greater) and can be powered from low voltage sources without expensive or bulky ballasts. This makes them particularly useful for battery powered applications such as dive lights, small AUVs or other vehicles as well as other restricted power sources (e.g., offshore buoys [61]). As the technology advances, higher power units will become available and will ultimately replace lamps that currently are rated at hundreds of watts or more.

B. Laser Technology and Detector Advancement

New developments in laser technology have achieved short pulses at blue-green wavelengths offering stable, high repetition rate (>500 kHz) and average power (>2W) laser sources (Q-Peak Inc., Aculight Corp.). In an LLS system, this technology enables temporal separation of the backscatter from the reflected target signal and allows primarily the integration of the target photons during the detection process. This tends to increase the SNR allowing a greater distance for detection/imaging of the target. Further refinements in laser technology will be higher speed modulation capability and greater uniformity of pulse-to-pulse energy stability, as well as increases in power, efficiency, and compactness. This will allow more advanced laser imaging systems to be developed and integrated onto small platforms. Development of detectors with extreme speed, high dynamic range, and accurate response to modulated waveforms will also be important.

C. Data Management

Managing data from multiple disparate sensors as well as sensors that produce vast amounts of data is currently a challenge and will continue to be so as technology continues to advance. Data management involves storing, cataloguing, searching, retrieving, *interpreting (human in the loop)*, sharing, editing, reusing, distributing, archiving and thinning. Though specialized systems will need to be developed for custom data types, rich media management and Digital Asset Management (DAM) software for high definition video (for example) and its related data is commercially available (Virage, Artesia). These software packages include features such as automatically capturing, encoding and indexing TV, video and audio content from any source dynamically; automatically generating a comprehensive range of metadata that is immediately fully searchable and accessible by any user; and full screen streaming of HD video content at reduced costs.

Manipulation of the data goes hand-in-hand with data management. Viewing and processing high volumes of data are often cumbersome for both the computer and the user due to memory swapping, slow processing and rendering of the data, and the inability to see all of the data on a typically-sized display. Specialized computers for high-end gaming and video editing are becoming popular, as well as large and multiple widescreen displays. As an example, Alienware presented a "giant 'curved' widescreen" display at the 2008 Consumer Electronics Show in Las Vegas. This display is equivalent to two slightly bent 24-inch liquid crystal display (LCD) screens glued together [62].

D. Three-Dimensional Television (3DTV)

A study undertaken by European researchers is exploring the feasibility of *3-D television* (3DTV) [63]. Developers of eHoloCam are lending their expertise in holographic imaging to this cause [64, 65]. In another example, deformable meshes and other generic 3-D motion object representation tools found in computer graphics technology provide many of the tools necessary for 3-D scene representation.

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The Sea

[Editor's note: A.C. Swinburne (1837–1909) was born in London, the son of Admiral Charles Henry Swinburne and Lady Jane Henrietta. He grew up on the Isle of Wight and attended Eton College. His other works include: Songs Before Sunset, Tristram of Lyonesse and Lesbia Brandon. He was nonconventional and even controversial in many ways but he possessed an excellent command of vocabulary and meter. This poem expresses a love for the sea that we can all relate to from time to time.]

Dawn is dim on the dark soft water,
  Soft and passionate, dark and sweet;
Love's own self was the deep sea's daughter,
  Fair and flawless from face to feet;
Hailed of all when the world was golden,
Loved of all lovers whose names beholden
Thrill men's eyes as with light of olden
  Days more glad than their flight was fleet.

So they sang; but for men that love her,
  Souls that hear not her word in vain.
Earth beside her and heaven above her
  Seem but shadows that wax and wane.
Softer than sleep's are the sea's caresses,
Kinder than love's that betrays and blesses.
Blither than spring's when her flowerful tresses
  Shake forth sunlight and shine with rain.

All the strength of the waves that perish
  Swells beneath me and laughs and sighs,
Sighs for love of the life they cherish.
  Laughs to know that it lives and dies;
Dies for joy of its life, and lives,
Thrilled with joy that its brief death gives,
Death whose laugh or whose breath forgives
  Change that bids it subside and rise.

Algernon Charles Swinburne

Sunset on the Bering Sea from the Bureau of Commercial Fisheries Ship BROWN BEAR. Photo by Harley D. Nygren of NOAA.

ARTWORK COURTESY OF ROBERT GANT

These ocean engineering professionals are having an adventure. Tell us about your adventures. Have you ever had a field test go exceptionally well or one that had one problem after another? Is there a person who inspired you to do your best? Did something interesting or funny happen? Do you have a sea story to tell? Send it to me at j.gant@ieee.org.

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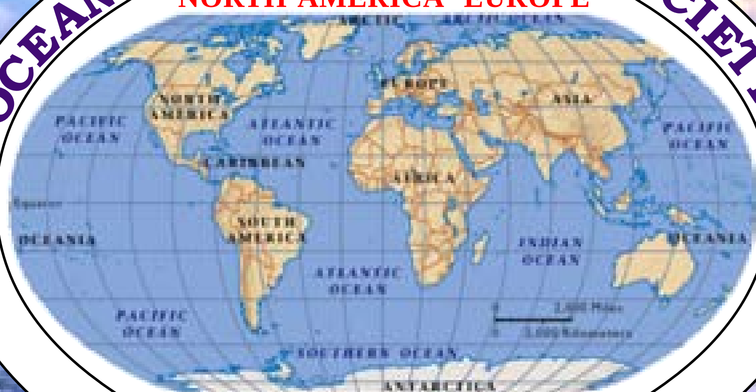

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