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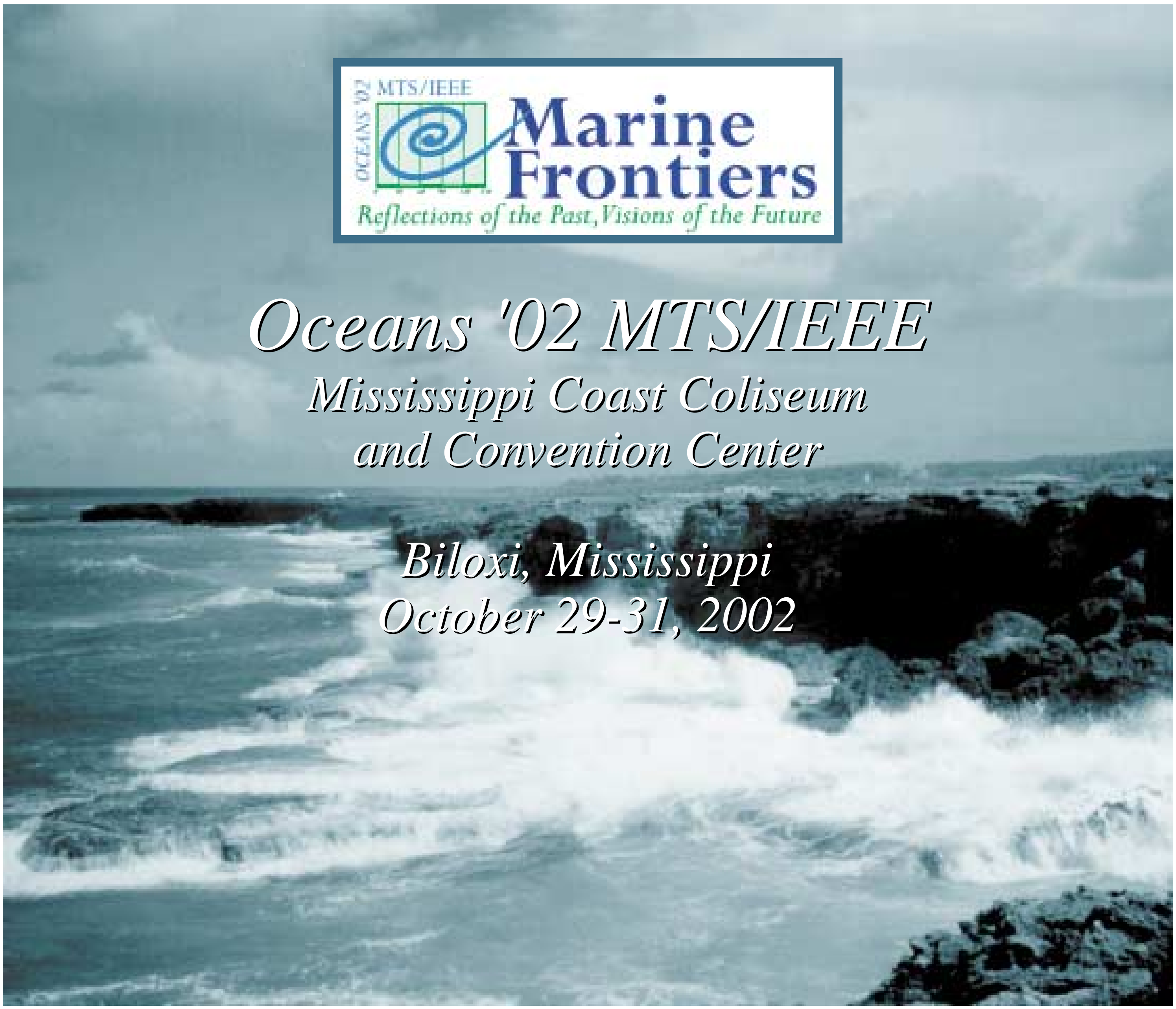

IEEE OCEANIC ENGINEERING SOCIETY

OES Journal Associate Editors

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President's Message

If you haven't registered for OCEANS '02 in Biloxi, now is the time. Indications are that it will be a useful and important conference, and you can stay a few extra days to enjoy the Mississippi Gulf Coast.

Thomas F. Wiener

The Administrative Committee meeting in Houston in May in connection with the Offshore Technology Conference dealt with several important matters that I will sketch here for you.

The most exciting outcome of the meeting was the determination to move ahead with the two Oceans policy that I proposed. We are planning OCEANS '05 Brest for the spring of 2005 and OCEANS '05 Washington MTS/IEEE. Key players in this effort are our Vice President for Technical Activities, Joe Vadus; the President of the OES France Chapter, René Garello; and Steve Holt. René' is our point man in Brest, and Steve is one of the Co-Chairs for OCEANS '05 Washington MTS/IEEE. We will have to work hard and carefully to pull this off, but I am confident we can do it.

Another exciting product of the meeting is the clearer definition of two groups that will help us do a more efficient job of presenting conferences. We, under the leadership of René Garello (there's that man again), in cooperation with the Marine Technology Society, are forming two groups to support conference organizers and institutionalize the successful processes we use in presenting our conferences. The first is the Joint Oceans Advisory Board (JOAB), comprising members from both Societies, which will be available to the local organizing committees to help them take advantage of lessons learned from past conferences. This will include explaining successful approaches and pointing out approaches that resulted in disappointing results. With Stan Chamberlain as the spark plug, a group of people is writing out the responsibilities of the various members of JOAB.

At the same time, we are moving forward with the formation of a permanent Technical Program Committee in support of the OCEANS conference Technical Committee. Our Society has Technical Committees coordinated by the Technical Committee Coordinator under the direction of the Vice President for Technical Activities. The Marine Technology Society has Technical Divisions, each responsible for several of the MTS Technical Committees. These OES Technical Committee Chairs and MTS Technical Division Directors will serve as (permanent) members of each OCEANS conference Technical Program Committee while they hold these positions within their respective society. These people will be a resource for the Conference Technical Committee Co-Chairs. They will support the conference by stimulating interest in the conference and encouraging members of the community to submit papers for presentation at the conference.

René and his committee will meet in July to finalize these arrangements and to begin the activities of these two committees. I am particularly pleased to report that René, as Chair of the Committee on Conference Policy, has kept the OES and the MTS fully engaged and cooperating as we move forward with this initiative.

In earlier columns, I have discussed the financial travails of the IEEE and the consequences to the societies, OES included. I mentioned that the focus has been on controlling expenses, and moving to a policy of having dues and other membership fees cover the incremental costs of providing services to each member. For example, it costs about $25 per copy to provide a paper copy of the Journal of Oceanic Engineering to each one of us. It costs about $4 to provide each one of us access to the Journal via IEEEXplore. Societies are being encouraged to set dues that will cover these and other costs.

As I noted in the previous issue of the Newsletter, It costs us $54 to provide the service to each member, while our due are only $12. Now obviously we can't pop the dues up to $54 per year starting with this fall's renewal, but we do need to make progress in this direction. The Administrative Committee voted to raise the OES dues for 2003 to $19. We discussed "unbundling" the Journal, which means that we would charge dues for Society membership, and would charge an additional fee for those members who wished to receive the JOE. This could be part of the strategy for bringing the dues in line with the costs of servicing members. Rather than take such radical steps immediately, I appointed Diane Dimassa the Chair of a committee to recommend a policy and plan for handling this issue. She will be assisted by Jim Barbera, our Treasurer, and Todd Morrison. The Committee will make an interim report in August, and recommend a policy and a plan for achieving the policy at the AdCom meeting in October at the OCEANS conference.

As always, I encourage you to share your views with me. Your thoughtful input is very important to the vitality of our Society. And should you care to participate with more than thought, I would welcome that. Please let me know.

And finally, please register for OCEANS '02 in Biloxi. You will have an excellent time.

Thomas Weiner

GREAT EXPECTATIONS: IEEE/OES Technical Activities

This annual editorial reports on planned conferences, some conference policy changes and some of my personal views.

Joseph R. Vadus

Conferences & Symposia

The next four OCEANS MTS/IEEE Flagship Conferences and several OES symposia are progressing with great enthusiasm.

Oceans 2001 (www.oceans2001.com). Conducted last November with great fanfare. Repeating Kudos to Executive Chairs, Liz Corbin and John Wilshire and their first class conference committee. Over 500 papers, "satellite" meetings along side, and close to 1000 at the evening Luau. A great success, while maintaining normalcy, despite the disruptions of the cowardly attack of 9-11. United we stand.

Underwater Technology 2002 & UT '02 Workshop (www.underwater.iis.u-tokyo.ac.jp/ut02/) (www.na.ntu.edu.tw/postut2002) In April, the UT 2002 Symposium was held for the third time in Tokyo, and followed by a UT'02 Workshop in Taiwan. Both were very successful despite the slowdown in the regional economy. National Taiwan University, especially the efforts of Prof. Forng-Chen Chiu and Prof. Yih-Nan Chen are congratulated for organizing the UT '02 Workshop. This newsletter reports on the symposium, workshop and the University of Tokyo's new Underwater Technology Research Center, which was highly endorsed by the UT Symposia. The new Taiwan Chapter, chaired by Prof. Sheng-Wen Cheng, was also promoted by the UT Symposia. We salute Prof. Cheng and the members of the new OES chapter.

AUV 2002 (www.AUV2002.swri.org). A workshop on AUV energy systems at the Southwest Research Institute, San Antonio, TX. June 20 and 21. Another, in the successful series chaired by Claude Brancart. This time, it covered batteries, fuel cells and other energy systems that are crucial for enduring autonomous operations. Details on the web.

Submarine Cables Workshop. Proposed by Robert Bannon. During discussions at UT'02 workshop in Taipei, Junzo Kasahara, Chair of the Japan Chapter described similar plans. It was logical to suggest a joint effort, which is now being considered. No dates are offered as yet. For information, contact Bob at (rtbannon@csrlink.net)

Oceans 2002 (www.mtsgulfcoast.org) October 28-31, in Biloxi, MS, the rapidly developing southeastern resort & casino town—about one hour from New Orleans or the Stennis Space Center, a bustling complex of Navy, NASA, NOAA and supporting industry. General Co-chairs are RADM Thomas Q. Donaldson, Commander Naval Meteorology and Oceanography Command and Herb Anderson, President of Northrop Grumman IT, who oversee a resourceful conference committee, effectively led by Executive Chairs Rebecca Smith and Jerry Boatman. The $600 Million Beau Rivage Resort & Casino Hotel is on the beach, and a short hop on a shuttle bus to the Mississippi Coliseum & Convention Center. Over 500 papers and over 170 exhibits will ensure another blockbuster conference. The fun side includes a Mardi Gras theme banquet with Cajun music.

Techno-Ocean 2002 (www.techno-ocean.com). This biennial conference will be held November 20-22 in Kobe, Japan. Prof. Toshitsugu Sakou is chair, and President of the Techno Ocean Network, which is helping to organize the subsequent Oceans/Techno-Ocean 2004 conference, also in Kobe. OES will be represented on the Techno-Ocean 2002 International Advisory Committee.

Oceans 2003 (www.oceans2003.org) in San Diego. It will be conducted in concert with Scripps Institution of Oceanography celebrating their Centennial during the conference, September 21-26, 2003. General Chairs are, Dr. Charlie Kennel, Scripps Director and Robert Wernli, who along with Kevin Hardy of Scripps are leading the charge. Once again, a powerful team is on hand, with planning underway. The AGU-Ocean Sciences Conference and American Society for Limnology and Oceanography conference and others are coming along side to share the Town & Country Hotel facilities as participating societies, drawing additional participants for Oceans' sessions and exhibits. It promises to be a great celebration.

Underwater Technology 2004 (www.na.ntu.edu.tw/postut2002) Following the successful UT'02 Workshop and formation of the OES Taiwan Chapter, the UT'04 Symposium is planned for Taipei in April 2004, and hosted by the National Taiwan University. Conference co-chairs are: Prof. Yih-Nan Chen; Prof. Tamaki Ura and Robert Wernli. An excellent facility at Taiwan's Civil Service Development is available, and there are many interesting cultural sites to visit in Taipei. There are non-stop flights from San Francisco to Taipei.

IGARSS 2004 (www.igarss.org) September 20-24, 2004 at the Egan Center, Anchorage, AK. OES is participating and ably represented by Rene Garello and Stan Chamberlain. The symposium includes a major component on ocean remote sensing. For more information contact Rene. (rene.garello@enst-bretagne.fr)

Oceans/Techno-Ocean 2004 (www.oceans-technoocean2004.com) in Kobe, Japan combining the premiere US and Japan conferences, supported by the OES Japan Chapter (our most active), the MTS Japan Section, the JAMSTEC and Kobe City. Dr. Hiroshi Ohba, Chairman of JAMSTEC is proposed as General Chair, who served in that capacity for the past 3 Techno Ocean Conferences, and received the 2001 MTS Compass International Award. OES participation, is headed by Prof. Tamaki Ura and MTS participation by Prof. Toshitsugu Sakou and Hiroyuki Nakahara. Together, they have begun the planning process and an "Operating Agreement" was drafted.

Oceans 2005 (Oceans2005@earthlink.net) in Washington D.C. in the Fall of '05, after a long hiatus. Conference facilities are being evaluated. General Chair is VADM Conrad C. Lautenbacher, Jr. USN (Ret), Dept. of Commerce Undersecretary for Oceans and Atmosphere, and NOAA Administrator. An experienced team of executive co-chairs are Barry Stamey, Washington MTS Section Chair, Capt. Fred Klien USN (Ret.), former Deputy Oceanographer, and Steve Holt, OES Executive Secretary.

Oceans 2005 (Europe) In Brest, France in June '05, repeating the venue of a successful Oceans '94. This time it will be held in the Congress Center, "Le Quartz," located in central Brest within walking distance. Prof. Rene Garello of ENST Bretagne, who Chairs the IEEE/OES Region 8 Chapter, is proposed as General Chair. IFREMER, Thales Underwater Systems and the City of Brest will be supportive. This conference is the first to implement the new two Oceans conferences per year policy. The time separation of 4 months is planned to facilitate participation by OES and MTS.

Oceans 2006: There are several venues suggested, including Monterey, Long Beach, Vancouver and even Las Vegas, but Lake Mead may not provide enough ocean visibility. Offshore venues suggested (for even years) include Australia and return to Kobe. Proposals are needed.

Oceans 2007: We are looking for Proposals. Oceans '87 & '97 were in Halifax. Is the Canadian Atlantic Chapter ready for an anniversary celebration? Boston is long overdue. Regarding offshore, we will be exploring with Bergen, Hamburg. Aberdeen and Genoa.

Special Kudos: The Technical Committees, coordinated by Stan Chamberlain, continue to do a superb job in supporting the technical programs; and Journal Editor James Lynch and Newsletter Editor Fred Maltz maintain excellence in publications, and publicity provided for conferences. All past OES technical publications are now on 6 CD's, as ably accomplished by Glen Williams. All of your valuable technical contributions are appreciated.

Conference Policy Changes

The Committee on Conference Policy (COCOPO), chaired by Rene Garello, with members from OES and MTS have made recommendations on several conference policy Issues, viz., (1) Holding two Flagship conferences each year: One in North America in the Fall and one outside North America in the Spring.. Even years in Europe and odd years in the Pacific Rim/Asia Pacific. (2) A Technical Program Committee (TPC) will be established to provide oversight and program management continuity (3) A Joint Ocean Advisory Board (JOAB) was established, with conference functional positions to be filled by OES & MTS members. The Board will review and assess proposals, conference issues , operational problems and future plans, and (4) A knowledgeable conference administrator will be hired.

Future Conference Venues: A "recon" committee was formed for long range planning to: help identify future conference venues; advise on personnel and facilities resources and supporting organizations; and identify prominent, respected chair or co chairs. Thus far, committee members include: Jim Barbera, Jerry Carroll, Rene Garello, Hisaaki Maeda and Bob Wernli. Of course, all proposals will be reviewed by the new JOAB.

My Personal Views: As before, these policy changes and any amendments thereof will require timely joint acceptance by OES AdCom and MTS Council. Implementation with another layer of experienced volunteers interacting with conference committees will present an operational challenge. It will be important to maintain a high standard and stature of two flagship conferences. Any major weaknesses could be challenged by competing conferences.

I am very interested in the outcome of Bob Wernli's approach integrating other societies as participants in Oceans 2003. This could bring the Flagship toward serving as an umbrella to other conferences with ocean interests.

All conference committee functions are important, however a technical program with 500 quality papers has collateral benefits of more authors, coauthors and session chairs for greater registration and attendance, and the latter will encourage exhibitors, further benefiting the conference. The core technical program should include the topics of the OES Technical Committees (12) and MTS Professional Committees (30). Each has an obligation to package at least one session for the Flagship Conference. Topics based on regional emphasis could be added at the Technical Program Committee's discretion.

Chapters are very valuable in developing conference proposals and having a local committee to handle many local functions.

P.S.I am interested in your comments and your suggestions for future venues including the rationale to assure success.

United we stand,

Joseph R.Vadus
Vice President, Technical Activities
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UT 2002

International Symposium
"Technology for the Last Frontier"
Tokyo, Japan, 16–19 April 2002

UT 2002 Reception in the New Sanno Hotel. L to R: C.K. Rheem, T. Fujii, T. Ura, R. Wernli, J. Vadus, A. Ashida, Y. Ishii.

Jerry Carroll distributing Oceans 2002 necklaces to T. Ura and H. Nakahara.

Co-Chairs proposed for UT'04 in Taipei (from L to R): Prof. Tamaki Ura, Mr. Robert Wernli, and Prof. Yih-Nan Cheng.

OES Planning Meeting, post UT 2002 Symposium. L to R: H. Maeda, J. Vadus, T. Wiener, J. Carroll, Kinoshita and R. Wernli.

OES and MTS Meeting in Tokyo to discuss Oceans/Techno-Ocean 2004 Agreement.

Underwater Technology 2002 (UT'02) Symposium and UT'02 Workshop

Principals of OES Japan Chapter. L to R: A. Ashida, J. Kasahara (chair), C. K. Rheem and T. Ura.

The Third International Symposium on Underwater Technology UT '02 was held at the New Sanno Hotel in Tokyo from April 16 through 19.

This international symposium, which was organized by IEEE/OES Japan Chapter, Institute of Industrial Science (IIS) of The University of Tokyo, and Office of Naval Research International Field Office, Asia, started in 1998 and has been held biennially since then.

The chairmen of the UT '02 were Prof. Tamaki Ura, Director of Underwater Technology Research Center at IIS, and Mr. Joseph Vadus, Vice President, IEEE/OES. Dr. Thomas Wiener, President, IEEE/OES gave opening remarks.

About 130 people participated in the symposium, which included four keynote talks by researchers from Japan, Taiwan, Korea, and the U.S., and about fifty papers on advances in underwater technology. Session topics in underwater technology included: vehicles and robotics, acoustic systems, underwater observation, positioning, underwater construction and biotechnology.

On the first day, May 16th, a bus load of participants visited Tsukuba Space Center of the National Space Development Agency of Japan (NASDA) and the Robot Laboratory of National Institute of Advanced Industrial Science and Technology (AIST) in Tsukuba City. They observed mock-up models of the space station, micro-manipulators of a robot, and a newly developed humanoid.

On April 22 and 23, a follow-on UT'02 Workshop was held in Taipei, Taiwan, at the National Taiwan University, and was organized by the newly established IEEE/OES Taiwan Chapter. There were about 65 underwater researchers participating, mainly from Taiwan, and included a delegation from Japan and the U.S. Papers and discussion at the workshop were centered on the workshop theme, "Advances in Ocean Monitoring and Exploration for the New Century".

Principals of UT 2002 in Tokyo: co-chairs Tamaki Ura and Joe Vadus flanking Pres. Thomas Wiener.

The Taipei Chapter, the second IEEE/OES chapter in Asia, held the first meeting, and Prof. Shen-Wen Cheng was elected as the first chairperson.

On the afternoon of the second day, IEEE/OES members visited the National Palace Museum, containing Chinese traditional treasure, arts and crafts.

This post-conference workshop will develop into the Fourth International Symposium on Underwater Technology UT '04 to be held at National Taiwan University in the Spring of 2004. Co-Chairs proposed for UT '04 in Taipei are: Prof. Tamaki Ura, Mr. Robert Wernli, and Prof. Yih-Nan Cheng And, once again, in 2006, the OES Japan Chapter proposes to host UT '06 in Tokyo.

Asian Chapters of OES recommend that members of IEEE/OES attend these symposia to exchange information on advances in underwater technology and also have the opportunity to appreciate the essence of Oriental culture.

UT 2002 Workshop in Taiwan at the National Taiwan University

Taipei, 22–23 April 2002

Prof. Forng-Chen Chiu, organizer of UT 02 Workshop in Taiwan, and Prof. T. Ura, co-chair for UT 02 in Tokyo.

UT 02 Workshop in Taiwan. L to R: H. Maeda, R. Wernli, J. Vadus, T. Wiener, T. Ura, and J. Lynch.

UT 02 Workshop final dinner meeting in Taipei.

UT 02 Workshop Dinner. L to R: T. Fujii, Mr. and Mrs. C. K. Rheem, Y. Ishii and F. C. Chiu (Taiwan).

Civil Service Development Institute proposed as site for UT 2004 in Taiwan.

Contributions to Advancement of Underwater Technology

Joseph R. Vadus
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Joseph Vadus presenting his paper at the UT 02 workshop in National Taiwan University, Taipei.

Introduction

Over the past 35 years, I have been involved with a number of research and development projects that have advanced the state of underwater technology. I will briefly describe the main features of each project, my role and modest contributions.

NR-1

NR-1 is a nuclear powered underwater research and ocean engineering vehicle, a mini submarine. It was conceived in the early 60's by the famous Admiral Hyman Rickover, who is the father of the US Nuclear Submarine Navy. He wanted to develop a small compact reactor, less than 200 kw, and operate in a small, deep submergence submarine. Rickover was a very strict leader and demanded perfection, and got it.

In 1964, I was at Sperry Rand Corp., Long Island, New York, in their Deep Submergence Systems Division. Rickover decided to invite Electric Boat Division, of General Dynamics and Sperry Rand Corp. to design and build NR-1. In 1965,I was responsible for preparing the system requirements document, and then headed the NR-1 Program Office responsible for the NR-1 electronic command and control system. Electric Boat was responsible for the hull and submarine structure.

NR-1 has a ring-stiffened cylinder hull structure, 12 ft. in diameter and made of HY-80 steel, 1.3 inches thick. Overall length is 137.5 ft., and coincidentally cost approximately $137.5 million, at time of launch. The major subsystems include:

- Nuclear reactor
- Propulsion & hovering system
  —Twin 30 hp submersible motors
  —Bow & stern cross thrusters
- Retractable wheels—-for seafloor positioning
- Integrated, computer- control & display system
- Sonar systems (for observation, collision avoidance and navigation
- Lighting & viewing system, including three viewports
- Manipulator system—- seven degrees of freedom
  Living and life support system for a crew of six

NR-1 requires a support ship for other than coastal deployment. She cruises at 5 knots and can hover like a helicopter holding a position within a one meter sphere.

NR-1 was launched in 1969, and it was believed by some, that NR-1 was, perhaps, as much as 20 years ahead of its time. I believe it's still ahead.

TRIESTE & DSRV

Other deep submergence projects at Sperry Rand included the electronic systems of TRIESTE II and the Deep Submergence Rescue Vehicle (DSRV). The original TRIESTE bathyscaphe was developed by Jacques Piccard, and, in 1960, he and Don Walsh descended to 35,800 ft. in the Marianna Trench (Challenger Deep). The record still holds.

In 1964, the TRIESTE was reconstructed (for 20,000 ft capability) as TRIESTE II, and Sperry developed the electronic command & Control system and a duplicate system for simulation and training. The system was arranged in a wrap-around configuration to fit the pressure sphere, and contained the usual instrumentation common to manned submersibles. TRIESTE II was used on many dives operating vertically like an underwater balloon, with slow horizontal maneuverability. In 1963, the submarine USS THRESHER accidentally sank in the Atlantic to a depth of 8400 Ft., and TRIESTE II was used later to survey the wreck site and retrieved pieces of debris for analysis.

DSRV

The Deep Submergence Rescue Vehicle (DSRV), was initiated soon after the loss of the SSN Thresher submarine. DSRV is capable of 2000 meters depth for mating with a special escape hatch of a submarine, that has sunken above its crush depth. After mating, the crew is transferred from the sub to the DSRV. It is highly maneuverable, to facilitate mating using computer-controlled cross thrusters and a high resolution docking sonar. It has a very sophisticated navigation, guidance and control system. Sperry added instrumentation to enable DSRV to perform alternate missions, such as ocean survey, when not rescuing.

Submarine Radar

Admiral Rickover was also interested in the Submarine USS DOLPHIN AGS 555. a diesel-powered deep submergence test platform. Rickover didn't like to have any rotating shafts through the hull (NR-1 has none). However, the DOLPHIN radar had a rotating microwave joint through the hull. Using my earlier radar experience, I designed a radar without a hull penetrating joint. Instead, a glass-filled coaxial cable passed through the hull to the antenna level, with the center conductor stub of the coax serving as the feed to the rotating antenna. In order to redirect the omnidirectional pattern of the "stub", a small reflector was mounted so as to direct the microwave energy toward the main antenna reflector. The small reflector and the main antenna reflector rotate concentrically around the coax stub to produce a narrow vertical surveillance beam. The system was tested at sea and performed as expected, with a small sacrifice to increased side lobes.

WORK SUB

Since unmanned vehicles began receiving increased attention in the late 60's, Sperry invested in developing a demonstration vehicle called "WORK SUB". It was built as an experimental model and tested in the Sperry Lab's pool. It was controlled in three axis like a small underwater helicopter, and was used as an underwater technology test platform. It should be noted that the three landing pods are actually bowling balls. It was an early remotely controlled vehicle.

ROV's

In the early 70's, there was a family of remotely controlled vehicles (RCV) developed by Hydroproducts Inc. In 1976, I initiated the first comprehensive study of the world's remotely controlled undersea vehicles, with the assistance of F. Busby Associates. The report needed a tile, and it could not be remotely controlled vehicles (RCV), because RCV was a trademark belonging to Hydroproducts Inc. So, ROV was introduced and has since become a globally accepted term. The US government doesn't impose trademarks on projects using public funds, so, now everyone can use the term ROV.

AUV's

At the late 60's, at Sperry, I became interested in autonomous undersea vehicles, based on applying available deep submergence technology and instrumentation. I was able to design a basic survey vehicle that could go to 20,000 ft., navigate with an inertial-doppler system and a small 3 kw radio isotope power source. It seemed like the ideal solution, until they said I would not be permitted to operate an unmanned nuclear powered vehicle, because of obvious risks and safety if the unmanned vehicle is lost. The design was still valid, but for a much lower capacity, non nuclear, power source. Power still remains as one of the greatest shortcoming of AUV's.

At NOAA, I supported the continued development of the Slocum Profiler, which was started at the Office of Naval Research. This vehicle uses gravity and buoyancy to propel the vehicle in a cyclic manner, diving by gravity, collecting oceanographic data and then reversing direction by a passive technique that increases buoyancy. The vehicle then rises to the surface where it can transmit data collected and GPS position to the Argos satellite. It can operate over long distances, not being limited by power.

While serving with the National Science foundation (1987-90), I funded and monitored several underwater projects. One of these, was the development of Woods Hole's Autonomous Benthic Explorer (ABE) which continues to be used successfully.

GATOR

At Sperry, around 1970, I developed a new concept for an amphibious vehicle for the US Marine Corps. It was called GATOR, because it could travel on the surface and underwater like a submersible, and crawl on the seafloor, through the surf and move inland. In essence, it's a lockout submersible with tracks. The design and model received a lot of attention from the Marine Corps as a reconnaissance vehicle; for army riverine warfare and the Navy as a swimmer delivery vehicle. Because of joint service interest the proposal was handled by the Advanced Research Project Agency (ARPA), but funds were not available. So, I quit Sperry and joined the Government. A year or two later, Sperry noted that a vehicle similar to Gator was built by the Soviet Union, deployed from a submarine, with tracks observed on Sweden's coastal sea floor.

Manned Undersea Science & Technology

In 1972, at NOAA's Manned Undersea Science & Technology (MUST) Office I managed projects related to underwater vehicles and underwater habitats. One interesting project was IGUANA (Intergovernmental Undersea Atomic Neutron Activation). The BEAVER submersible was instrumented with passive and active neutron activation analysis systems to assay the surficial sediments for heavy metal pollutants and mineral deposits using Raleigh back scattering techniques. Special procedures were required for handling radioactive material and loading the manipulator with a canister of Californium 252. The stern was equipped with passive Sodium Iodide sensors to make passive measurements. BEAVER was deployed in Long Island Sound and data on heavy metal pollutants were documented. These measurement techniques, using X-ray fluorescence, were applied in a new surficial sediment sampling system developed at the University of Georgia, and used in several estuary surveys.

Underwater Habitats

NOAA's Manned Undersea Science & Technology (MUST) Office operated a modest underwater habitat called HYDROLAB in the Bahama Islands and was used for hundreds of saturation dives, that required living on the seafloor. In 1974,The MUST office became partners with the German Government in using their underwater habitat called Underwater Lab HELGOLAND in the North Sea and Baltic Sea with an international team of aquanauts. In 1975, it was shipped to Boston and then deployed off Rockport, MA for in situ fisheries experiments.

Some of the technology developments included: Underwater instrumentation to study benthic organisms on the sea floor; underwater welding experiments conducted by M.I.T. engineers; mixed gas diving procedures were refined. This led to other underwater laboratories viz., Puerto Rican International Underwater Lab (PRINUL), and later the AQUARIUS, now operated by NOAA's Undersea Research Project (NURP) Office, that succeeded MUST. A design for a mobile underwater habitat called "MOBILAB" was completed, but could not justify the construction and operating costs, versus existing underwater systems.

Ocean Energy Technology

At NOAA, from 1979-1985, I managed the Ocean Energy Technology Development Program. Ocean Thermal Energy Conversion (OTEC) required many advances in underwater technology including: large scale cold water pipes to 3000 ft. depth, deep ocean mooring and station keeping; and underwater inspection, maintenance and repair, using dedicated ROV's. There are technical reports of all the research, design, test and evaluation that were completed. Current energy conversion was considered for the Gulf Stream. Design studies were completed and experiments were conducted with flexible rim mounted turbine blades.

Advanced Ocean Development Test Project (AODTP) Vehicle

At NOAA in the Late 70's, a joint project was initiated with Jet Propulsion Lab to develop a remotely operated vehicle that would incorporate the latest U.S. space technology. It was called the Advanced Ocean Development Test Platform (AODTP). In particular it featured the latest digital control, sensors, data collection and signal processing technology. In particular, it featured sidelooking sonar digital image processing. The AODTP was shallow water tested and demonstrated, but, as a demonstration model it was not used in a mission. Perhaps it had another life, because the electronic subsystems and components were transferred to Woods Hole's Deep Submergence Lab.

RMS TITANIC Discovery

At NOAA, from 1980-1995, I served as U.S.Leader for Marine Technology in cooperation with France. One of the cooperative marine technology projects involved evaluation of deep ocean survey systems at 6000 meters depth. These were: Woods Hole's Argo System (2 metric ton) and France's (IFREMER) SAR System (2.4 metric ton). ARGO was equipped with sidelooker and an array of lights and cameras (video and high speed photographic). SAR (System Acoustique Remorque), was a towed instrumented platform with a sidelooking sonar The tests were planned in Toulon, France in 1984, and intended for evaluation near the Canary Islands in the eastern Atlantic at depths on the order of 6000 meters.

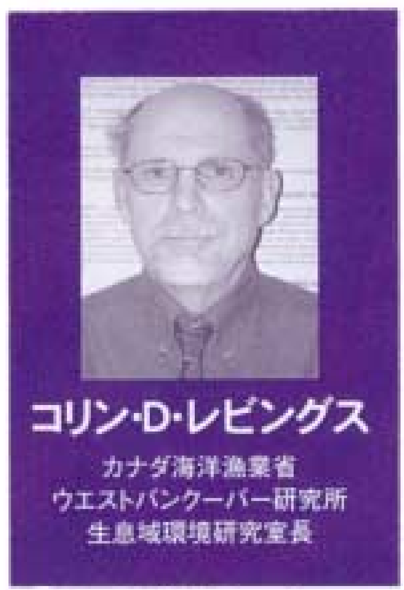
The test site was later changed to the approximate location of the RMS TITANIC (230 mi south of Nova Scotia), sunk on April 15, 1912. In the summer of 1985, at sea tests were conducted jointly with ARGO on Wood's Hole's ship Knorr and SAR on IFREMER's ship Le Suroit. On September 1, 1985, the TITANIC was discovered at a depth of 4000 meters by the ARGO System. Later surveys were made using manned submersibles Alvin, Nautille and the Russian MIRS vehicles.

Conclusions

I am grateful for having the opportunity to participate in some very interesting underwater projects over a 35-year period, and adding to the body of knowledge. At the present time, you are making even greater contributions in advancing underwater technology, and I am greatly impressed with your accomplishments. Many were reported in the Underwater Technology 2002 Symposium (UT '02) in Tokyo; and others reported here, in this UT 2002 Workshop in Taipei. Well done.

Special Program at Osaka Expo Center
April 30, 2002

Joseph Vadus, IEEE/OES Vice President Technical Activities



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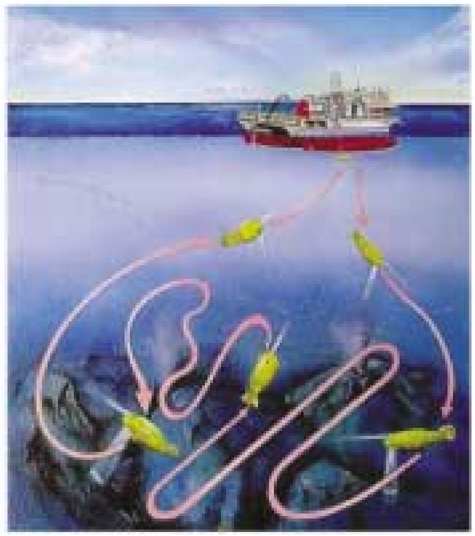
教授

Prof. B. Murata, Nara University

In a special program sponsored by the Sankei Shimbun Newspaper, Joseph R. Vadus gave the keynote address, about the future of ocean development to 700 students at Osaka's Expo Center, April 30. This was followed by a panel discussion with Dr. Collin Lemming from Canada, Toshitsugu Sakou, chair for MTS Japan Section, Prof. Tamaki Ura, past chair for OES Japan Chapter, and Prof. Buichiro Murata, Nara University.

The Underwater Technology Research Center

The Institute of Industrial Science, The University of Tokyo



The Underwater Technology Research Center was established in the Institute of Industrial Science (IIS) at the University of Tokyo on April 1, 1999 to accelerate research and development of new platforms for underwater activity, which include AUVs. Although there is an Ocean Research Institute in the University of Tokyo, the new research center was established in the IIS in order to inspire and introduce advanced technologies from different fields of engineering. The Center was supported by the Ministry of Education, Science, Sports and Culture. The center consists of six laboratories which are supervised by four professors (two of them are guest chairs) and two associate professors. Each laboratory is named after the name of the supervisor in accordance with the IIS's traditional culture, because research topics of the laboratory can be directed to any direction by the idea of the supervisor without restriction by the name of the laboratory. The laboratories and their fields of interests at present are as follows:

URA (Director, Prof.) Lab. : Underwater Robotics
ASADA (Prof.) Lab. : Underwater Acoustics Systems Engineering
TAKAGAWA (Guest Prof.) Lab. : Subsea Technology
ASAKAWA (Guest Prof.) Lab. : Underwater Inspection
FUJII (Ass. Prof.) Lab. : Marine Bio-Mechatronics
RHEEM (Ass. Prof.) Lab. : Ocean Environmental Engineering

AUV Tri-Dog 1

In order to get mutual understanding between engineers, natural scientists, and operators of research ship and vehicles, the AUV Council was organized in the Center. Needs from the scientists, ideas from the engineers, and demands from the operators are presented and considered in the council. It is anticipated that a new strategy for R&D of AUVs in Japan and collaboration with institutes of foreign countries can be promoted and planned by the council.

High Resolution Seafloor Imaging with Synthetic Aperture Sonar

M. A. Pinto

Introduction

High resolution imaging sonars are widely used in all water depths to deploy or locate a large variety of underwater objects on the seafloor, such as pipelines, cables and lost objects or wrecks. Military applications include detailed characterization of given littoral waters with objectives such as detecting, classifying and identifying sea mines and mine-like objects, as well as hazards to navigation. These objects may be either proud on the seafloor or, naturally or purposely, buried in the first few meters of marine sediment.

For reliable object recognition, the resolution of an imaging sonar must be a small fraction (typically 1/10 to 1/20), of the size of the object under investigation. Depending on the application, the sonar resolution can vary from a few centimeters to a few meters, at ranges varying between a few tens of meters and a few hundreds of meters. More precisely, the resolution of a linear array is characterized by a set of two parameters: the range resolution, determined by the sonar bandwidth, and the angular resolution, determined by the ratio of the aperture length L to the acoustic wavelength λ. The cross-range resolution is the product of the angular resolution and the range, and therefore degrades with range. It is the single most important parameter that determines the performance of an imaging sonar.

For the range of operating frequencies used in imaging sonar, say from 10 kHz to 1 MHz, it is generally not difficult to achieve high range resolution, especially with the recent advances in wideband sonar technology. As an example, consider a sonar aperture of L=1.2 m operating at 500 kHz (λ=3 mm), with 20 kHz bandwidth, i.e., a 4% relative bandwidth, which is modest according to present standards. The corresponding range resolution is 3.75 cm, which should be sufficient for even the most demanding applications. However, the cross-range resolution at 150 m is 37.5 cm, i.e., ten times larger. Increasing L by an order of magnitude is usually not an option due to platform constraints (size, weight). The tenfold gain in cross-range resolution can then only be obtained by reducing the operating range and operating at a higher central frequency, e.g., at 25 m range with a central frequency close to 900 kHz. This, however, considerably increases the survey time and, in applications such as minehunting with manned surface vessels, is simply not acceptable, due to the increased risk to personnel and equipment involved.

Synthetic aperture sonar (SAS), is the only technology that allows an order-of-magnitude increase in the cross-range resolution with a limited aperture size. The basic idea ([1]) is to displace the aperture across range, in order to reproduce the characteristics of a large virtual antenna. More precisely, the data from multiple successive pings are collected and processed as though they were the elements of a virtual (or synthetic) array, whose length is determined by the displacement of the real (or physical) antenna during the data collection. Due to the linear increase of the transmission beam footprint, the number of integrated pings, and hence the length of the synthetic aperture, increases in proportion to range. Thus an SAS achieves, in theory, a cross-range resolution which is constant with range.

For example, assume the above 500 kHz sonar were displaced across range at v=6 knots. With a ping repetition period (PRP), of T=0.2 s, corresponding to a maximum range of 150 m, it is sufficient to integrate a maximum of N_{max}=10 pings to achieve a cross-range resolution of 3.75 cm over the whole swath. This corresponds to a maximum SAS integration time TSAS = N_{max} T = 2 s. The same array length could be used to achieve even more ambitious SAS performance, such as a 1.25 cm x 2.5 cm resolution in range x cross-range up to 225 m. Typical operating parameters of this SAS could be f_0 = 300 kHz, B=60 kHz, v = 4 knots, T=0.3 s.

Even more obvious are the potential benefits of SAS for imaging the superficial layer of marine sediments, as required for locating shallowly buried objects. A bottom penetrating sonar must operate at low frequencies (typically below 15 kHz), in order to reduce the absorption of sound in the sediment, which is usually much higher than in seawater. The problem is then to maintain sufficient cross-range resolution to detect and classify buried objects. For a sonar aperture L= 1.2 m operated at 12 kHz (λ=12.5 cm), the cross-range resolution is close to 15 m at 150 m, which is much too large for the

Fig. 1: Ocean Explorer UUV operated by the NATO SACLANT Undersea Research Center. This UUV is being equipped with an 8-16 kHz low frequency SAS for buried mine detection, which will be tested at sea in October 2002. The SAS receiver array features 4 rows of 16 elements spaced at 6.25 cm. Both the UUV and the SAS were manufactured by Florida Atlantic University.

identification of small objects, e.g., sea mines. If this sonar were displaced across range at v =6 knots, with a ping repetition rate of T=0.2s, a 15 cm cross-range resolution up to the range[1] of 150 m could be achieved with N_{max} =100 pings (giving T_{SAS} = 20 s).

The synthetic aperture concept was introduced in airborne radar back in the 50's and then successfully extended to spaceborne systems in the 80's, despite order of magnitude differences in the speed and range of the respective systems. There are numerous operational synthetic aperture radar (SAR), systems throughout the world. The situation in sonar is markedly different, with only a small number of experimental prototypes operated by universities or naval research laboratories. The important differences in the physics explain only in part this development lag relative to radar. It is clear that mankind has devoted much more effort to the observation of the Earth's surface than to the bottom of its oceans, likely due to the much greater impact of the former on the world's economy and politics. Nevertheless, the interest in SAS has markedly increased during the past few years, as illustrated for example by the increased number of sessions and publications on this topic at the last Oceans' 01 conference and the large attendance for the one-day SAS tutorial. This is closely related to the keen interest of several NATO navies in high-resolution surveys of the underwater battlespace using unmanned underwater vehicles (UUVs), in which SAS is identified as an enabling technology. Several UUV-based SAS systems are being assembled for demonstration in naval exercises in the very near future. In particular the NATO SACLANT Undersea Research Centre, La Spezia, Italy (Saclantcen), is integrating a low frequency SAS system for high resolution sub-bottom profiling and buried mine hunting into its UUV for trials beginning in October 2002 (Fig. 1). It is likely that, if the remaining technical issues find a satisfactory solution, these systems will lead to the first of their kind operated by NATO navies, hopefully followed by other scientific and commercial applications.

The main technical issues in SAS relate to spatial sampling and adaptive focusing to compensate for unwanted platform motion and sound speed variations. In addition there is a requirement for image formation algorithms which are both accurate and computationally efficient. None of these issues are new. They also arise in SAR where satisfactory solutions have been found. The applicability of these solutions to SAS is not always obvious due to order of magnitude differences in the physical parameters involved, and the SAS community is actively investigating this. In addition, SAS, unlike SAR, will often have to operate in a shallow waveguide where multipath is the rule rather than the exception.

Spatial Sampling

Imaging sonars operate with a PRP equal to the two-way travel time to (and from), the maximum range. A basic constraint on synthetic aperture operations is that the distance traveled between two successive pings should not exceed half the length of the physical aperture, in order to ensure adequate spatial sampling of the SAS. That is,

$$vT = v\,\frac{2R_{\max}}{c} \le \frac{d}{2}, \tag{1}$$

where d is the length of the physical aperture, assumed to consist of a single transmit/receive element and c the sound velocity. The quantity $v\,R_{max}$ can be interpreted as the (one-sided) area coverage rate (ACR). The quantity $d/2$ on the right hand side is well known as the cross-range resolution of the synthetic aperture, which is constant with range and frequency. This equation therefore shows that the ACR is limited by the cross-range resolution. The consequences for SAS design are fairly disastrous. To achieve 3.75 cm cross-range resolution up to 150 m, as for the 500 kHz SAS system discussed in the introduction, the along-track speed v would have to be less than 0.5 knot!

The spatial sampling constraint is much more of an issue in SAS than in airborne SAR because of the much higher relative velocity v/c, in (1), of underwater platforms with respect to aircraft. For a slow-speed SAS cruising at 1.5 m/s, v/c is 10^{-3}, whereas for an airborne SAR cruising at a typical aircraft speed of 300 m/s, v/c is 10^{-6}. This arises from the fact that c is approximately 1500 m/s for sonar compared to 300,000 km/s for radar, i.e., 200,000 times smaller. For the above platform velocities, a 1 m physical aperture limits the range of the SAS to 250 m, whereas the airborne SAR can reach 250 km.

A major step towards reducing the spatial sampling shortfall was taken by Cutrona in 1973 ([2]), who, by so doing, possibly made the single most important contribution to the field of SAS. He extended the SAR design of a single transmit/receive element of length d to what is known today as a multi-element (or vernier) synthetic aperture. This consists of a transmitter of length d and a receiving array of N elements, of total length Nd=L. He showed that the cross-range resolution was d/2 for both single and multi-element systems but that the ACR of the second was greater by a factor of N. In other words the ACR is determined solely by the length L of the physical receive aperture, independent of the resolution. For a multi-element SAS, the spatial sampling spatial criterion reads

$$\alpha \equiv \frac{L}{2vT} \ge 1. \tag{3}$$

As an example, a minimum[2] of 16 receive elements, each of length 7.5 cm, is required to achieve the above 3.75 cm resolution SAS.

It is inevitable that for a multi-element SAS, the increase in ACR obtained at the price of an increase in the aperture length, will at some stage become a problem. For example, operation at 10 knots speed, up to 750 m range, requires a 10 m long aperture. Many clever designs have been proposed, using multi-

[1] In hard marine sediments, such as sand, and in shallow or very shallow water, critical angle effects will limit the achievable range to significantly less.

[2] It can be shown that a single-element SAS sampled at d/2 is undersampled, i.e., exhibits azimuth grating lobes which reduce the image contrast. The same holds for a multi-element SAS but the problem can then be mitigated, without reducing the area coverage, by further increasing the spatial sampling of the physical receive array: for instance, a receive array of 2N elements spaced at d/2 and a transmitter of length d with horizontal shading.

ple transmitters, multiple frequencies or coded waveforms, in an attempt to increase the ACR beyond the limit (3). However in all the cases reviewed by this author ([3]), there is a price to pay in terms of image quality, in terms of either resolution or contrast, compared to the correctly sampled SAS. Whether this loss is acceptable or not depends on the application. The loss in contrast leads to the filling in of shadows, which can be very damaging for mine classification applications. Thus it seems that the only convincing way ahead for increasing the ACR is to investigate the technological issues associated with the deployment of long physical apertures, possibly flexible towed arrays analogous to those used, at much lower frequencies, for active detection of submarines.

Adaptive Focusing

The most important practical problem in implementing SAS is associated with the effects arising from track-keeping errors, i.e., the deviations of the platform from an ideal linear track due to external forces acting on it, such as propulsion and underwater currents in the case of an UUV. The projection of these errors in the line of sight introduces phase errors in the SAS beamforming, given by

$$\phi(t) = 4\pi \frac{\gamma(t)}{\lambda}, \tag{4}$$

where $\gamma(t)$ is the projected error and λ the acoustic wavelength. If $\gamma(t)$ contains only low frequencies, compared to the characteristic frequency 1/TSAS, the maximum acceptable phase errors are of the order of 100 deg rms. For high frequency errors, the tolerance is much smaller, of the order of 10 deg rms. It is clear therefore that, for most applications, the track-keeping errors cannot be ignored. The solution, which is straightforward in principle, is to base the SAS beamforming on the actual (in general non-linear), track followed by the UUV, rather than the ideal linear one. This poses the problem, however, of sensing the UUV motion with sufficient accuracy. These accuracy requirements can be quite challenging since, at 300 kHz, a 10 deg phase shift correspond to a motion of less than 0.1 mm. The term micronavigation has been introduced to describe the very specific, short term, relative positioning determination required by SAS.

A similar problem occurs in airborne SAR ([4]), where the aircraft can be buffeted randomly by turbulent flow. It was solved there by using very low noise inertial navigation systems (INS) to sense the high frequency errors (compared to $1/T_{SAS}$), and data driven techniques, known as autofocusing techniques, to sense the low frequency errors. The performance tradeoffs between a variety of autofocusing algorithms, such as fitting the target return, phase gradient autofocus (PGA), contrast maximization and multi-look registration have recently been reviewed in the SAR domain ([5]). The fact that the wavelength and the characteristic frequency $1/T_{SAS}$ are not so different for a SAS compared to an airborne SAR (at least for the systems described in the introduction), makes these solutions worthy of investigation.

Unfortunately, there is as yet very little to review in the literature on the use of an INS for SAS. This situation is likely to change in the immediate future with the emergence of UUV-based SAS demonstrators. These UUVs are equipped with a high grade INS to address the long-term underwater positioning issue, a critical problem for an UUV. In addition, high-grade INS systems are becoming much more affordable with recent advances in solid state technology, in particular fiber optic gyros.

Amongst the SAR autofocusing algorithms, PGA seems to have been the most successful in SAS ([6,7]). The promising results obtained to date show that the algorithm certainly has potential and is worthy of further investigation. It assumes the presence of strong point-like scatterers in the field of view, which are used to extract the phase error. The origin of the phase error, whether platform motion or phase fluctuation, is at this stage unimportant. However the question of the robustness of the algorithm in conditions which depart from its basic assumptions, such as in the absence of strong scatterers or in the presence of strong scatterers that are not point-like, requires further study.

Displaced Phase Centre Antenna

The renewal of interest in SAS has much to do with the use of the Displaced Phase Center Antenna (DPCA) technique, which holds the promise of providing a robust solution to the micronavigation problem. F.R. Dickey and coworkers ([8]), from General Electric are generally credited with inventing the DPCA back in the 1950's, to improve the performance of Moving Target Indicator (MTI) radars mounted on moving platforms. Dickey had also noted that the DPCA could be used to measure the ground velocity of a radar (or sonar) and introduced the terminology of correlation navigator to describe this variant of the principle. The DPCA is used to measure the across-track displacements of the sonar between successive sonar pings, which are then integrated along the length of the SAS. The principle of the measurement is as follows:

Assume first that the sonar antenna is aligned along track and that it does not move in the along-track direction between two successive pings 1 and 2, being subject only to a small cross-track displacement γ. This will lead to a phase shift between the two echoes from a given scatterer on the seafloor, which is given by

$$\phi = \frac{4\pi}{\lambda}\gamma\cos\theta \approx \frac{4\pi}{\lambda}\gamma, \tag{5}$$

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[3] A ground-based MTI radar exploits the Doppler effect to detect moving targets in large ground clutter. The problem is that when the MTI radar is mounted on a platform moving at ground velocity v, ground clutter returns also have a Doppler shift, given by $2v/\lambda \cos\theta$, where θ is the angle between the direction of the clutter return and the aircraft velocity vector. The Doppler spread due to the antenna beampattern can then mask that of low velocity targets. By shifting the effective radiation center of the antenna backward between instants t_1 and t_2, using several transmit or receive elements on board the aircraft, the DPCA compensates for the forward motion of the radar with the result that the radar is effectively stationary between t_1 and t_2. For example, subtracting the two signals at t_1 and t_2 cancels out the return from fixed ground targets, leaving only the returns from moving targets (up to noise). The introduction of phase arrays and digital signal processing has led to a considerable expansion of the initial DPCA technique, which is now best viewed as a particular case of Space Time Adaptive Processing (STAP), a topical subject in radar. In the recent years there has also been interest in applications of STAP in low frequency active sonar.

where θ is the angle between the direction of the scatterer and boresight to the sonar antenna. Provided the cross-track displacement and the angular spread in θ around broadside due to the sonar beampattern remain small, this phase shift can be assumed constant for all the scatterers in a given range bin, or even a small set of range bins. It can then be estimated by a short-term phase+amplitude cross-correlation of the signals from the two pings. The correlation is expected to be high, regardless of the presence or absence of strong scatterers, provided the medium and the scattering geometry do not change significantly between pings and the noise is low. In addition, temporal changes in the medium which do not decorrelate successive pings but only introduce an additional phase shift can be treated as effective motion errors and corrected for as well. On the other hand time-varying multipath, due to sea surface interactions, will lower the correlation. This has indeed been found experimentally to be a major cause of decorrelation.

Next, when the platform is moving along-track, the DPCA principle is applied to arrive at an effective fixed along-track position. For a transmitter T and a receiver R, the effective radiation center, or phase center, is the point C=(T+R)/2, i.e., at the middle of segment TR. Consider next two sub-arrays Rl and Rt of the receiving array, respectively at the leading and trailing edge of the array, whose centers are separated by 2vT. The length of these sub-arrays is $L-2vT=L(1-1/\alpha)$, so that a basic requirement for DPCA micronavigation is an oversampled SAS, i.e., $\alpha > 1$. By arrangement, the leading phase centers at ping 1 have the same along-track position as the trailing phase centers at ping 2 (Fig. 2). Therefore the correlation should be performed between the seafloor echoes received by the leading sub-array at ping 1 and the trailing sub-array at ping 2.

In this derivation it is assumed that the along-track displacement vT is known. When this is not the case, the whole procedure can be repeated while varying the sub-array length, to retain only the length for which the correlation peak is greatest. This length relates directly to the required displacement vT.

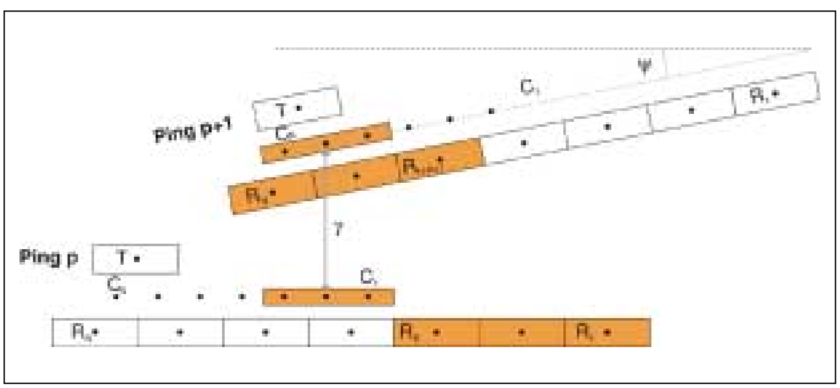

Fig. 2: Displaced Phase Center Antenna (DPCA) technique. Shown are the sonar transmitter T, the receiving array of N elements $R_1, \ldots, R_N$, and the corresponding phase centers $C_1=(T+R_1)/2, \ldots, C_N=(T+R_N)/2$ at two successive pings p and p+1. Shown in color are the DPCA elements, whose phase centers have the same along-track position for both pings, effectively canceling the along-track displacement of the sonar to increase the cross-correlation of the seafloor backscatter at p and p+1. The cross-track displacement γ is estimated as the corresponding correlation lag. Also shown is a change in heading ψ of the array between pings.

A theoretical study regarding the accuracy of DPCA micronavigation ([9]) has revealed that the main sources of error are those induced by errors in estimating the heading of the physical array during the SAS integration time. Initial applications of DPCA ([10]) assumed that the sonar kept a constant heading during the SAS integration time. This requires, however, a high degree of vehicle stability. A more robust alternative is to estimate the heading of the physical array. Raven ([11]) invented an extension of DPCA capable of estimating the changes in heading of the sonar antenna from ping to ping. The attractive feature of this algorithm, for relatively low budget SAS experiments, is that all the components of the motion required to focus the SAS can be extracted from the data, without the need for any additional instrumentation. It has been implemented and validated experimentally by several authors ([12,13]).

The problem with extracting all of the motion components using DPCA is that it puts very stringent accuracy requirements on the algorithm which, as shown in [9], severely limit the achievable SAS performance, in terms of both image quality and ACR. The most promising way ahead is by use of inertial gyroscopes to measure the heading, since most often only a medium accuracy gyro (e.g., 0.1 deg/√hr), is needed. The first experimental results to date using a "gyro-stabilized" DPCA were presented at the last Oceans'01 conference ([14]), using an underwater rail system, and a wideband sonar/INS combination mounted on a multi-axis motion actuator, allowing arbitrary non-linear trajectories to be generated. Excellent SAS performance was obtained even in the presence of large changes in heading. More results will be presented at the coming Oceans'02 conference ([15]).

Advanced Operating Modes

The squint mode and the spotlight mode are advanced SAR operating modes. In the squint mode the radar beam is steered away from the track by a given angle, known as the squint angle, whereas in the spotlight mode the beam is continuously trained on a given area of limited extent. The synthetic aperture length is then unlimited, allowing very high resolution to be obtained. Both these modes are applicable to SAS ([7,16]).

Multi-aspect SAS ([13]) is a more advanced mode which features a very broad transmission beam, well in excess of that required to achieve the specified resolution. It allows multiple squinted SAS beams to be formed simultaneously in the signal processor, without having to steer the transmission beam or maneuver the sonar platform. As the sonar flies by a given target, multiple high resolution looks are formed from different points of view, allowing the highlight and shadow structure to be tracked as a function of the squint angle (Fig.3). It is believed that this could further improve our ability to discriminate between objects. The SAS image in the bottom of Fig. 4 is an example of such a mode of operation. The image is formed when the sonar is broadside to the tripod. The targets to the right (resp. left) of the tripod are imaged with SAS beams which squint progressively forward (resp. backward), as can be seen from the different orientation of their shadows. However a drawback of the multi-aspect SAS design is cost since the sampling of the physical receiving array must be increased to support the broad transmission beam.

Another extension is Interferometric SAS (InSAS), which is the counterpart of InSAR, which provides co-registered imaging and bathymetry with high spatial resolution. It uses two vertically superposed linear receiver arrays, which are displaced in cross-range to form two SAS images, and the interferometric principle to estimate the depth of the target below the sonar ([17]).

Conclusion

SAS has the potential for providing image quality that is unmatched by current sonars and is a key technology whenever high resolution is required. It is presently believed that the technology can contribute towards the reduction of several capability shortfalls identified by the NATO navies, such as the current difficulties in detecting and classifying mines for reasons of size, shape, material or location (e.g. burial). However SAS imposes substantial demands on navigational accuracy, which have, up to recent years, prevented its implementation in the ocean. This situation has changed, due to the emergence of powerful algorithms and low cost inertial instrumentation. Demonstration programs are underway in several NATO navies, as well as at the NATO SACLANT Undersea Research Center, to assess the robustness of these techniques in harsh environmental conditions (e.g. shallow and very shallow water).

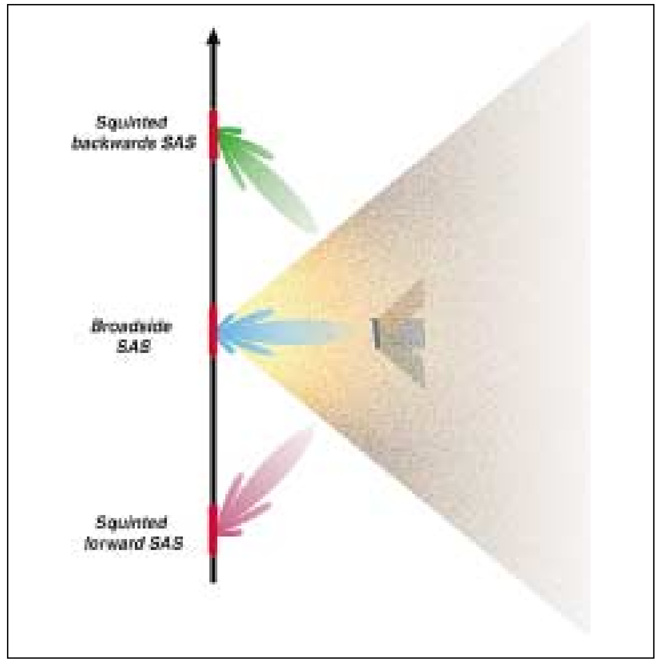

Fig.3 Multi-aspect SAS. Shown are the track of the sonar platform (vertical), a broad transmission beam and multiple SAS beams, which are towards a given target. The squint in the SAS beams leads to the different orientation of the target shadows, which enhances its recognition.

Furthermore, a product of SAS is a highly accurate ground velocity estimate which should be of great interest for autonomous navigation applications, to further limit the drift of aided inertial navigation systems. In addition, the high quality of InSAS imagery and bathymetry should facilitate the recognition of fea-

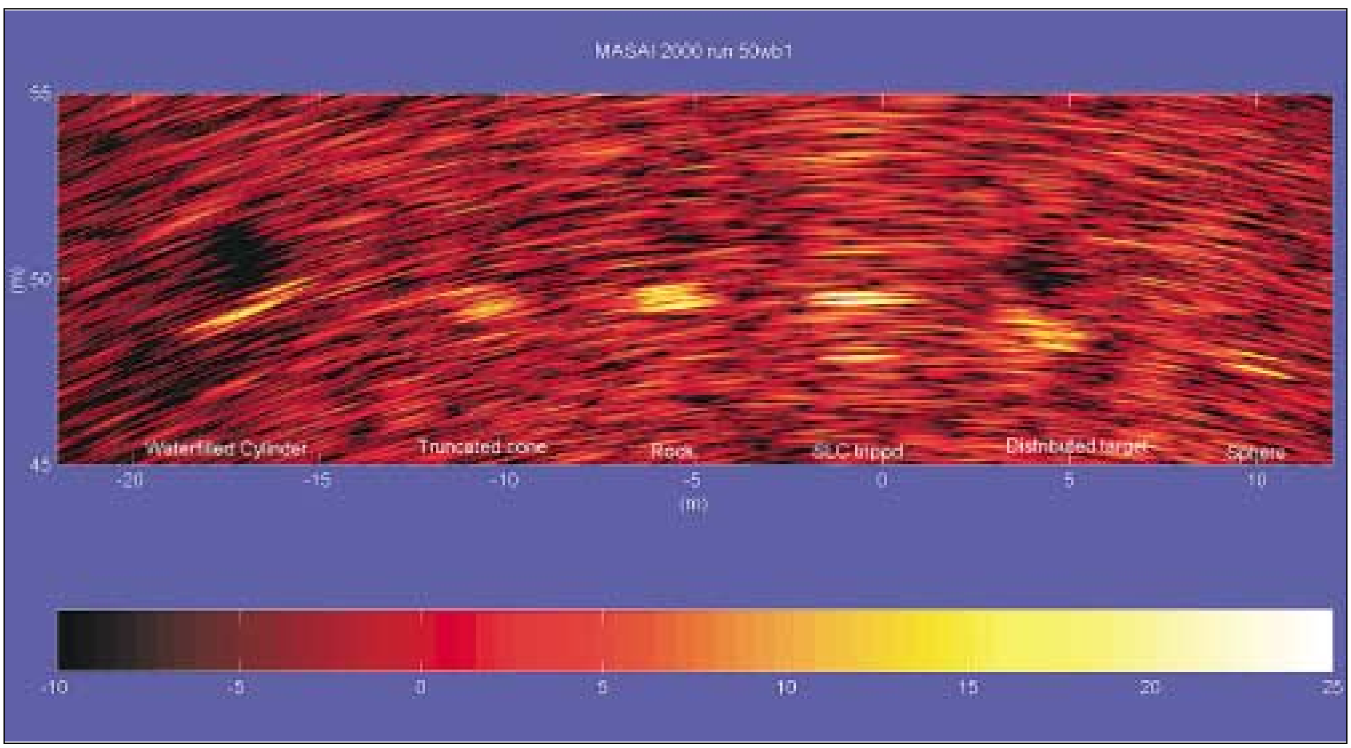

Fig. 4 Multi-aspect SAS. A target field is imaged by a 90-110 kHz sonar before (top) and after (bottom) SAS processing. The micronavigation was performed using DPCA. The receive array features 128 elements spaced at 7.5 mm for a total length of 96 cm. It was mounted on a passive towbody and towed from R/V Alliance in 30 m water depth at an average speed of 3 knots in sea state 1-2.

tures for the implementation of map matching techniques, to further improve navigational accuracy.

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Marc Pinto was born in Wellington, India in 1960. He graduated from the Ecole Nationale des Ponts et Chaussees, Paris (France) in 1983. In 1991, he received the Ph.D. degree in Solid State Physics from the University of Paris, Orsay. From 1985 to 1989 and 1989 to 1993 he worked as a research engineer for Thomson-CSF, specializing in the application of numerical techniques to magnetic recording. In 1993 he joined Thomson-Sintra ASM (now Thales Underwater Systems) as Head of the Signal Processing Group, specializing in research into advanced MCM and airborne ASW sonar. In 1997 he joined the NATO Saclant Undersea Research Center, La Spezia, Italy and was appointed Head of the Mine Countermeasures Group, in the Signal and Systems Division. He is presently leading a research project entitled "Advanced minehunting sonar concepts for UUVs".

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[*Editor's note*: This article is the latest in the series of Technology Overview Papers contributed with the cooperation of the IEEE Oceanic Engineering Society Technology Committee Chairs]

Soundings

Welcome to the latest installment of "*Soundings*", a column that reports on a broad spectrum of news items from the mainstream media as they relate to Ocean Engineering technologies. The purpose of this column is to inform the ocean engineering community of our industry's visibility in the media and how the general public perceives our efforts.

Web Cam at the Top of World

You've probably enjoyed using "webcams" to peek in on the latest happenings of Picadilly Circus in London or underwater life off the shore of the Caribbean island of Bonaire. Well, you can add a new webcam to your list and this one will give the definitive "view from the top."

Web Cam at the Top of World

Officially called the North Pole Environmental Observatory, the web cam component sits alongside scientific instruments which reside atop an ice floe, and will slowly drift with the current in coming months. The webcam uploads via satellite 4 new pictures each day, although it can be operated by remote control to zoom in on specific areas and increase its upload frame rate. The webcam can be accessed from the NOAA's Arctic Theme web site: http://www.arctic.noaa.gov/

Shipwrecks Making the News

The mainstream media frequently "connects" with our industry when the topic of shipwrecks makes the news. The recent months have seen a flurry of wreck-related news.

Bob Ballard seems to have scored another hit, apparently finding the wreck of the PT-109, the boat that former U.S. President John F. Kennedy captained during World War II. The PT (Patrol Torpedo) boat was sliced in two by a Japanese destroyer in August 1943 near the Solomon Islands.

Ballard is returning to Washington DC with photographs of two torpedo tubes that are believed to be from the PT-109. US Navy experts will examine the photographs to make an official determination of the vessel's identity.

Note to wreck divers: depth to the wreck is 1,320 feet! This summer the US Navy's NR-1 nuclear powered minisub will head to the Gulf of Mexico to do a little wreck mapping. Back in February of 2001, an ROV operated by ExxonMobil discovered a 65-foot long wreck sitting upright next to a recently laid oil pipeline.

Dr. Jack B. Irion, a marine archaeologist with US Government's Minerals Management Service — the federal agency responsible for historical artifacts discovered on the outer part of the continental shelf — led a follow-on investigation of the shipwreck which piqued everyone's interest. It turns out that the ship was made from American white pine and sheathed with nearly pure copper plates to fend off wood eating marine organisms; definitely a high-tech design for its day.

The 145-foot long NR-1, with its 5 man crew, along with 2 scientists will first create a high resolution sonar map of the wreck site followed by a photomosaic baseline map. The sub will then settle to the bottom and collect samples of the wreck and, hopefully, ceramic artifacts.

The recently raised US Civil War submersible H.L. Hunley continues to provide archaeologists with surprises. The latest find from the Hunley's hull: a gold pocketwatch used by the sub's commander Lt. George Dixon. Dixon almost certainly used this watch to determine when the incoming tide occurred so that he could bring his ship home to port.

The Hunley currently sits in a 90,000 gallon tank of pH-controlled water while the excavation of the hull's interior winds down. The next step in the investigation is the forensic examination of the remains of the eight crew members. It is still not know why all of the crew appeared to have perished at their stations.

United Nations Atlas of the Oceans

An impressive new Internet information resource has been launched by the United Nations Foundation. The UN Atlas of the Oceans is an Internet portal providing information relevant to the sustainable development of the oceans. It is designed for everyone from policy-makers to students and scientists.

The site features information about an extensive assortment of issues including over-fishing, pollution, and coral reef depletion. Consisting of 14 global maps, links to numerous related sites, and more than 2,000 documents on 900 topics, the site is an excellent starting point for any ocean researcher. You can find the Atlas of the Oceans on the web at http://www.oceansatlas.com

If you see an article (whether in print or in electronic form) that you would like to see mentioned in this column, please let me know by email, fax, phone, or regular mail. Email contributions can be sent to a special address: Soundings@ Sygnus.Com. Information for phone, fax, and regular correspondence can be found in the back of newsletter where I am listed in the AdCom section.

by John Irza

Who's Who in the OES

C. David Chadwell received his BS Engineering Degree in 1985, MS Geodesy in 1989 and PhD in Satellite Geodesy in 1995 from The Ohio State University. During the 1980's first as an undergraduate and then as a graduate researcher, he was a member of a team at the Byrd Polar Research Center (OSU) that recovered ice cores from high-altitude low-latitude glaciers in Peru and China for paleo-climate studies. Dave developed techniques to measure the surface motion of the glaciers — a key component in reconstructing the climate history from the flow-deformed ice. During his final years at OSU and for his thesis he refined estimation techniques to improve GPS orbits calculated by GEODYN for the Space Geodesy Branch of the NASA Goddard Space Flight Center. Upon completing his PhD he joined the Marine Physical Laboratory in 1995 to work with Fred Spiess and John Hildebrand on the further development of GPS and acoustic techniques to measured precise (centimeter-level) position markers located on the seafloor.

C. David Chadwell

This technology can be applied to measure the motion of the submerged portion of tectonic plates. His current NSF sponsored geophysical research projects include measurement of seafloor deformation offshore Lima Peru to better understand subduction zone dynamics, present-day motion of the Juan de Fuca plate offshore Oregon and Washington state and slumping of the offshore portion of the Kilauea volcano, Hawaii.

In addition to the geophysical applications, Dave has been working on several technology development efforts. Recently, in an ONR and NOAA sponsored project he demonstrated that observing delays in GPS phase data to estimate water vapor could be extended from static land-based receivers to dynamic ocean surface floating platforms (ships and buoys). Dave and Yehuda Bock at SIO have demonstrated an epoch-independent processing of dual frequency GPS phase and pseudorange data that provides sub-decimeter positioning of a surfaced AUV. Applied acoustic related research includes development of an observatory-style instrument to make acoustic range measurements with centimeter resolution between senors deployed on the seafloor approximately 1-km apart, across geologic faults (e.g. mid-ocean ridges) and decimeter-level positioning of a submerged AUV based upon precise acoustic ranging to a network of seafloor transponders.

He has published in Geophysical Research Letters, Physics of the Earth and Planetary Interiors, Marine Geodesy and IEEE Journal of Oceanic Engineering. He has presented talks on seafloor geodetic technology at national and international meetings.

He is a member of the American Geophysical Union, International Association of Geodesy, Marine Technology Society, Acoustical Society of America and a registered Professional Surveyor. He spends an average of 60 days per year at sea.

OTC 2002 Concludes with 49,620

HOUSTON, Texas, U.S.A. (9 May 2002) - The 34th Offshore Technology Conference concluded Thursday at Reliant Center with its second-best attendance in 17 years and another successful showcase of emerging technology in the oil and gas industry.

The four-day conference drew 49,620 participants, an increase of 1,971 from 2001 and the second-best overall total since the 1985 event drew 56,483. The 1998 OTC saw 49,641 attend. This year, more than 2,000 exhibiting companies, divisions, and subsidiaries were part of the exhibition in the new Reliant Center, which held more than 375,000 net square feet of exhibition space.

Twenty-six countries were represented among the exhibition and conference attendees, again displaying the international flavor of the conference. In addition, 279 technical presentations were part of the technical program. Other events included eight Topical Luncheons, three Industry Breakfasts, and the annual OTC Awards Luncheon.

Founded in 1969, the Offshore Technology Conference is the world's foremost event for the development of offshore resources in the fields of drilling, exploration, production, and environmental protection. OTC is held annually in May at Reliant Center at Reliant Park in Houston. For more information, visit the OTC 2002 Web site at "http://www.OTCnet.org".

News Items

Environmental Groups Use ROV to Gather Evidence

East Taunton, Massachusetts — Christopher Combs of JW Fishers Mfg. Inc. reports that a coalition of environmental groups from New York and New Jersey are using Fishers' SeaOtter ROV to gather evidence on the state of the marine environment in the area's coastal waters. A spokesman from the group, Frank Crescitelli, said, "One of our main concerns is the use of contaminated material to fill holes in the bottom of New York Harbor that were created by previous dredging operations. Our other concern is the dredging operations that remove contaminated material from the bottom. These types of operations put contaminants back into the water which can then spread throughout the entire marine ecosystem."

Crescitelli operates the charter fishing boat, Neptune's Champion, and is also the vice president of the Staten Island chapter of the Coastal Conservation Association (CCA). CCA and the Natural Resources Preservation Association (NRPA), two lay environmental groups whose members include fishermen and boat captains, are hoping to convince the U.S. Army Corps of Engineers that life abounds in the "borrow pits" — pits that are underwater craters created when material was dredged from the harbor bottom for landfill projects in years past. Now the Corps, by order from the state, is investigating the environmental and technical feasibility of filling in the pits with dredged material from other areas. The environmental groups contend the dredging and filling operations will put contaminants back into a healthy marine environment that is recovering nicely after years of pollution.

The position of the branch chief of environmental analysis at the Corps of Engineers is that the pits are almost completely devoid of oxygen and contain only minimal forms of life.

To prove their case, the environmental groups needed to purchase equipment that would allow them to videotape life in the borrow pits. "We looked at several underwater cameras before deciding on Fishers' SeaOtter", said Crescitelli. "We needed a system that could maneuver around in the pits. Simple drop cameras wouldn't work here. This led us to an ROV, but we needed one powerful enough to handle the harbor currents, something the smaller ROVs couldn't do." Equipped with a high-tech underwater camera, the groups have been able to show the pits are complete marine ecosystems teeming with life. "We were amazed at the amount of life down there. The video showed the ocean bottom in these pits is blanketed with mussels, clams, and a variety of other marine creatures." To read more in Fishers' newsletter Search Team News, contact Combs at +1 (800) 822-4744 or e-mail jwfishers@aol.com. Website is http://www.jwfishers.com/.

NOAA Great Lakes Lab to Operate University Research Vessel

Ann Arbor, Michigan — The U.S. National Oceanic & Atmospheric Administration's Great Lakes Environmental Research Laboratory here is expanding its research capabilities with the addition of a new ship, R/V Laurentian. According to a NOAA spokeswoman, the ship is being transferred to the laboratory's control through a partnership between NOAA and the University of Michigan. A ceremony commemorating the transfer is slated for July 2 in Muskegon, Michigan.

NOAA's Great Lakes Environmental Research Laboratory will base and operate the Laurentian out of GLERL's Lake Michigan Field Station in Muskegon, where it will serve as the primary vessel supporting the lab's research missions, said Steve Brandt, GLERL director. The ship that was serving those functions, the Shenehon, has already been moved to Alpena, Michigan, on Lake Huron to support field season activities at the Thunder Bay National Marine Sanctuary and Underwater Preserve.

The 80-foot, 129-ton Laurentian was built in 1974 in Pascagoula, Mississippi, and has supported university research and educational needs throughout the Great Lakes region. With a crew of four and accommodation for up to 10 scientists, the ship has a cruising range of 2,500 nautical miles at a speed of 10 knots. Under the agreement, GLERL will lease the Laurentian for the next 15 years while taking on the responsibility of the vessel's operation, maintenance, and scheduling of ship time. Brandt said that University of Michigan scientists would still have opportunities to use the vessel, with additional time being set aside for university educational activities. For more, see http://www.glerl.noaa.gov/.

U.S. Senators Threaten Action over Corps of Engineers Reforms

Washington, D.C. — A pair of senators have threatened to stall funding for several U.S. Army Corps of Engineers projects unless the U.S. Congress reforms the federal agency responsible for multibillion-dollar dams and public works, according to news reports from Reuters. Republican Robert Smith of New Hampshire and Democrat Russell Feingold of Wisconsin claimed that the Corps' credibility must be restored after years of criticism for mismanagement and make-work projects.

At risk is passage of the Water Resources Development Act - legislation that authorizes every two years which projects the Corps can begin - unless Congress agrees to overhaul the agency. Smith threatened that lawmakers were not going to be able to pass on the projects "unless we get reform."

Several unsuccessful attempts have been made to reform the agency in Congress during the last few years. A bill introduced in March by Sen. John McCain of Arizona, Smith, and Feingold would subject the Corps to an independent peer review and improve the financial benefits of a project before it can be allowed to proceed. The beleaguered Corps has a backlog of about $52 billion in unfinished projects.

Lt. Gen. Robert Flowers, chief engineer, separately told a Senate hearing he agreed changes were needed to reduce the agency's huge backlog of projects, according to reports in The Washington Post. "We have about $5 billion worth of inactive projects that technically remain on our books but whose designs won't solve the original problems or for which there is no longer support," Flowers told the Senators. Keep track of the controversies via http://www.usace.army.mil/.

Seventh Human-Powered Submarine Races Scheduled

Allentown, New Jersey — International Submarine Racesä officials have announced that its seventh engineering design competition will again be held at the U.S. Naval Surface Warfare Center's Carderock facility in Bethesda, Maryland, June 23-27, 2003. One and two-person teams from universities, colleges, technical education centers, and high schools are invited.

Considered the "grandfather" of similar events, this will be the fourth time that the ISR will be staged at the 3,200-foot-long David Taylor Model Basin test tank at NSWC. The submarine races are a challenge that began in 1989 and have grown to an event that has seen the participation of teams from the United States, Canada, Mexico, and Europe. Typical teams consist of student athlete/engineers, wearing scuba gear, who provide propulsion and navigation as their subs run against the clock along a fixed underwater course. The competition focuses upon the educational aspects of submarine team efforts such as use of materials, efficiency of hydrodynamics, propulsion and underwater air supply, and life support systems.

According to a spokeswoman, the first human-powered International Submarine Race was held in 1989 off Riveria Beach, Florida, and drew 17 boats. The race grew to 35 boats in 1991 and 44 contestants for the 1993 race off Fort Lauderdale, Florida. The 1995 event (the first ISR indoors) at the Naval Surface Warfare Center (David Taylor Model Basin) drew 11 entrants. The 1997 event at David Taylor drew 16 boats. The contestant manual will be available on the ISR website at http://www.isrsubrace.org/ in a few weeks.

During the sixth ISR at Carderock, Omer 4, a sleek, dolphin-like one-person submarine built and raced by students from the University of Quebec, Ecole de Technologie Superieure, Montreal, established a world speed record of 7.192 knots — over 8.2 miles per hour — on the final day of racing, beating its previous record set the day before and besting the existing world record of 6.997 knots Omer 3 established in 1997. For more information now, contact the ISR Organization at P. O. Box 563, Allentown, NJ 08501; +1 (609) 259-3540.

The IEEE History Center On YAHOO!

Congratulations to the IEEE History Center, www.ieee.org/history_center/. Yahoo! search engine has placed it at #3 on its Most Popular Science History Site List (as of June 2002). According to Yahoo!, the listings in the Most Popular

Sites feature are determined by using a "complex ranking algorithm based on relevance." The algorithm also determines the placement of a site on this list. The IEEE History Center is in good company with the Smithsonian and the National Oceanic and Atmospheric Administration History. Check out the newest addition to the IEEE History Center, Legacies, www.ieee.org/history_center/legacies/legaciestoc.html. Biographies of 150 leading engineers who have been honored with the IEEE Medal of Honor or IEEE Edison Medal are now posted.

Accreditation Evaluators Needed

Contribute to the engineering professional and public good. The IEEE Educational Activities Board seeks engineering professionals from industry, government, and academe to serve as program evaluators for accrediting engineering and engineering technology programs at U.S. universities. Nominations for the five-year term starting 2003 will be accepted through 31 October 2002.

Information packages, including the application and nomination forms, will be available on the web as of 15 June 2002, at www.ieee.org/organizations/eab/apc/ceaa/engapplication.htm (engineering programs) and www.ieee.org/organizations/eab/apc/ctaa/techapplication.htm (engineering technology programs). Get a flavor of what it's like to be an evaluator by reading comments from a first-time evaluator at www.ieee.org/organizations/eab/apc/news5.htm. For more program information, contact eab-accred@ieee.org.

Contribute To DLNET

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Upcoming Conferences and Meetings

AUV 2002
Automonous Underwater Vehicles
A Workshop on AUV Energy Systems
June 20 & 21, 2002
Southwest Research Institute
San Antonio, Texas
http://www.AUV2002.swri.org

Third Ocean Technology Workshop
September 23-25, 2002
Plymouth, MA
www.motn.org

Oceans 2002 Conference & Exhibition
October 29-31, 2002
Mississippi Coast Coliseum & Convention Center
Biloxi, Mississippi
http://www.OCEANS2002.com

TECHNO-OCEAN 2002, 9th Techno-Ocean International Symposium and International Exhibition/Research Organizations Exhibition
November 20-22, 2002
Kobe International Exhibition Hall
Kobe Port Island, Japan
http://www.techno-ocean.com

ECUA 6th European Conference on U/W Acoustics & Exhibition
June 24-27, 2002
Gdansk, Poland
www.ecua2002.gda.pl/

Coastal Environment 4th International Conference
September 16-18, 2002
Rhodes, Greece
www.wessex.ac.uk

DP 2002, Sixth Dynamic Positioning Conference
September 17-18, 2002
MTS Houston, Texas
www.dynamic-positioning.com

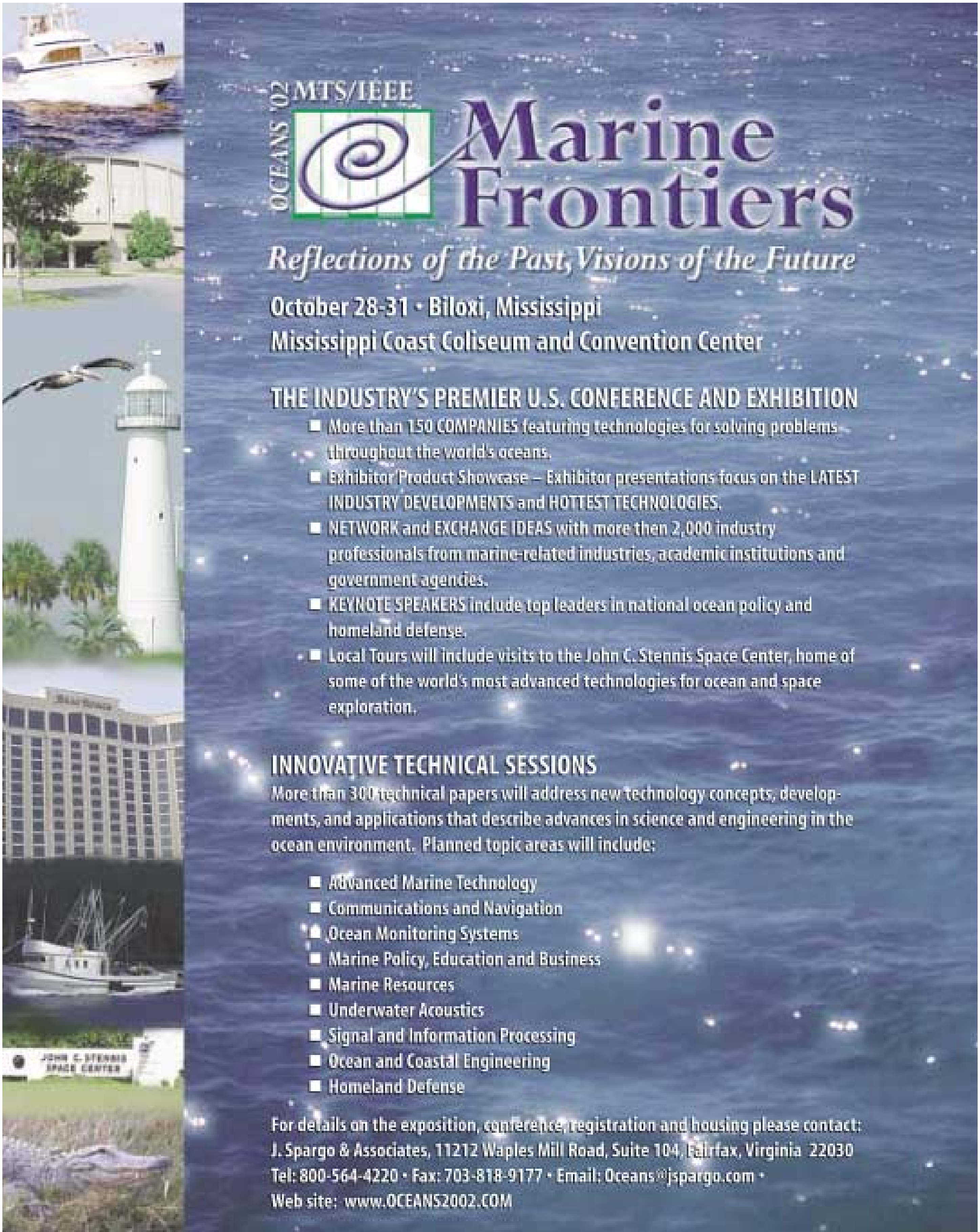
Unmanned Underwater Vehicle Showcase
Sept 25-26, 2002
Southampton, UK, Spearhead
www.uuvs.net

Undersea Defense Technology Conference & Exhibition
October 8-10, 2002
Korea, Nexus Communication
www.udtnef.com/korea

14th Deep Ocean Technology Conference & Exhibition
November 13-15, 2002
New Orleans, Penwell
www.deepoffshoretechnology.com

Ocean Optics XVI Conference and Exhitition
November 18-22, 2002
Santa Fe, New Mexico
Office of Naval Research, NASA, The Oceanographic Society
oceanopticxvi@aibs.org

Oceans 2003
September 22-26, 2003
San Diego, CA
http://www.oceans2003.org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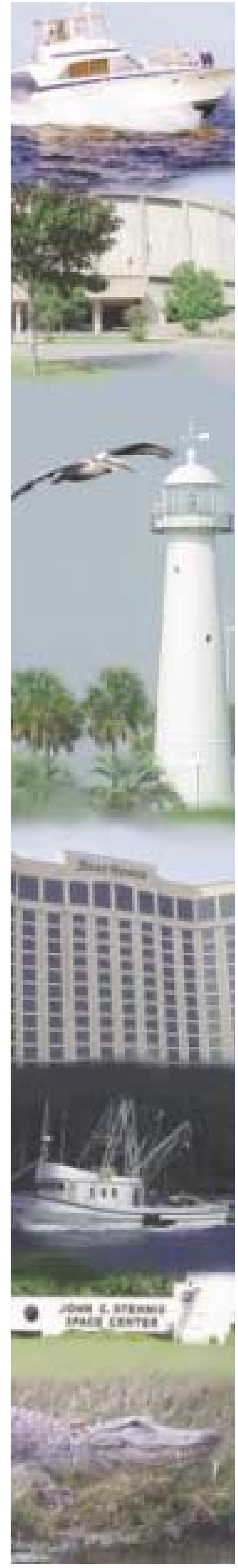

OCEANS 2002 will be held in Biloxi, Mississippi, October 29-31, 2002. The conference is expected to attract more than 2000 attendees from across the United States, Canada, Japan and other counties around the world.

Conference co-participants are the American Geophysical Union; the American Meteorology Society; the Society of Naval Architects and Marine Engineers; the Hydrographic Society of America; the Society of Exploration Geophysicists; the Oceanography Society; the Minerals, Metals, and Materials Society and the American Fisheries Society.

Technical Sessions and Tutorials

OCEANS 2002, the most significant conference for ocean science and technology, will provide forums to discuss applications and developments. Over 500 presentations will encompass ocean observation and data collection, modeling, data management, engineering, fisheries, and the role of the ocean in homeland defense. The regional presence of large federal agencies for ocean measurement will result in a wide range of presentations on high technology applications and developments of the Navy, NOAA, NASA, and numerous supporting industries.

On October 28 ten technology tutorials will be conducted at the Marine Education Center of the University of Southern Mississippi.

Exhibits

Approximately 175 exhibitors from commercial, government and academic marine product and service providers will display their latest developments and capabilities. There will also be an exhibitor's showcase to allow demonstration of new products. Additionally, there will be an opportunity for attendees to tour industry, Navy and NOAA ocean survey ships and receive updates on ship instrumentation and capabilities.

Preliminary Program

The opening ceremonies of the conference will be held on Tuesday, October 29. Introductory plenary speakers will address the future of U. S. ocean policy. Afterwards, there will be a grand opening of the Exhibit Hall, followed by the beginning technical sessions. Wednesday will begin with a plenary session on Homeland Defense, with talks by leaders of ocean agencies. Technical sessions will continue Wednesday and Thursday.

Other Activities

On Friday November 1 tours will be available to view the advanced technologies at the John C. Stennis Space Center, home of the US Naval Meteorology and Oceanography Command, US Naval Oceanographic Office, National Data Buoy Center, Naval Research Laboratory, Department of Defense High Performance Computing Center, US Geological Survey Hydrology Laboratory, NASA Earth Research Center and NASA Propulsion Testing Center.

Additional Information

Technical activities will be held at the Mississippi Coast Coliseum and convention Center along the beachfront of Biloxi, Mississippi. Blocks of rooms are reserved at the Beau Rivage Resort and Casino. Room reservations are handled by J. Spargo and Associates, (800) 564-4220 or (703) 631-6200.

Registration Information

Registration is mandatory for participation in conference activities. Prospective exhibitors should contact J. Spargo and Associates. More information is available on the conference web site: www.oceans2002.com.

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