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OCEANS '91

OCTOBER 1-3, 1992

HONOLULU,HAWAII

(Continued on inside back cover)

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President's Message

Glen N. Williams

Oceans '91 — It's just around the corner (figuratively speaking, of course.)! You have already received your Technical Program for the Conference by now. I am continually impressed by the lineup of technical presentations put together by Joe Vadus and Paul Yuen as the Co-Chairs of the Technical Program. Major appreciation is also due Stan Chamberlain and the OES Technical Committee Chairs for their programming and authorship efforts. With around 400 papers and a five volume set of Proceedings, this promises to be quite a technically productive meeting. As the Flagship Conference for the Oceanic Engineering Society, we certainly expect a significant attendance. The Hilton Hawaiian Village has set aside a block of rooms for conference attendees; however, I might suggest that you register a bit early to make sure that you're assured your desired accommodations.

On a more personal note, you might think of staying a couple of extra days for a short "getaway." If so, be sure to contact the Hawaii Visitors Bureau at 808-923-1811 for information on sites on Oahu or the other islands. If I can be of service to you, don't hesitate to call me.

Again - The word is Aloha Wear - Nothing formal.

I just returned from the IEEE Technical Activities Board (TAB) meeting in San Francisco. I attended an IEEE Membership Seminar at which membership problems at the Institute, Section, Chapter and Society levels were discussed. The Bottom line is that the OES is not unique in our campaign to extend society membership to the right body of engineers, scientists and other ocean practitioners. Sitting in those meetings however, I came to the personal conclusion that membership in a professional society, whether it is the IEEE, ASCE, ASME, or whatever, is not only a right — it is also a responsibility. This responsibility extends from the people who have entrusted their safety and/or livelihoods to us, to our colleagues and the organizations in our scientific discipline. Through our appropriate professional affiliations, activities and networking, we have the opportunity to enhance and improve both the technical and personally interactive aspects of the Society. In my opinion, this is what a professional society is all about, and I'm going to do my utmost to get this message across to my students.

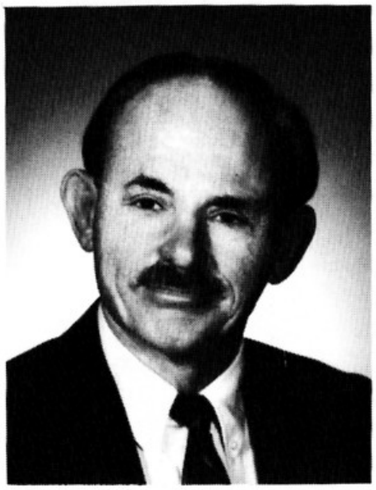
On another topic, you will soon receive a mailout from IEEE concerning a proposed re-merger of the IEEE/OES and the Marine Technology Society, for the purpose of cosponsoring the Oceans 'xx Conference. The OES Administrative Committee will be deciding this issue at its next meeting. In order for the AdCom to be responsive to the Society membership, please return the enclosed postcard with your opinion.

One last topic. The IEEE TAB has taken an action which will be of interest to quite a few of you — the institution of a new journal. "Transactions on Image Processing." This new Transactions will be run by the Signal Processing Society under the auspices of a governing body of representatives from other interested Societies, of which the OES is a member. I am temporarily serving as the OES representative. However, I would invite participation by other OES members involved in image processing. If you are so inclined, drop me a line.

See You in Honolulu.

Glen N. Williams
President, Oceanic Engineering Society

Editor's Comments



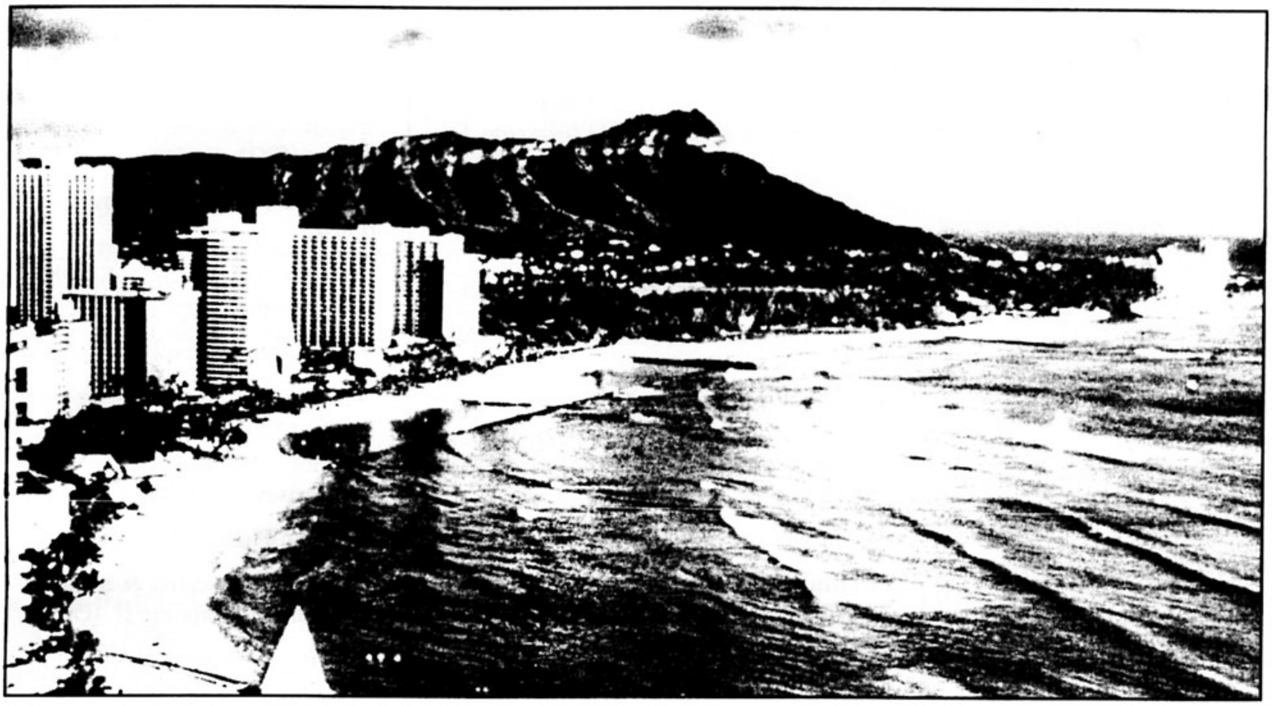
Fellow members — It's been a year since I assumed editorship of the IEEE, OES Newsletter. We are on track with four issues yearly; spring, summer, fall, and winter. This past year has been a good experience in getting up to speed, and I am as excited now (more so) as when I first took over as editor. Hope to improve the newsletter with more offerings in subsequent issues. This is where you come in. If you have any news you think would be of interest to the membership, or information that you would like to pass along, please send these items to my home address: 2154 Sand Hill Road, Menlo Park, California 94025. I also welcome inputs from the membership on your opinion as to what you think would be of interest to readers of the OES Newsletter. Should we add new features, IEEE coverage, technical/administrative reports/activities, etc. Anyone wishing to submit an article for publication in an area of interest of concern to the OES, is welcomed to do so. I am thankful to those who have participated in past publications and encourage your continued support in the future. Your inputs are always welcome.

This year's Oceans '91 conference in Hawaii promises to be quite exciting and informative, thanks to the efforts of everyone involved. Looking forward to seeing you there. Aloha!

Frederick H. Maltz
OES Newsletter Editor

OCEANS HAWAII

Events: Sept. 25 - Oct. 4, 1991



• OCEANS '91

Oct. 1-3,

Hilton Hawaiian Village

- NSF Workshop on Engineering Research Needs for Offshore Mariculture Systems
  Sept. 26-29, East-West Center

- NSF Workshop on Marine Minerals: Stockpile 2000
  Sept. 26-28, Turtle Bay Hilton

- Undersea Mining Institute '91
  Sept. 29-Oct. 2, Turtle Bay Hilton

- Wild Ocean Reserve Workshop
  Oct. 4, Hilton Hawaiian Village

- PACON International - Planning Meeting
  Oct. 4, University of Hawaii

- Ocean Mapping Workshop
  Oct. 4, University of Hawaii

- U.S.-Japan Cooperative Program in Natural Resources (UJNR) Marine Facilities Panel Planning Meeting
  Oct. 4, Hilton Hawaiian Village

- IOTC - International Ocean Technology Congress Planning Meeting
  Oct. 4, Hilton Hawaiian Village

- ASCE - American Society of Civil Engineers Ocean Energy Committee Meeting
  Sept. 30 & Oct. 4, Hilton Hawaiian Village

OCEANS '91 CONFERENCE

Tuesday, October 1	Wednesday,
1700 - 2000 Registration	**0730-1630** Registration
0830 - 1000 Plenary Session	**0830 - 1000** Exploitation & Conservation of Ocean Space (SP3) Ocean Wave Energy Conversion II (OR4) Acoustic Backscatter & Swath Bathymetric Mapping I (OC4) Underwater Acoustics IV (AT4)
1030 - 1200 Int'l Overview of Ocean Science & Technology R&D Programs & Opportunities in the Pacific (SP1) Ocean Energy Conversion I (OR1) Marine Geophysical Measurements (OC1) Underwater Acoustics I (AT1) Marine Communication & Navigation I (AT11) Fiber Optic Ocean Systems I (AT19) Marine Biotechnology, Bio-Sensors (AT29) Applications of Technology for Search & Rescue (AT34)	**1030 - 1200** Development Opportunities & Ocean Enterprises (SP4) Offshore Floating Facilities (OS1) Acoustic Backscatter & Swath Bathymetric Mapping II (OC5) Underwater Acoustics V (AT5)
1200 - 1330 Lunch Break	**1200 - 1330** Exhibits Lunch
1330 - 1500 Pacific Ocean Resource Development (SP2) Ocean Energy Conversion II (OR2) Ocean Ranching (OR5) Underwater Acoustics II (AT2) Marine Communication & Navigation II (AT12) Fiber Optic Ocean Systems II (AT20) Ocean Mapping I (OC2) Environmental Monitoring Methods I (EM5)	**1330 - 1500** International Programs in Undersea Technology (SP5) Ocean Space Utilization Projects I (OS2) Acoustic Backscatter & Swath Bathymetric Mapping III (OC6) Oceanographic Instrumentation I (AT6)
1530 - 1700 National Needs in Marine Electronic Instrumentation (AT13) Ocean Wave Energy Conversion I (OR3) Artificial Upwelling (OR6) Underwater Acoustics III (AT23) Modeling, Simulation & Data Bases I (AT14) Marine Transportation Needs for the 90's (OS6) Ocean Mapping II (OC3) Environmental Monitoring Methods II (EM6)	**1530 - 1700** Artificial Intelligence/Knowledge-Based Systems (AT40) Ocean Space Utilization Projects II (OS3) Acoustic Backscatter & Swath Bathymetric Mapping IV (OC7) Oceanographic Instrumentation II (AT7)
1900 - 2200 Luau	**2100 - 2300** NAVATEK I Cruise

PROGRAM AT A GLANCE

<table>
<tr><th>October 2</th><th colspan="2">Thursday, October 3</th></tr>
<tr><td></td><td colspan="2">0730-1200 Registration</td></tr>
<tr><td>Modeling, Simulation & Data Bases II (AT15)
Polar Instrumentation (AT21)
Large Scale Pacific Ocean Observations for TOGA I (EM1)
Environmental Monitoring Methods III (EM7)</td><td>0830 - 1000
Unmanned Underwater Vehicles I (AT37)
Large Floating Platforms/Facilities (OS4)
Energy Pacific 2000 I (OR10)
Advanced Signal Processing (AT8)</td><td>Ocean Minerals Technology I (OR7)
Matched Field Tomography I (AT25)
Recent Developments in Diving Physiology & Technology (AT31)
Automatic Object Recognition (AT33)</td></tr>
<tr><td>Acoustic Current Measurement Technology I (AT16)
Radar and Passive Sensing of Ocean Dynamics (AT22)
Large Scale Pacific Ocean Observations for TOGA II (EM2)
Environmental Monitoring Methods IV (EM8)</td><td>1030 - 1200
Unmanned Undewater Vehicles II (AT38)
Coastal Development (OS5)
Energy Pacific 2000 II (OR11)
Advances in Sonar Technology I (AT9)</td><td>Ocean Minerals Technology II (OR8)
Matched Field Tomography II (AT26)
Marine Instrumentation Opportunities (OP1)
Oil Spill Technology (EM10)</td></tr>
<tr><td></td><td colspan="2">1200 - 1400 Awards Luncheon</td></tr>
<tr><td>Acoustic Current Measurement Technology II (AT17)
Remote Sensing of Surface Winds & Waves I (AT23)
Acoustics & Digital Signal Processing I (AT35)
Environmental Monitoring Methods V (EM9)</td><td>1400 - 1530
Underwater Robotics (AT39)
Ocean Space Utilization Opportunities (OP2)
Energy Pacific 2000 III (OR12)
Advances in Sonar Technology II (AT10)</td><td>Ocean Minerals Technology III (OR9)
Human-Powered Submersibles I (AT27)
Magnetohydrodynamics (AT32)
Global Warming - Mitigation & Adaptation Strategies I (EM11)</td></tr>
<tr><td>Current Measurement Technology (AT18)
Remote Sensing of Surface Winds & Waves II (AT24)
Acoustics & Digital Signal Processing II (AT36)
World Ocean Circulation Experiment (EM3)</td><td>1600 - 1750
Low-Power Technology (AT30)
Ocean Energy Opportunities (OP3)
Ocean Minerals Opportunities (OP4)
Neural Networks in Ocean Engineering (AT41)</td><td>Marine Weather Prediction (EM4)
Human-Powered Submersibles II (AT28)
AUV's, ROV's, UUV's, & Robotics Opportunities (OP5)
Global Warming - Mitigation & Adaptation Strategies II (EM12)</td></tr>
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EXHIBITORS - JOIN US AT OCEANS '91

OCEANS '91 EXHIBITORS

Exhibitors are Invited

(Use Enclosed Forms)

Networking Opportunities

- **OCEANS '91** will review the latest in Ocean Technology and Systems.
- **OCEANS '91** provides a forum to discuss opportunities, explore cooperative projects, and encourage partnerships.
- **OCEANS '91** provides an opportunity to present their latest equipment and Systems aimed at developing the vast Pacific marketplace.
- **OCEANS '91** provides opportunities for: Networking for equitable technology exchange with the experts; and seeing the latest technology.
- **OCEANS Hawaii** - Two weeks of workshops and meetings with OCEANS '91 as the centerpiece. All of these associated activities will reinforce participation in OCEANS '91.

Poster Session

Chairman: Norman D. Miller, West Sound Associates Inc., Seattle, WA

To encourage and foster student participation in the OCEANS '91 Conference, the IEEE-OES is sponsoring a Student Technical Poster session. Graduate and undergraduate engineering and science students from universities throughout the USA were invited to submit poster abstracts for a Poster Session competition. The students selected from this poster competition will present their posters and be on hand to explain the work and answer questions about their research projects. Conference attendees are invited to view the posters and help to select the outstanding poster for the session.

OCEANS '91 EXHIBITORS INFORMATION

OCEANS '91 will feature exhibits of marine products and services available from a wide variety of firms, institutions, and agencies. All participants will be encouraged to visit the exhibits to discover new products and services.

Exhibit Hours:	Tuesday, October 1	8:30 a.m.-5 p.m
	Wednesday, October 2	8:30 a.m.-5 p.m.
	Thursday, October 3	9:00 a.m.-1:30p.m.

If your firm or institution would like to exhibit at OCEANS '91, please fill out the exhibitor contract below:

Exhibitor ______________________________

Contact Name ______________________________ Title ______________________

Address ______________________________

Phone ______________________ FAX ______________________

Name desired on booth plaque ______________________________

Space Requirements ________ sq. ft. ____________ 10x10 __________ Other __________

Space rental fee for a 10'x10' booth: $1500 (50% deposit ude at time of application. Balance due September 1)

Additional cost per square foot: $15 $_____ x # feet needed _______ = $ ____________

Cancellation Penalties: 25% of Total Booth Cost after June 1, 1991
50% of Total Booth Cost after July 1, 1991
75% of Total Booth Cost after August 1, 1991

Booth location choice: On a "First Come" basis

Do not assign our booth alongside: ______________________________

Products, systems, or services to be featured: ______________________________

We agree to abide by the cooperative rules of the show as set by the IEEE OCEANS '91 Committee. Acceptance of this application by OCEANS '91 converts this into a contract for exhibit space.

By ______________________________ Date ______________________
(Signature)

Title ______________________________ Phone ______________________

OCEANS '91 Coordinator Signature ______________________ Date __________

Mail contract and checks to: IEEE OCEANS '91
P.O. Box 37607
Honolulu, HI 96837

If you would like to make an inquiry or to FAX your contract, please contact:

Lianne Loo Chan
Phone: (808) 546-3491 Fax: (808) 546-3122

(Reprinted from Oceans '91 Proceedings)

Ocean Acoustic Tomography Programs: Accomplishments and Plans

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and

Peter F. Worcester

Scripps Institution of Oceanography, A-013,
University of California at San Diego, La Jolla, California 92093

Summary

The concept of time-of-flight ocean acoustic tomography was formulated just over a decade ago. Since then there has been an evolving (and expanding) research program, involving at least a half a dozen institutions and many more scientists and engineers, to test and evaluate the utility of the idea and to develop practical implementations. Advances in technology have resulted in low-frequency, wideband transmitting and receiving devices with the required millisecond timing accuracy, the development of new navigation techniques for precise positioning at sea, and schemes for wide time-bandwidth signal processing used with fixed and moving tomographic sensors to achieve large signal gains under peak power constraints. Comparison of measured and computed broadband arrival patterns has shown resolvable, stable, and identifiable multipaths up to ranges in excess of 1000 km for frequencies of a few hundred hertz. Both geometric and non-geometric arrivals are typically observed. Travel time fluctuations are consistent with those expected from internal waves, the ocean mesoscale, and other known oceanographic phenomena such as the formation and erosion of the summer thermocline. As the acoustic measurements, environmental measurements, and predictions have improved, agreement between the measured and predicted arrival patterns has also steadily improved. Work in inverse theory, including the incorporation of appropriate ocean basis functions, has resulted in techniques for extracting maximum resolution sound speed maps from tomographic data, including information on ocean scales that are short compared with a ray cycle. Tomography experiments in the Atlantic and Pacific oceans and the Greenland Sea have demonstrated the ability of acoustic tomography to map mesoscale sound speed variability and measure spatially averaged ocean currents. Longer range tomographic transmissions have hinted at the possibility of measuring ocean basin scale variability. In this paper we review these programs, highlight their achievements, and outline future plans.

Introduction

Since the concept of acoustic tomography for mapping ocean mesoscale variability was first articulated by Walter Munk and Carl Wunsch in 1978,[1] there has been a continually growing research program aimed at understanding the capabilities and limits of tomographic techniques in the ocean. Along with this, there has been an evolving technology program directed at developing instruments for tomographic measurements. These programs have been conducted at a variety of institutions, starting with the Massachusetts Institute of Technology, the Scripps Institution of Oceanography, the University of Michigan, and the Woods Hole Oceanographic Institution. Today, these have been joined by others, including the University of Miami, the University of California at Santa Cruz, the University of Washington, the Naval Research Laboratory, the Naval Postgraduate School, NOAA laboratories, IFREMER in France, the Japan Marine Science and Technology Center, and several businesses. This paper presents a brief review of the accomplishments of these tomography programs in the past decade and outlines plans for the future. Table I provides a summary of major tomographic experiments. The principal accomplishments have been to demonstrate that acoustic tomography can be used to map ocean mesoscale variability and that acoustic transmissions can be used for integrating measurements.

Ocean tomography as conceived by Munk and Wunsch and as currently practiced, consists of measuring the trave[l] time of acoustic signals transmitted between multiple points. The travel time is proportional to the average along-trac[k] sound speed and can be inverted to reveal the intervenin[g] sound speed structure. Reciprocal transmissions allow meas[-]urement of currents; the difference in travel times betwee[n] signals propagating in opposite directions is proportional [to] the average along-track component of water velocity. Th[e] distribution of transmitters and receivers, or transceivers, [in] the x-y plane determines horizontal resolution. Discriminati[on] in the vertical arises naturally as a consequence of the ocean

Table I. Major ocean tomography experiments.

Year	Experiment	Institutions[a]	Accomplishments
1978	900-km Propagation Test	WHOI/SIO/UM	Demonstrated multipath resolution, stability, and identification
1981	1981 Tomography Demonstration	WHOI/SIO/ UM/MIT	Demonstrated mesoscale sound speed mapping Demonstrated Gulf Stream tracking
1983	RTE83 - Atlantic	WHOI/SIO/UM	Demonstrated current measurement by reciprocal transmissions Demonstrated single-slice tomography
1983	Florida Straits	UMiami	Demonstrated measurement of areal average relative vorticity
1984	Pacific Basin, Hawaii to mainland	WHOI/UM	Identified ray paths at 4000 km
1987	RTE87 - Pacific	SIO/WHOI/UM	Measured barotropic currents, vorticity
1988-89	Greenland Sea	SIO/WHOI/ UM/UW	Designed to test moving ship tomography and to study gyre-scale dynamics and deep water formation
1988-89	Gulf Stream	WHOI/MIT	Designed to study dynamics of Gulf Stream Extension
1988	Monterey Canyon	WHOI/NPGS	Demonstrated surface-wave tomography
1989	SLICE89	UW/SIO	Demonstrated 1000-km single slice tomography
1990	ATE90	UW/SIO/UM	Designed to demonstrate utility of tomography in ocean nowcasting and forecasting
1991	Heard Island	SIO/UW/UM/ CSIRO, et al.	Designed to test acoustic measurement of global warming
1991-92	AMODE	SIO/UW/UM	Designed to measure gyre-scale dynamics and to test moving ship tomography

[a]WHOI - Woods Hole Oceanographic Institution; SIO - Scripps Institution of Oceanography; UM - University of Michigan; MIT - Massachusetts Institute of Technology; UMiami - University of Miami; UW - University of Washington; NPGS - Naval Postgraduate School; CSIRO; Commonwealth Scientific and Industrial Research Organization.

vertical sound speed profile, which causes multipath propagation. The depths of the upper and lower turning points of cycling multipaths are determined by the details of the vertical profile, the depth of the source and receiver, and the launch angle of the transmitted signal. Usually a geometry can be found that produces multipaths with good vertical distribution and discrimination. Upon reception, the multipaths can be distinguished by their different arrival times and angles. The tomographic procedure requires that multipath arrivals be identified with the path they traverse to distinguish sound speed or current changes that occur along that path.

Multipath Resolution, Identification, and Stability

From the very beginning it was recognized that, for tomography to work, the multipath structure must have some measure of predictability and stability. At the time, very little work had been done either with signals that had sufficient time resolution to separate individual multipaths or with receivers having sufficient apertures to resolve multipaths by angular discrimination. It was not generally known whether the propagation structure could be predicted with enough accuracy to identify a particular arrival with the geometric path it traversed, or whether the arrivals, even if identified with the correct path, were sufficiently stable to allow arrival time measurement to the required accuracy. There was concern about whether changes in travel time would be so large as to cause previously separable multipath arrivals to overlap, interfere, and become unresolvable. There was also concern about the magnitude of arrival time jitter, or noise, arising from small, relatively rapid sound speed fluctuations caused by small-scale mixing processes and internal waves. At best these processes could be treated as additive noise; at worst they might cause single paths to scatter into micro-multipaths that would spread a propagating pulse so much that accurate arrival times could not be determined.

One of the major early accomplishments of the tomography program was to settle some of these ocean acoustic issues. An experiment in 1978 in which pulse-like signals were transmitted over a 900 km distance in the Atlantic Ocean south of Bermuda for 48 days showed a stable multipath arrival structure in which individual arrivals could be clearly resolved and tracked.[2] Most of the arrivals corresponded almost exactly to those predicted by ray theory, while a few required a more exact solution of the wave equation. Although some arrivals remained that were not well predicted, it was clear that most could be identified with specific ray paths. Figure 1 shows a comparison between measurement and ray theory. These data also provided a rough estimate of arrival time jitter. Hourly incoherent averages greatly smoothed the data (which were taken every 10 minutes); averaging beyond 24 hours did little to reduce the variance (Figure 2). This suggested causative processes with time constants ranging from somewhat less than an hour to a day. Detailed analysis showed that arrival time jitter was in substantial agreement with fluctuations expected from internal waves, and was small enough to allow arrival time measurements to the precision necessary for mesoscale tomography.[3] This internal-wave-induced noise,

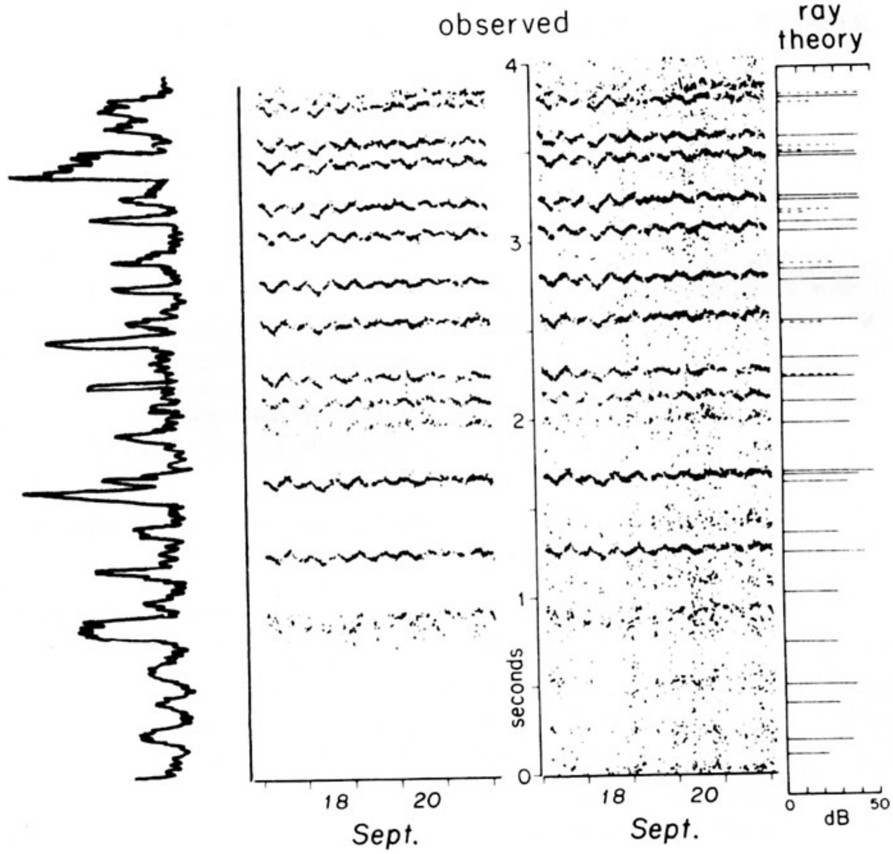

Figure 1. Observed multipath arrivals for a 5-day period at 900-km range compared with travel times computed from ray theory using a sound speed profile consisting of an average of 18 profiles between transmitter and receiver. Because all the multipaths arrive within a few seconds, only the last 4 s of the approximately 600 s total travel time are shown. A transmission was made every 10 minutes; a typical reception is shown on the left. In the two inner panels, the receptions are thresholded and a dot is plotted only for those parts of the reception that exceed a certain signal-to-noise ratio. Both inner panels show the same data; the inner left panel has a higher threshold than the inner right. This method of presentation allows the eye to track arrivals over long time periods. The two cycle/day oscillation evident in all arrivals is primarily due to tidal motion of the transmitter mooring and the barotropic tidal current component along the transmitter-receiver line. All ray paths intersecting the surface or bottom have been excluded from the ray theory prediction on the right. (Reproduced in part from Spiesberger et al.[2])

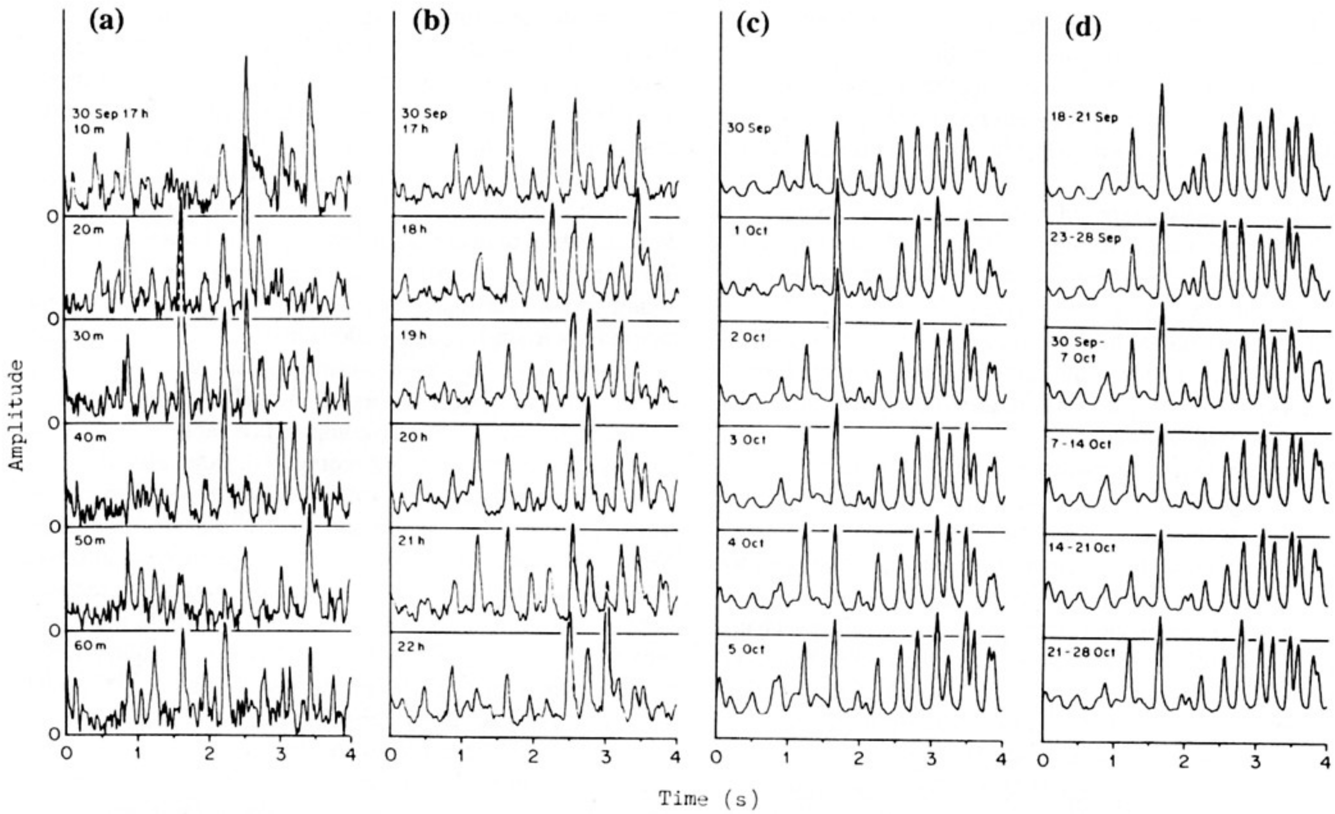

Figure 2. (a) Six consecutive multipath arrival records (10 minute spacing). (b) Six consecutive hourly averages; the top frame is the average of the six records from (a). (c) Six consecutive daily averages; the top frame includes the six hourly averages in (b). (d)Six averages over 3, 5, 7, 7, 7, and 7 days. (Reproduced from Spiesberger et al.[2])

however, remains the principal factor limiting the accuracy with which sound speed and current maps can be produced by time-of-flight tomography.

There have been continued refinements in acoustic propagation modeling and ray arrival identification. Agreement between measured and predicted arrival patterns has steadily improved as measurement techniques have become more accurate and as more precise environmental data are incorporated into the predictive acoustic models. Generally, predictions now agree with measurements to within a few milliseconds.[4] Comparisons of measurements with two commonly used sound speed algorithms, Del Grosso's and Chen and Millero's, have shown that arrival patterns and times are predicted best by the Del Grosso algorithm.[5] Predictions of single path transmission loss due to spreading and attenuation also have become much more accurate.

The addition of small vertical arrays to tomography instrumentation has further improved identification because it allows discrimination by vertical arrival angle as well as arrival time.[6] Figure 3 compares predicted arrival times and angles with measurement results.

Tomography has made significant contributions to general ocean acoustics apart from an increased understanding of single path acoustic propagation. The regions of applicability of various turbulence theories (Kolmogorov, Tatarski, Chernov) and various mathematical methods (small perturbation, Rytov, geometric optics, path integral) are now understood. Fluctuations due to internal waves, the limiting noise in arrival time measurement, are more precisely quantified, and their effect on the performance of other systems, including sonar systems, is more fully appreciated. Most experimental verification in the last 10 years has occurred as part of the development of tomography. Our understanding of the effects of larger scale ocean/acoustic interactions such as fronts and eddies goes well beyond pretomography days. Our ability to predict the parameters of long-range propagation is much improved. Indeed, tomography transmissions have been used to compare empirical sound speed equations and attenuation constants.

Demonstrations of Mesoscale Tomography

Following the 1978 propagation experiment which showed that multipaths were predictable, resolvable, and stable, there have been several demonstrations of mesoscale ocean tomography. An early, rather crude demonstration using acoustic transmitters with limited bandwidths was conducted south of Bermuda in 1981. Acoustic transmissions were in one direction only, allowing inversion for the sound speed field but not for the current field. Maps of the changes in the sound speed field were produced by initializing the inversion with sound speed data acquired by (nonacoustic) CTD casts on a 20-km grid.[7] It was also shown that maps could be produced from the acoustic data alone, using a single historic sound speed profile for initialization.[8] It is important that there be an adequate climatological data bank for initializing the inversion process. Figure 4 shows a sound speed map produced by the tomography system and one for the same time period produced from a conventional ship CTD survey. A time series of tomographic maps like these was computed to illustrate the evolution of the eddy field over a 2-month period. It showed rapid changes occurring in periods as short as 4 or 5 days that would be difficult to observe by any other means.

The 16-Hz bandwidth of the acoustic transmitters used in this experiment limited resolution to a barely adequate 60 ms. Resolution of 10 ms or better is required for good multipath separation and identification.

A later experiment, conducted north of Bermuda in 1983, employed higher frequency, wider bandwidth transmitters to realize the narrower pulses and better arrival time estimates needed for accurate measurement of sound speed as well as measurement of ocean currents via reciprocal transmissions. Whereas ocean mesoscale variations cause arrival time changes of tens of milliseconds over 1000-km paths, differences in reciprocal travel times caused by currents are of millisecond order. This experiment demonstrated that barotropic currents of a few centimeters/second could be measured.[9] Figure 5 shows velocity profiles computed for 2 days 3 weeks apart.

This experiment also showed that spatial diversity of tomographic instruments was not necessary to obtain range-dependent sound speed variations. They could be determined from measurements along a single slice, i.e., between a single source and receiver. Analysis of pulses transmitted simultaneously in opposite directions along the same path demonstrated that, for the purpose of making mesoscale inversions, reciprocal paths are identical. Finally, it was noted that travel time noise introduced by internal waves largely cancels in differential measurements, giving greater travel time precision than achievable for one-way travel times.

A longer range reciprocal transmission experiment conducted north of Hawaii in 1987 has provided the best demonstration to date that differential travel times computed from reciprocal acoustic transmissions can be inverted to obtain ocean currents. Three tomography instruments were moored in a triangle roughly 1000 km on a side. Tidal currents computed from the acoustic transmissions agree well with values derived from a numerical model and from moored current meter data. They also compare favorably with low-frequency barotropic currents computed from electric-field measurements made with bottom-mounted instruments and with vector current meter measurements.[10] Figure 6 compares the low-frequency currents computed from differential travel times along a 750-km path with those measured by a moored current meter and a bottom-mounted electric-field meter approximately midway along the path. The tomographic measurement is both range and depth averaged whereas the current meter data are essentially point measurements. Although the electric-field meter averages the barotropic current over a small range interval, it is essentially a point measurement when compared with the 750-km scale of the tomographic average. Thus the agreement is not expected to be perfect. Relative vorticity computed around the triangle is roughly 10^{-8} s^{-1}. Vorticity has also been measured using this technique on 20 to 50 km scales in the Straits of Florida,[11] where the relative vorticity is roughly 3 orders of magnitude larger.

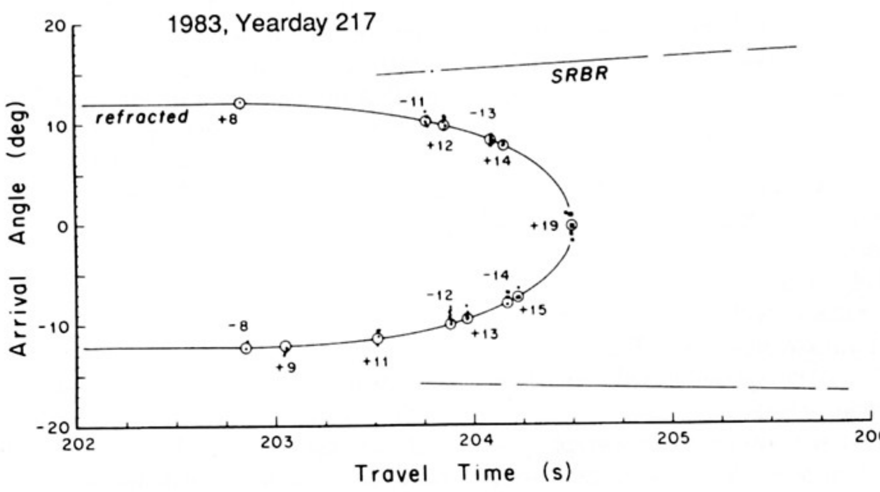

Figure 3. Ray arrivals plotted against travel time and arrival angle. Predicted arrivals via wholly refracted paths are shown as open circles connected by the smooth solid curve. Measured arrivals are plotted as points. The arrivals are labeled n, where the sign refers to whether the launch angle of the ray is up or down respectively, and n refers to the number of upper turning points. The straight lines are the loci of surface reflected, bottom reflected rays (SRBR). (Reproduced from Howe et al.[9])

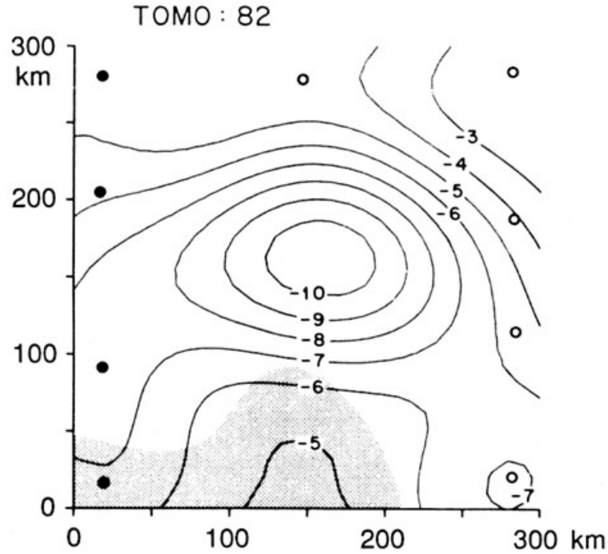

Figure 4. Comparison of tomographic and CTD maps of sound speed at 700-m depth from a 1981 experiment. The contours are in meters/second relative to 1510.6 m/s, and the contour interval is 1 m/s. In the left panel, acoustic transmitter locations are shown as solid dots and receiver locations as open dots. CTD stations are shown as solid dots in the right panel. The tomographic map used data from yearday 82; the CTD map is for yeardays 66-85, the time it took the ship to complete the survey. The shaded area indicates where the total error variance exceeds 70% of the expected solution variance, which corresponds to an error bar of about 3 m/s. The solution is poorer in this region than to the north because of the extra receiver on the northern boundary. (Reproduced from Cornuelle et al.[8])

Integrating Measurements

Acoustic transmissions are inherently averaging observations and as such constitute a unique ocean measurement. There is no comparable way to extract integral or large area average information about fields of fundamental importance to large-scale ocean physics—temperature, heat flux, horizontal velocity, vorticity, and open-ocean upwelling. A significant aspect of the development of ocean tomography and one of its main accomplishments has been to exploit the integrating features of acoustic measurements.

The 1978 multipath stability and resolution tests discussed above provided a crude measurement of average barotropic tides along the transmission path. An experiment a year later allowed measurement of north-south meandering of the Gulf Stream.[12] The preceding section discusses the integrating measurements of current and vorticity in experiments in 1983 and 1987. In the last section we mention an experiment in the Greenland Sea (which is essentially an integrating experiment since the ocean scales are so small) and several experiments in the planning stage that exploit the integrating features of acoustic measurements.

Technology for Ocean Tomography

Technology has been the primary limiting factor in applying ocean tomography. A tomographic system requires devices capable of emitting and receiving acoustic pulses narrow enough to resolve arrivals via separate multipaths. The pulses must be sufficiently above the background noise for precise arrival time estimation and they must be transmitted and received with coordinated time bases. Further, unless the instruments are fixed rigidly in place, provision must be made to account for travel time changes due to mooring motion so as not to confuse them with changes due to variations in the ocean sound speed field. Ideally, there should be means for telemetering arrival time data to shore for immediate analysis. In practical terms these requirements translate into pulses of several milliseconds duration, timed to within about 1 ms/year, at sound pressure levels exceeding 215 dB re 1 Pa. Instrument motion must be monitored to within about 1 m. A major accomplishment of the tomography program has been the development of equipment that meets these specifications. Indeed, one version of a tomography transceiver is now in commercial production.

Early tomography transmitters were extensions of the technology employed by neutrally buoyant SOFAR floats. These contained acoustic transmitters that consisted of high-Q, open-end, resonant tubes, approximately 1/4 wavelength long, driven at one end by a piezoelectric transducer. These devices had sound pressure levels approaching 180 dB re 1 Pa and bandwidths from 16 Hz (in 1980) to 100 Hz (in 1983). Signal processing gains of some 35 dB yielded sound pressure levels equivalent to 215 dB re 1 Pa. Time resolution with a 16-Hz bandwidth was barely adequate. The data storage of early tomography receivers was severely limited, and extensive data compression techniques were required. 13,14 Receptions were by single hydrophone, so there was no discrimination of multipaths by arrival angle. Timing accuracy was maintained by rubidium clocks, but there was no provision to check timing once the instruments were deployed.

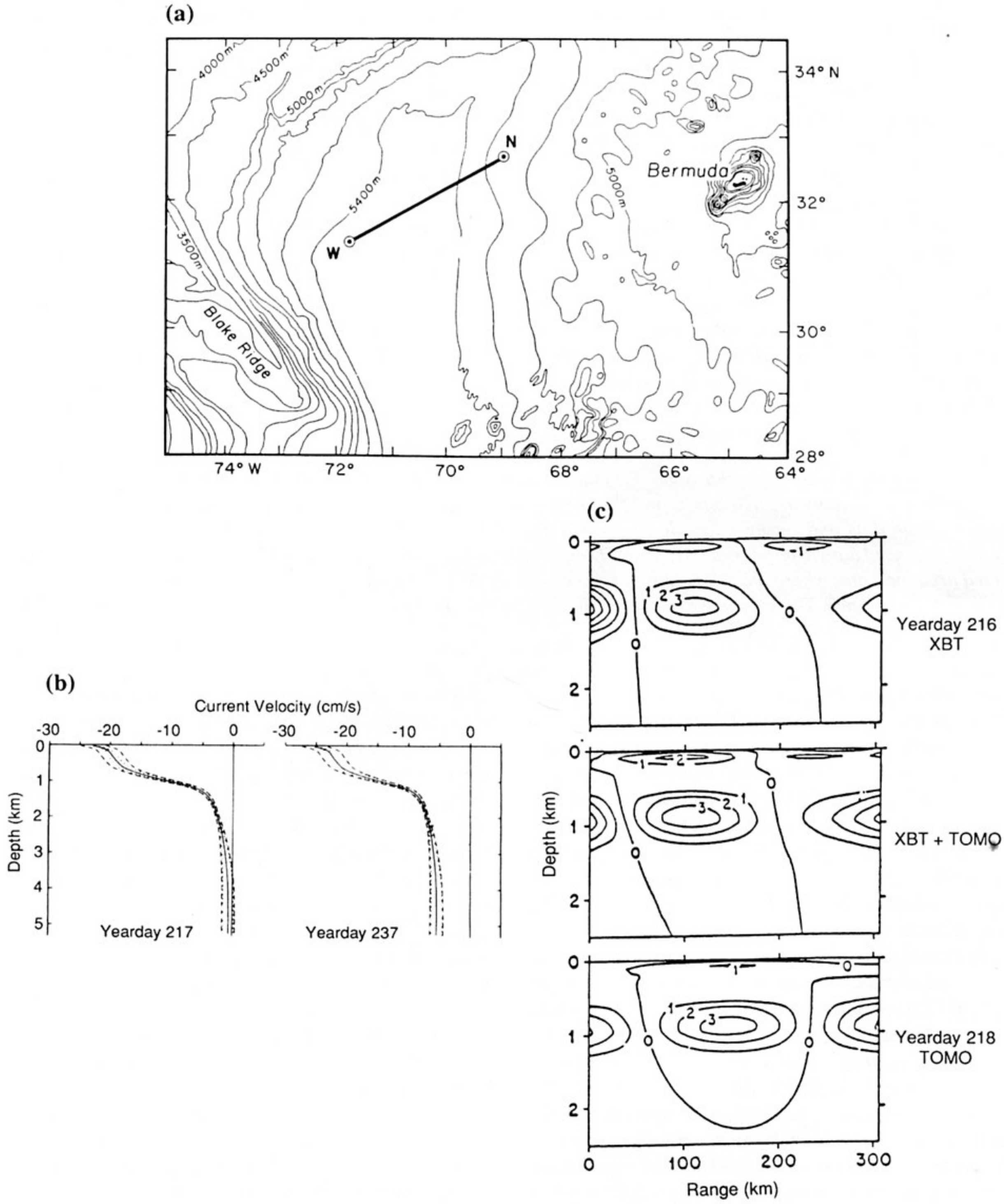

Figure 5. Tomography experiment north of Bermuda in 1983. (a)Reciprocal transmission path; tomography transceivers were moored at N and W at 1300 m depth, close to the axis of the sound channel. (b)Range-averaged current velocity for yeardays 217 and 237. (c)Single-slice tomographic reconstruction of the sound speed field between source and receiver. The upper panel, for yearday 216, is the result of a ship XBT survey. The lower panel is the tomographic inversion immediately following the survey on day 218. The center panel is an objective combination of the two data sets.

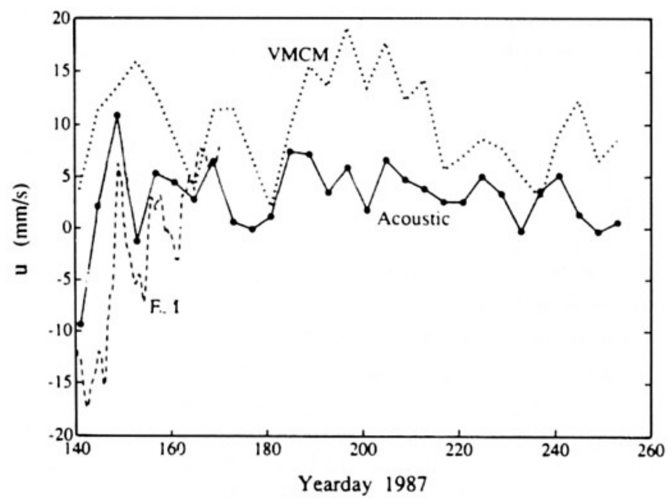

Figure 6. Low-frequency currents computed from differential acoustic travel times along a 750-km path north of Hawaii, compared with current meter and electric-field meter measurements at a point approximately midway along the path. (Reproduced from Worcester et al.[10])

Present day instruments are much improved. For long-range experiments, hydraulic-acoustic sources with a 100-Hz bandwidth centered at 250 Hz are used. These have sound pressure levels of 193 dB re 1 Pa, which together with signal processing gains produce an equivalent 228 dB signal. Although adequate in bandwidth and output power, unfortunately these sources are not very efficient (12%) and must be pressure compensated for operation at depth. Receivers (which are combined with these transmitters, thus producing transceivers) are equipped with vertical arrays of four to six hydrophones for arrival angle discrimination. Data storage, which is based on small hard-disk technology, is no longer limiting.[5,16] Some versions of later instruments include acoustic telemetry links to read out system performance data and clock times. (A mooring with satellite telemetry link is being developed by the Woods Hole Oceanographic Institution to provide near real-time tomography data transmission to shore.) For shorter range experiments, single hydrophone instruments that transmit less intense signals at higher frequency (centered at 400 Hz) are available commercially.[17]

There have been numerous developments in signal processing techniques for tomographic signals. To cope with the limited peak power capabilities of the tomography transmitters, it has been the practice to transmit wide time-bandwidth signals, usually phase-modulated pseudorandom codes. Methods have been developed for efficiently processing and compressing these signals to maximize temporal resolution and expedite insitu data processing and storage.[18,19] These include phase-only matched filtering for simplified processing and maximum resolution, and the use of Hadamard transforms for speed. The latter is particularly important to accommodate unknown Doppler shifts that arise when tomography experiments are conducted from moving ships.[20] High-resolution tomography of a quality comparable to a medical CAT-scan would require an impractical number of fixed instruments. Augmenting a moderate number with shipborne instruments is an attractive alternative that is being explored.

In this connection, a recent development has been a portable, acoustic navigation system for use with moving ship tomography. It consists of rapidly deployable and retrievable spar buoys that form a floating, long-baseline acoustic navigation system. The buoys are equipped with GPS receivers to determine their positions, thus eliminating the need for survey, and they have acoustic transmitters, receivers, or transponders to perform the underwater acoustic navigation function. Position and acoustic data are telemetered to the ship by an RF link.[21]

Probably the single factor most limiting wider application of tomography is the unavailability of broadband, low-frequency, depth-independent, efficient, and inexpensive acoustic sources.

Oceanography and the Future

For ocean tomography, this has been a decade of learning and development. The primary focus has been on demonstrating that ocean tomography works, that it can be used to map the mesoscale sound speed and current fields with accuracy and precision, and that it is an efficient measurement tool. A great deal of effort has gone into technology development, refinement of technique, and exploration of experimental limits. A steady progression of field experiments has validated most of the assumptions basic to the method, and a rapidly advancing technology development program has provided the necessary instrumentation. Inversion models and methods have resulted in efficient techniques for extracting maximum-resolution sound speed maps and current fields. The emphasis is now shifting toward application.

In the past few years at least three major tomography experiments have been conducted that focused on using the technique rather than on developing it. The first took place in the Greenland Sea during 1988-89, the second was in the region of the Gulf Stream extension in the central North Atlantic during the same period, and the third was in Monterey Bay. The Gulf Stream experiment and a part of the Greenland Sea experiment were designed to map mesoscale variability and large-scale mixing processes in these regions of intense eddy kinematics and dynamics. The Greenland Sea work also had a component that was essentially a gyre-scale integrating experiment to study the response of the Greenland Sea gyre to changing wind and ice conditions over a 12-month period. The Monterey Bay experiment was designed to measure surface and internal wave activity in the bay. The data from these experiments have not yet been fully analyzed, but based on the several successful demonstrations of the past 10 years the prospects are optimistic.

Several experiments are being planned for the near future (Table 1). Scientists from the Scripps Institution of Oceanography, the University of Michigan, and the University of Washington are preparing for an experiment to be conducted south of Bermuda. The major goals of AMODE, for Acoustic Mid-Ocean Dynamics Experiment, are to (a) assimilate tomographic data into nowcast and forecast models, (b) acquire a 1-year time series of sound speed, current, and relative vorticity as a function of depth, thereby providing information on gyre-scale dynamics at seasonal and shorter time scales, (c) determine the mapping performance of a combined moored and moving tomographic system, and (d) evaluate the feasibility of using tomographic data to provide information on the frequency-wavenumber spectrum of the sound speed and current fields. A group from the Woods Hole Oceanographic Institution and the Massachusetts Institute of Technology has proposed a decade or longer tomographic experiment, also in the North Atlantic. In addition, there is a mid-1990 experiment that focuses on the assimilation of single-slice tomographic data into ocean nowcast and forecast models.

The ocean tomography program has been the genesis of several interesting spin-offs. Tomographic techniques have been used to probe the sub-seafloor structure.[22] They have also been used to estimate sea-surface roughness and internal properties of sea ice in the Arctic.[23,24] Tomographic techniques have been proposed for mapping spatial variability of the internal wave field.[25] Perhaps the most ambitious program, at least in terms of spatial scales, is the Heard Island experiment, which is designed to measure changes in acoustic travel times over paths as long as 16,000 km to estimate the magnitude of global ocean warming or cooling. The idea of using acoustic signals as the basis for an ocean thermometer arose early in the tomography program.[26] The proposal is to transmit signals from Heard Island in the southern Indian Ocean and monitor them at widely scattered geographic points. Participation is international and includes scientists from U.S. universities, government laboratories, and industry, as well as groups in Australia, Canada, India, and the U.K.[27]

Although there is a general move toward application, there are still significant tomography developments under way. Tomography from moving ships is one that has been under development for several years. Here, the notion is to create a synthetic tomography array, thereby providing high resolution without an inordinately large number of fixed instruments. Two tests have been conducted to date, one in 1988 and one in 1989, both in the Greenland Sea. In these, several moored instruments were augmented by a shipborne receiving array. The development of near real-time data telemetry, mentioned above, will have great impact on future tomography systems.

Finally, this has been only a brief review. Further detailed information is available in the more than 120 journal articles and additional workshop proceedings and society and symposia presentations that have been contributed since 1979.

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ENGINEERS IN AMERICA'S FUTURE: SHORTAGE OR SURPLUS?

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IEEE-USA Pays Tribute to Engineers

IEEE-USA's National Government Activities Committee, chaired by Dr. Edward C. Bertnolli, created, developed, and purchased full-page advertisements, headlined "Winning With Technology," in the March 7 issues of *The Wall Street Journal* and *The Washington Post.* The ad pays tribute to the central role played by electrical, electronics, and computer engineers in developing the technology that contributed to victory in Operation Desert Storm. Additionally, the ad calls for a renewed commitment to tackling U.S. competitiveness problems.

"Operation Desert Storm has dramatized that the United States is capable of developing outstanding electronic technology with military applications," said 1991 USAB Chairman Michael J. Whitelaw. "The United States will reclaim its role in the world market as a top competitor, if the same commitment that was applied to military high technology is applied to commercial products and services." IEEE-USA recommends strengthening Cabinet-level advice in engineering and technology and restructuring technical activities within the Commerce Department to provide a coordinated approach to achieving industrial competitiveness.

For copies of IEEE-USA's "Winning With Technology" ad, contact the IEEE Public Relations Department at the IEEE-USA Office in Washington, D.C.

IEEE-USA Hosts Competitiveness Workshop

IEEE-USA's Technology Policy Conference Committee organized a ***Workshop on Competitiveness and Technology Policy*** in conjunction with the 1991 American Association of Engineering Societies (AAES) Government Affairs Conference on March 6th in Washington, D.C. The AAES-sponsored Conference attracted approximately 200 leaders from the science, engineering, and technology community, Members of Congress, Executive Branch staff, and the press.

The conference theme, "Technology, Competitiveness and the Future of America," was addressed by Robert White, Undersecretary of Commerce for Technology, during the morning plenary session. That theme was advanced in IEEE-USA's workshop session, composed of consecutive panels moderated by former National Science Foundation Director Erich Bloch.

The first panel provided industry views on the economic underpinnings and necessary incentives for U.S. competitiveness. Kent Hughes, President of the Council on Competitiveness, criticized short-term industry perspectives. Ray Waddoups, Vice President and Director of Research for Motorola's Government Electronics Division, pronounced the 1990s to be "the decade of total quality concurrent engineering." Gilbert Kaplan, a prominent trade attorney with the firm of Hale and Dorr, highlighted the fundamental ideological debate between interventionists and non-interventionists on the role of Government in promoting U.S. technological competitiveness.

The second panel commented on critical Federal strategies. Raymond Kammer, Deputy Director of the National Institute of Standards and Technology (NIST), John Alic of the Office of Technology Assessment, and James Ling of the Office of Science and Technology Policy highlighted the Administration's technology policy—including support for development of critical pre-competitive generic and enabling technologies.

Copies of Undersecretary White's remarks and a summary report of IEEE-USA's Competitiveness and Technology Policy Workshop can be obtained from Chris Brantley at the IEEE-USA Office in Washington, D.C.

COMAR Responds to EPA Report

James C. Lin, Chairman of IEEE-USA's Committee on Man and Radiation (COMAR) wrote a letter on the Committee's behalf to the Environmental Protection Agency's (EPA) Science Advisory Board Subcommittee on Nonionizing Electric and Magnetic Fields. The letter was submitted for the record of hearings on the EPA Draft Report, "Evaluation of the Potential Carcinogenicity of Electromagnetic Fields."

IEEE-USA believes that more research about the biological effects of exposure to the electric and magnetic fields associated with electric power distribution and utilization is needed before the scientific community can determine which components of exposure, if any, are factors in health risks. The Committee cited a critical need for increased Federal research funding for interaction mechanisms and animal studies, for maintaining efforts in human health studies with emphasis on known cancer-causing agents, and for a measurement program to identify and characterize sources of electric and magnetic fields.

In other activity, COMAR provided copies of IEEE-USA's Position Statements on microwaves, video display terminals, and power-frequency electromagnetic fields to the House Subcommittee on Water, Power, and Offshore Energy Resources. The Committee also released its information paper, ***'Currents of Death' Rectified,*** by Committee member Dr. Eleanor Adair, in response to assertions made by author Paul Brodeur on the potential health effects of electric and magnetic fields. Additionally, COMAR responded with letters to articles in *The Wall Street Journal* and *The Washington Post* covering these issues.

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IEEE-USA Backs Major Competitiveness Report

IEEE-USA has joined with other members of the Council on Competitiveness in presenting the report ***Gaining New Ground: Technology Priorities for America's Future*** to Congress. The report is the result of a two-year effort by top technology experts around the country to identify the critical generic technologies driving U.S. economic performance. Admiral Bobby Ray Inman chaired the task force involved in this effort.

Concluding that the U.S. position is slipping, the report calls on the President to act immediately to make technological leadership a national priority. Further, it recommends that Federal and state governments implement programs to strengthen the U.S. technology infrastructure. Additionally, the report urges U.S. firms to meet and surpass the best commercialization practices of their competitors, and it encourages universities to develop closer ties to industry.

IEEE-USA works through the Council as a National Affiliate to advance common positions on competitiveness issues. The Council is a private, non-profit organization. Copies of the report can be obtained for $20 from the Council on Competitiveness, 900 17th Street, N.W., Suite 1050, Washington, D.C. 20006, (202) 785-3990.

Precollege Education Committee Calls for Volunteers

IEEE-USA's Precollege Education Committee is in the process of establishing a discipline-based Volunteer Student Guidance Network and is looking for volunteers willing to serve as resource persons. If you enjoy working with high school students and would be willing to answer an occasional request for career information in your particular area of expertise, we need your help. For more information and to volunteer, please contact Ann Hartfiel at the IEEE-USA Office in Washington, D.C.

Aerospace R&D Policy Committee Testifies On Space Program's Future

At the invitation of Congressman George Brown (D-California), IEEE-USA's Aerospace R&D Policy Committee Chairman George Sponsler submitted testimony on the *Report of the Advisory Committee on the Future of the U.S. Space Program* (the Augustine Report) for the record of hearings held by the House Committee on Science, Space, and Technology. Following the testimony, USAB Chairman Michael J. Whitelaw sent a letter to Vice President Dan Quayle, Chairman of the National Space Council, outlining the Committee's views on the Augustine Report.

In the letter, Whitelaw said IEEE-USA's principal disagreement with the Augustine Report is with its primary recommendation. IEEE-USA believes NASA's first priority should not be to support science per se, but to use our investment in space to improve the U.S. economy, education, the environment, and the quality of life on earth.

IEEE-USA proposed two actions for consideration:

- Formulate policy and set goals for the United States in developing space applications. Reorganize NASA and the Departments of Commerce and Transportation to pursue those goals in alliance with U.S. industry, while simultaneously enhancing international cooperation in civil space; and
- Formulate policy and set goals for the United States with regard to the role of NASA and its space program in order to enhance U.S. technological leadership. Encourage more effective transfer of NASA-supported space technology into the private sector.

IEEE-USA Supports Software Bill

IEEE-USA's Intellectual Property Committee Chairman David Ostfeld and IEEE-USA staff met with Barry Beringer, Minority Counsel for the House Science, Space, and Technology Committee, and Brian Wu, Legislative Assistant to Representative Constance Morella (R-Maryland) in February about amendments to *H.R. 191*, the ***Technology Transfer Improvements Act of 1991.*** The bill would permit Government employees to copyright software prepared in cooperative research and development agreements with private industry. The bill would also provide incentives to software development, as well as enhance U.S. competitiveness. IEEE-USA's Intellectual Property Committee has been asked to testify on behalf of H.R. 191 in June.

IEEE-USA's Federal Legislative Agenda Now Available

IEEE-USA's Federal Legislative Agenda Task Force has published an ***Agenda*** for the 102nd Congress. Available from the IEEE-USA Office in Washington, D.C., the ***Agenda*** provides a synopsis of the legislative and public policy concerns of IEEE's U.S. members. Through the issue briefs, index of key words and phrases, and lists of IEEE and IEEE-USA Positions, the Task Force hopes to acquaint members of Congress, the Executive agencies, and the general public with U.S. members' interests in a spectrum of issues.

The issues included in this ***Federal Legislative Agenda*** are retirement income policy; industrial competitiveness; career issues relating to engineers, which includes sections on manpower, intellectual property, anti-discrimination, and engineering ethics; the U.S. civilian space program; computers and communications; education; engineering in health care; research and development; and tax policy.

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Job Fairs Spread Nationwide

Job fairs and job search seminars are growing nationwide in an attempt to help unemployed members. Conducted by The Lendman Group, a national operator of technical job fairs, the events are produced under a contractual agreement with IEEE. IEEE-USA's Employment Assistance Committee oversees the job fairs and seminars on the national level.

Using its outplacement division personnel and materials, The Lendman Group provides a free, one-day job search seminar—a workshop on how to find employment—for IEEE members, in exchange for IEEE's co-sponsoring the job fairs. The seminars are usually scheduled in advance of the job fairs so that members have an opportunity to use their newly acquired job-seeking skills.

The Committee has scheduled job fairs and job search seminars through the remainder of 1991. For more information about these events, contact William R. Anderson at the IEEE-USA Office in Washington, D.C.; or, contact IEEE's Career Fair Coordinator at (800) 562-2820; in Virginia, call (800) 533-1827.

Local Assistance Needed With IEEE-USA's Careers Conference

You can make a difference in the quality of engineering careers at your workplace. Every two years IEEE-USA sponsors a Careers Conference, spotlighting and disseminating successful programs that have a positive impact on engineering careers. This year's Conference, "Change & Competitiveness & Careers," will be held October 10-11, 1991 in Denver, Colorado.

In order to reach more policymakers among employers of IEEE members, we are asking you to help by distributing Careers Conference brochures at your worksite. For copies of the brochure or more information about the Conference, please contact Bill Anderson at the IEEE-USA Office in Washington, D.C.

IEEE-USA's 1991 Congressional Fellows Begin Their Assignments on Capitol Hill

Dr. Dharmendra K. Sharma and Donald L. Willyard, the two 1991 IEEE-USA Congressional Fellows, have begun their terms. Willyard is working on the staff of Rep. Steven Schiff (D-New Mexico). Sharma is working on the staff of Sen. Wendell Ford (D-Kentucky), the Senate Majority Whip.

An Associate Program Manager for the Electric Power Research Institute in Palo Alto, California, Sharma said he believes more scientists and engineers should become involved with the legislative process. "Since fewer than five engineers serve in Congress, providing technical advice to policymakers helps them understand the issues," he said.

A desire to contribute is Willyard's reason for wanting to serve as a Congressional Fellow. "Such problems as nuclear waste, airline safety, and rebuilding our land transportation infrastructure need technical input to reach the best solutions," he said. Willyard works for Allied-Signal Aerospace Company in Albuquerque, New Mexico.

Sharma concentrates on energy issues on Senator Ford's staff. The Senator is a ranking member of the Senate Energy and Natural Resources Committee and Chairman of its Energy Research and Development Subcommittee. Willyard is working on a variety of issues, including the Department of Energy Waste Isolation Pilot Plant, the National Laboratories, and general science and technology issues under the jurisdiction of the House Science, Space, and Technology Committee.

IEEE-USA's 1991 Salary Survey Report Available

Preliminary results of IEEE-USA's 1991 survey of U.S. members' salaries and fringe benefits showed that the average salary of U.S. members rose just over five percent in the past year, going from an average of $57,825 to $60,850. This increase was preceded by an approximate four percent rise over the 1989 average of $55,700.

Salaries and income are reported in the ***1991 U.S. Membership Salary and Fringe Benefit Survey*** using more than 280 variables as cross tabulations. This latest survey report also provides readers with a regression analysis, which estimates the relationship of such factors as education, years of experience, and location (30 in all) to annual salary.

The survey is available for $74.95 to members and $99.95 to non-members from the IEEE Service Center in New Jersey. Call (800) 678-IEEE. These prices do not include tax or shipping and handling charges. Remember to ask for IEEE Catalog No. UH0185-9 when placing your order.

"Strength Through Technology" Poster Promotes U.S. Competitiveness

IEEE-USA's National Government Activities Committee has produced color posters to promote U.S. competitiveness. ***"Strength Through Technology"*** is the slogan for the five-color, 20″ by 30″ design.

In a brief message, the poster pledges the support of IEEE's 250,000 U.S. members to continuing to achieve successes in high-technology commercial products and services. The poster calls attention to the contributions of electrical engineers and IEEE-USA's commitment to enhance U.S. competitiveness.

You can order the poster by writing to the IEEE Service Center, 445 Hoes Lane, Piscataway, New Jersey 08855-1331 and asking for IEEE Catalog No. UH0189-1; or, call (800) 678-IEEE. Prices are $10 to members and $15 to non-members, plus postage and handling.

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Pension Legislation Introduced on Capitol Hill

IEEE-USA's Pensions Committee is backing legislation introduced in the U.S. House of Representatives on May 20 by Representative Sam Gibbons (D-Florida), the second-ranking Democrat on the House Ways and Means Committee. ***H.R. 2390, the Pensions Coverage and Portability Act,*** will expand pension coverage, improve the portability of benefits when workers change jobs, and increase individual savings for retirement. The legislation addresses such problems as lack of coverage, failure to vest, lack of portability from defined benefit plans, and consumption of pre-retirement lump-sum distributions.

The Pensions Committee worked closely with Representative Gibbons in developing the bill, which represents a significant step for IEEE-USA's efforts. Pension and U.S. competitiveness issues constitute the two components of its Legislative Initiative, begun in 1990. Upon introduction of the bill, George F. McClure, IEEE-USA's Pensions Committee Chairman emphasized that "Federal legislation is needed to resolve pension coverage and portability problems and to encourage individuals to save for their retirement years." IEEE-USA also supports ***H.R. 1406*** and ***S. 612,*** bills that would restore universal eligibility for making tax-favored IRA contributions. For additional information on pensions legislation, contact Vin O'Neill at the IEEE-USA Office in Washington, D.C.

Global Competitiveness Symposium Set for September

Through its Committee on U.S. Competitiveness, IEEE-USA has agreed to be an associate sponsor of a symposium on ***Technology Policy for Global Competitiveness: Forging a National Consensus for the Twenty-First Century.*** The symposium, sponsored by the National Center for Advanced Technologies (NCAT) and the American Institute for Aeronautics and Astronautics, will be held on September 5-6 at the Ramada Renaissance Techworld in Washington, D.C.

Featuring nationally and internationally known speakers, the symposium will address basic policy issues related to technology development and focus on charting a course to keep American business competitive in the global marketplace. Dr. William D. Phillips, Associate Director of Industrial Technology at the White House Office of Science and Technology Policy, will deliver the symposium's keynote address on "A National Technology Policy."

NCAT is a non-profit organization formed to coordinate the activities of government, industry, and academia in order to expedite the development of key technologies. Additional associate sponsors of the symposium include other engineering, science, industrial, and defense organizations.

WISE Interns to Spend Summer in Washington

IEEE-USA and TAB have selected two students to participate in the 1991 Washington Internship for Students of Engineering (WISE) program. They are Steven J. Ebel, an electrical engineering major at the University of Minnesota in Minneapolis, Minnesota, and Robert J. Lasser, an electrical engineering major at Temple University in Philadelphia, Pennsylvania. The WISE program brings engineering students to Washington, D.C., to learn about the relationship between engineering and public policy. The program's long-term goal is to enhance the engineering profession's ability to contribute to public policy decision-making on technology issues.

Steven Ebel's project, "SEMATECH: America's Answer to the Japanese Semiconductor Challenge: An Assessment," will focus on SEMATECH as an R&D consortium, as a public policy initiative, and as a possible model for consortia expansion. Robert Lasser will examine legislation and technology issues in telerobotics, specifically focusing on NASA's Flight Telerobotic Servicer.

IEEE-USA Technology Policy Council Calls For New Space Station

In a national press conference on June 25, IEEE-USA leaders called on the U.S. Senate to oppose funding a proposed $30-$40 billion space station and support development of a scaled-back version costing less than $10 billion. "We do not support further funding of the space station program as it is currently conceived," Arvid G. Larson, Vice Chairman of IEEE's United States Activities Board, told attendees.

IEEE-USA does support the concept of a space station as an important step in establishing the permanent presence of human beings in space. Further, IEEE-USA believes a properly funded space station program must be part of a balanced science and application program providing satisfactory national economic return on U.S. space investment.

The press conference was arranged to release a position statement developed by IEEE-USA's Technology Policy Council and its Aerospace R&D Policy Committee. The statement concludes that a single, smaller space station developed and employed solely for studying human beings in the space environment would be less costly and probably of equal technical value. Full funding of Space Station Freedom would seriously detract from other important civilian space programs, such as satellite communications and remote sensing, requiring diversion of public funds needed for other purposes.

Copies of the position statement and Larson's statement to the press can be obtained from the IEEE-USA Office in Washington, D.C.

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7th International Symposium on Unmanned Untethered Submersible Technology

September 23-25, 1991

New England Center
Durham, New Hampshire

The Marine Systems Engineering Laboratory at the University of New Hampshire will sponsor the 7th International Symposium on Unmanned Untethered Submersible Technology on September 23-25, 1991. The symposium will be held at the New England Center which is located in Durham, New Hampshire on the campus of the University of New Hampshire.

The emphasis of the symposium will be placed on the discussion of technologies that will provide new insight and understanding. A major focus of the symposium is to provide an atmosphere conducive to information exchange and to stimulate informal interaction among the participants.

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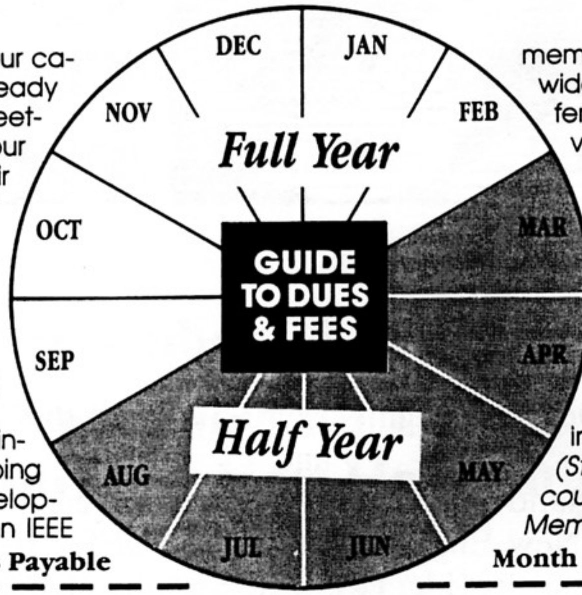

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