Session 1pAA

Architectural Acoustics: Performing Arts Center Acoustics–Pre-Tour Talk

Robert C. Coffeen, Cochair
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Norman H. Philipp, Cochair
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Chair's Introduction—1:35

Invited Papers

1:40

1pAA1. Acoustical design of Calderwood Hall at the Isabella Stewart Gardner Museum. Daniel Beckmann, Motoo Komoda, and Yasuhisa Toyota (Nagata Acoustics, 2130 Sawtelle Bl., Ste. 308, Los Angeles, CA 90025, beckmann@nagata.co.jp)

The Isabella Stewart Gardner Museum opened the expansion to its historic "Fenway Court" Palace in the Back Bay district of Boston, Massachusetts in January, 2012. Renzo Piano Building Workshop was the design architect for the 70,000 square foot addition to the museum. The new Calderwood Hall serves the music programming mission of the museum by creating a 300-seat space where chamber music can equally be enjoyed by all members of the audience. A novel audience configuration is perhaps the most defining element of this highly intimate space for music, where a stage measuring 30 feet square is centered on the bottom level of the space measuring 42 feet square and 45 feet tall. Three stacked balconies, each one row deep, look down on the stage from all four sides. The integrated acoustical and architectural design features are reported.

2:00

1pAA2. Acoustical design of Muriel Kauffman Theatre at the Kauffman Center for the Performing Arts. Motoo Komoda, Kayo Kallas, Daniel Beckmann, and Yasuhisa Toyota (Nagata Acoustics, 2130 Sawtelle Bl., Ste. 308, Los Angeles, CA 90025, komoda@nagata.co.jp)

Muriel Kauffman Theatre, the horseshoe-style proscenium theater in the Kauffman Center for the Performing Arts in Kansas City, Missouri, opened in September, 2011. The 1800-seat theater was designed by the architect Moshe Safdie, and serves as the principal residence of both the Kansas City Ballet, and the Lyric Opera of Kansas City. Since ballet and opera performance were programmed as the primary use, the primary focus of the room acoustical design was to provide good natural acoustics for singers on the stage, and for the orchestra in the pit. This was achieved through careful study on the shape of the room. The walls surrounding the stage and proscenium, and the configuration of the ceiling were among the primary aspects of the room shape which were studied, as well as flexible room acoustics for programs with using amplified sound, such as pop music and spoken-word programs. The acoustical design and characteristics of the Muriel Kauffman Theatre are reported.

2:20

1pAA3. Acoustical design of Helzberg Hall at the Kauffman Center for the Performing Arts. Daniel Beckmann, Kayo Kallas, Motoo Komoda, and Yasuhisa Toyota (Nagata Acoustics, 2130 Sawtelle Bl., Ste. 308, Los Angeles, CA 90025, beckmann@nagata.co.jp)

Helzberg Hall, the arena-style concert hall in the Kauffman Center for the Performing Arts in Kansas City, Missouri opened in September, 2011. The 1600-seat concert hall was designed by the architect Moshe Safdie, and serves as the principal residence of the Kansas City Symphony. The hall measures 150 feet long, 100 feet wide, and 90 feet tall at the highest point, with an ensemble reflector suspended at 50 feet above the stage to support the stage acoustics. Stage acoustics are also enhanced by motorized risers on the stage, to give the orchestra layout a three-dimensional quality. Motorized draperies concealed in the walls also give flexibility to the acoustics of the space, in order to accommodate amplified events. A 1:10 scale model test of the hall was performed at the end of the design phase to verify the acoustics of the hall. The acoustical design and characteristics of the new space are reported.

Session 1pAB

Animal Bioacoustics, Engineering Acoustics, and Signal Processing in Acoustics: Echolocation, Bio-Sonar, and Propagation

Whitlow W. L. Au, Chair
Hawaii Institute of Marine Biology, University of Hawaii, Kaneohe, HI 96744

Contributed Papers

1:30

1pAB1. Bio-sonar signal processing. Harry A. DeFerrari and Jennifer Wylie (Applied Marine Physics, University of Miami, 4600 Rickenbacker Cswy, Miami, FL 33149, hdeferrari@rsmas.miami.edu)

An ideal sonar for biological observations in the ocean should employ very long signals for Doppler resolution, wide bandwidth for time resolution and pulse compression properties for gain in order to reduce sound pressure levels to mitigate marine mammal concerns. Signal spread in time and Doppler (leakage) must also be eliminated so that direct arrival and reverberation signals do not leak and swamp bio-signal returns when operation in a continuous transmit and receive mode. Orthogonal codes would help multi-static applications. Here two types of signals and processing are presented and analyzed; 1) M-sequences with matched filter processing and 2) Inverted binary sequence with matched- inverse processing. Ambiguity diagrams of conventional active sonar signals are compared with the two candidate signals. Then the two methods are compared by numerical simulation for propagation in shallow channels with zero Doppler returns and moving bio-scatterers. It is shown that for realistic conditions leakage from direct and zero Doppler reverberation can be eliminated not just reduced. Limits on temporal coherence times of shallow water propagations channels are discussed. These approaches improve Figure of Merit of conventional active sonar by 10 to 15 dB and displays in the time Doppler plane simplify the interpretation of clutter.

1:45

1pAB2. Effects of local shape features on the beampatterns of a dynamic biomimetic baffle. Mittu Pannala, Sajjad Z. Meymand, and Rolf Mueller (Mechanical Engineering, Virginia Tech, 1110 Washington Street, SW, Blacksburg, VA 24061, mpannala@vt.edu)

Horseshoe bats have mobile pinnae that can change their shapes as a result of active actuation. A common pattern is an alteration between an upright and a bent-tip geometrical configuration. Numerical predictions of reception beampatterns associated with these different shape geometries have indicated that the upright configurations are associated with beampatterns dominated by a single mainlobe whereas the bent-tip configurations have prominent sidelobes. Using a biomimetic baffle prototype, we have found that this effect can be reproduced qualitatively with just a plain obliquely truncated cone that is fabricated from flexible material (rubber) and bent at the tip. However, local shape features can have a strong impact on the quantitative expression of this effect. The three features studied here were a vertical ridge, an equivalent to the bat's antitragus, and a lateral incision into the baffle rim. The effects of these features on the beampatterns where found to interact with each other and also depend strongly on the deformation stage of the baffle shape. Hence the corresponding biological features may offer bats an opportunity to fine-tune their beampatterns as a function of deformation stage. However, control strategies for biomimetic devices with variable beampatterns have yet to be developed.

2:00

1pAB3. Analysis of biosonar beamwidth with spherical harmonics power spectra. Mohammad Motamedi (Mechanical Engineering, Virginia Tech, Blacksburg, VA 24060, m.motamedi.85@gmail.com), Qiuping Xu, Washington Mio (Mathematics, Florida State University, Tallahassee, FL), and Rolf Mueller (Mechanical Engineering, Virginia Tech, Blacksburg, VA)

Ultrasound emission and reception in bats are characterized by beampatterns that can be predicted from digital models of the geometries of noseleaf and pinna structures numerically. One obvious way in which beampatterns can differ across species is in the overall width (angular extent) of the beams. But since biosonar beams also vary in many other ways such as in their orientation and their shape, quantifying overall beamwidth poses a challenge. Here, the power spectrum of a beam decomposition based on spherical harmonics has been used to obtain a quantitative measure of beamwidth. Due to the reciprocity between transform domains, narrower beams correspond to spectra with a higher bandwidth and vice versa. Using power spectral magnitudes, it has been possible to classify emission and reception beampatterns as well as beampatterns from different taxonomic bat groups across 176 noseleaf and 185 pinna samples representing 106 species. Furthermore, when the power spectra of the actual biosonar beams were replaced with those of fitted single heat functions, classification performance suffered little. Since the heat kernel approximations did not differ in any property other than beamwidth, this demonstrates that beamwidth alone is a discriminating factor between bat taxonomic groups as well as emission and reception.

2:15

1pAB4. Examining the effects of propagation on perceptual features used for automatic aural classification. Carolyn M. Binder, Paul C. Hines, Sean P. Pecknold, and Jeff Scrutton (Defence R&D Canada, P.O. Box 1012, Dartmouth, NS B2Y 3Z7, Canada, carolyn.binder@drdc-rddc.gc.ca)

A prototype aural classifier has been developed at Defence R&D Canada that uses perceptual signal features which model the features employed by the human auditory system. Previous effort has shown the classifier reduced false alarm rates and successfully discriminated cetacean vocalizations from several species. The current paper investigates the robustness of the aural features against propagation effects for two of those species - the bowhead and humpback whales. This is achieved by comparing the classification results of the original vocalizations to classification results obtained after the vocalizations were re-transmitted underwater over ranges of 2 to 10 km. To gain additional insight into the propagation effects, synthetic bowhead and humpback vocalizations, with features similar to the most important aural features for classification of bowhead and humpback vocalizations, were also transmitted. In this paper, the classifier performance on both real and synthesized vocalizations are compared before and after propagation, to quantify the effect of propagation on the features used in the aural classifier.

2:30

1pAB5. Propagation modeling techniques for marine mammal management studies. Elizabeth T. Küsel, Martin Siderius, and Scott Schecklman (Northwest Electromagnetics and Acoustics Research Laboratory, Portland State University, 1900 SW 4th Ave., Portland, OR 97201, kusele@alum.rpi.edu)

Acoustic propagation modeling techniques are often used to estimate the impact of anthropogenic sound sources on the marine environment, and to estimate population density and detection ranges of marine mammals from their vocalizations. Sophisticated propagation models can be used to accurately calculate acoustic transmission loss as a function of range and depth. This is often done along a number of uniformly spaced radials surrounding a sound source and results are interpolated to each simulated animal location. Computational time, detailed input parameters, and interpolation over complex bathymetry can be a hindrance to efficient and accurate results. This work investigates the impact of using simple propagation modeling that avoids interpolation between radials. Differences will be compared between direct and interpolated values as well as between coherent and incoherent transmission loss solutions. The accuracy and efficiency of the different approaches are evaluated by comparing the number of animals that would be taken by the sound field, which are associated with randomized animal locations in Monte Carlo simulations. [Work supported by ONR.]

2:45

1pAB6. Passive acoustic detection and classification of *Ziphius cavirostris*. Ryan Goldhahn (NATO Undersea Research Centre, Viale San Bartolomeo, 400, La Spezia 19126, Italy, goldhahn@nurc.nato.int)

Cuvier's beaked whales, Ziphius cavirostris (Zc), are a species of marine mammals particularly sensitive to anthropogenic noise. Estimating their habitats and abundance is thus of particular importance when planning and conducting active sonar exercises. Since their deep-diving behavior make them difficult to observe visually, passive acoustics is frequently used for detection. A method of automatic detection and classification of Zc is presented based on the inter-click interval, click spectrum, and direction of arrival estimated on a volumetric array. Specifically, click spectra are compared against a signal subspace constructed from eigenvectors of previously identified beaked whale clicks. The direction of arrival is estimated by cross correlating the received click across a three-dimensional array and clicks are classified based on their estimated elevation angle. Additionally, since Zc are known to produce click trains rather than single clicks, detections made without neighbouring detections are discarded as interference. These three criteria are used to detect and classify Zc, in the presence of dolphin clicks and/or other interference. Results are presented on data collected during the SIRENA10 and SIRENA11 experiments conducted by the NATO Undersea Research Centre in the Atlantic Ocean and Mediterranean Sea respectively, and compared against detections made by human operators and a team of visual observers.

3:00

1pAB7. Interesting properties of toothed whale buzz clicks. Odile Gerard (LSM, DGA TN, Avenue de la Tour Royale, Toulon 83000, France, odigea@gmail.com), Craig Carthel, and Stefano Coraluppi (Fusion Technology and Systems, Compunetix, Inc., Monroeville, PA)

Toothed whales are known to click to find prey. The characteristics and repetition rates of the echolocation clicks vary from one species to another, but clicks are fairly regular during the phase in which the animals are searching for prey. Once they have found prey the repetition rate of the clicks increases; these sequences are called buzzes. Some previous work was done to classify Blainville's beaked whale buzz clicks. While we did not succeed to classify these clicks individually because of the variation of their characteristics, we found buzz clicks have slowly varying properties from one click to the next. This similarity permits their association as a sequence using multi-hypothesis tracking algorithms. Thus buzz classification follows the automatic tracking of clicks. We also found that buzz clicks from other toothed whales species often have similar properties. In some cases a variant of this property has been found, whereby sub-sequences of clicks also exhibit slowly varying characteristics.

Session 1pAO

Acoustical Oceanography and Underwater Acoustics: Memorial Session in Honor of Clarence S. Clay II

Dezhang Chu, Cochair
NOAA Fisheries, NWFSC, Seattle, WA 98112

John K. Horne, Cochair
School of Aquatic and Fishery Sciences, University of Washington, Seattle, WA 98195

J. Michael Jech, Cochair
Northeast Fisheries Science Center, Woods Hole, MA 02543

Timothy K. Stanton, Cochair
Woods Hole Oceanographic Institution, Woods Hole, MA 02543-1053

Contributed Papers

1:00

1pAO1. Feature extraction for classification of fish species using the Cepstral analysis. Ikuo Matsuo, Masanori Ito (Department of Information Science, Tohoku Gakuin University, Tenjinzawa 2-1-1, Izumi-ku, Sendai, Miyagi 9813193, Japan, matsuo@cs.tohoku-gakuin.ac.jp), Tomohito Imaizumi, Tomonari Akamatsu (National Research Institute of Fisheries Engineering, Fisheries Research Agency, Hasaki, Ibaraki, Japan), Yong Wang, and Yasushi Nishimori (Furuno Electric Co., Ltd, Nishinomiya, Hyogo, Japan)

Identification and classification of fish species are essential for acoustic surveys of fisheries. The echo from the fish contains components from multiple reflections, including the swimbladder and other organs. The target strength (TS) and temporal structure, which were measured and analyzed by using the broadband signal, were changed dependent on the incident angles and fish species. The cepstral analysis, which was defined as the inverse Fourier transform, was used to discriminate between the spectral pattern associated with the swim bladder and the interference pattern associated with these reflections. Echoes of Japanese jack mackerel (Trachurus japonicus), chub mackerel (Scomber japonicus), and red sea bream (Pagrus major) were measured and analyzed in the sea and tank. It was clarified that the spectral pattern associated the swim bladder was strongly dependent on both the tilt angle and the fish species. [Supported by the Research and Development Program for New Bio-industry Initiatives, and CREST, JST.]

1:15

1pAO2. Exploring the capabilities of an 18-kHz split-beam scientific echosounder for water column mapping and seafloor positioning of methane seeps in the northern Gulf of Mexico. Kevin Jerram, Thomas C. Weber, and Jonathan Beaudoin (Center for Coastal and Ocean Mapping, University of New Hampshire, 24 Colovos Road, Durham, NH 03824, kjerram@ccom.unh.edu)

Underwater methane seeps support diverse biological communities on the seafloor and, in cases of bubble survival to the surface, contribute to the quantity of atmospheric methane. The National Oceanic and Atmospheric Administration (NOAA) ship *Okeanos Explorer* completed two research cruises for seep mapping and characterization in the northern Gulf of Mexico during August and September of 2011 and April of 2012. A 30-kHz Kongsberg EM 302 multibeam echosounder (MBES) and an 18-kHz Simrad EK60 split-beam scientific echosounder were employed to detect and observe seeps during multiple transects over areas of known seep activity at depths of approximately 1500 m. This presentation includes analyses of EK60 data from both research cruises with emphasis on seep mapping in the water column and seep source positioning on the seafloor using EM 302 MBES observations of seeps as benchmarks. Uncertainty associated with interferometric principles employed by the EK60 and limits to midwater positioning capability imposed by its beam pattern are discussed. The importance of sound speed measurement at the transducer face and the effects of refraction correction are estimated by comparison of isovelocity and constant-velocity layer models using sound speed profiles collected during the research cruises.

1:30

1pAO3. Observation of sound fluctuations in presence of internal waves: Difference between refractive and adiabatic regimes. Mohsen Badiey (College of Earth, Ocean, and Environment, University of Delaware, 261 S. College Ave., Robinson Hall, Newark, DE 19716, badiey@udel.edu) and Boris G. Katsnelson (Department of Physics, Voronezh State University, Voronezh, Russian Federation)

Angular dependence of sound field on the internal solitary wave propagation in shallow water has been previously shown [JASA, vol.122, p747-760, 2007]. In the presence of moving nonlinear internal waves, the interaction between sound field and internal waves can vary from refractive, to adiabatic, and mode coupling regimes. The mechanism is largely dependent on the angle between the direction of an acoustic track and wave front of internal waves. For small angles, refraction of horizontal field (focusing and de-focusing) can occur. However, for larger angles, the characteristics of the interaction between the acoustic field and internal waves is very different. For example for angle of about 15-20 degrees, the variations of the sound field follow variations of the sound speed profile while for the angle of about 5 degrees, focusing is observed. In this paper experimental observations and the corresponding modeling results showing the difference between the sound field for the small and larger angles are presented. This observation has prompted theoretical investigation [shown in an accompanying paper, Katsnelson, Badiey, et al.] showing the analytical aspect of the problem. Good agreement between the model and the experimental data is shown. [Work was supported by ONR.]

1:45

1pAO4. Mode-2 internal wave generation and propagation-impact on acoustic signal properties. Marshall H. Orr (Acoustics Division, The Naval Research Laboratory, 4555 Overlook Ave SW, Washington, DC 20375, rubyspiral@gmail.com) and Thomas E. Evans (Remote Sensing Division, The Naval Research Laboratory, Washington, DC)

Mode 2 internal wave spatial distributions, generation, propagation and dissipation in the vicinity of bathymetry variably on the continental shelf and near the shelf break of New Jersey, USA will be overviewed for early fall oceanographic conditions. The 3-D spatial and temporal evolution of

the mode 2 waves, as simulated with the Naval Research Laboratory nonhydrostatic Model for Coastal Oceans, will be compared to tow-yo conductivity, temperature and depth (CTD) and high frequency acoustic flow visualization observations of mode -2 internal waves. Sound speed field perturbation and acoustic field spatial and temporal distributions in the presence of mode-2 internal waves will be summarized.

2:00

1pAO5. Ecosystem-based management: What would Clay do? J. Michael Jech (NEFSC, 166 Water St., Woods Hole, MA 02543, michael.jech@noaa.gov)

Fisheries resource management is in a state of transition from managing populations at the species level to managing living marine resources at the ecosystem level. This transition will require changes in the way data are collected, analyzed, integrated, and finally utilized in management decisions. C. S. Clay "Clay" was a pioneer in underwater acoustics, but my first experiences and interactions with him were as a graduate student biologist learning to observe and understand the underwater environment in new and innovative ways. Clay's collaborations with biologists, ecologists, and oceanographers spawned novel methods of integrating and analyzing disparate data sets and many of these methods are being used today. While Clay's influence on fisheries acoustics has been monumental, his approaches to understanding the ocean environment may be most valuable to ecosystem-based management strategies. I will highlight examples of Clay's innovative approaches that have been used and ways they could be applied to ecosystem-based management and research.

MONDAY AFTERNOON, 22 OCTOBER 2012 — BENNIE MOTEN A/B, 2:00 P.M. TO 4:30 P.M.

Session 1pID

Interdisciplinary: Introduction to Technical Committee Research and Activities: Especially for Students and First-Time Meeting Attendees

Eric A. Dieckman, Cochair
Dept of Applied Science, College of William and Mary, Williamsburg, VA 23187

Samuel L. Denes, Cochair
Acoustics, Pennsylvania State Univ., University Park, PA 16802

Chair's Introduction—2:00

Invited Papers

2:05

1pID1. Introduction to animal bioacoustics. Holger Klinck (Cooperative Institute for Marine Resources Studies, Oregon State University and NOAA Pacific Marine Environmental Laboratory, Hatfield Marine Science Center, 2030 SE Marine Science Drive, Newport, OR 97365, Holger.Klinck@oregonstate.edu)

Animal bioacoustics (AB) covers all matters related to the production, transmission, and reception of sound in nature, as well as the investigation and use of natural sound by people and impacts of anthropogenic sounds by on animals. Topics include animal communication; sound production mechanisms; sound reception mechanisms; evolution of sound production and hearing mechanisms; effects of acoustic propagation on natural sounds; sound detection, classification, localization and tracking; estimating populations and population density; impact of human-generated noise on animals; and a variety of other topics. All animals, and indeed all organisms, are considered within the scope of AB, though the most common taxa are marine mammals, birds, primates and other mammals, fishes, frogs and other amphibians, and insects.

2:15

1pID2. An introduction to the Biomedical Acoustics Technical Committee. Robert McGough (Department of Electrical and Computer Engineering, Michigan State University, 2120 Engineering Building, East Lansing, MI 48824, mcgough@egr.msu.edu)

An overview of the activities of the Biomedical Acoustics Technical Committee will be presented, along with a brief survey of some of the ongoing research projects in Biomedical Acoustics. For example, the Biomedical Acoustics Technical Committee organizes a student poster competition every year, and special sessions are arranged at each meeting to highlight some of the latest research in the diagnostic and therapeutic applications of acoustics. Some of the topics include ultrasound imaging, high intensity focused ultrasound, ultrasound mediated drug delivery, ultrasound contrast agents, ultrasound-induced cavitation, and ultrasound elastography, among several others. In this presentation, selected examples of active research topics in Biomedical Acoustics will also be described in greater detail.

2:25

1pID3. Psychological and physiological acoustics: From sound to neurons to perception … to clinical and engineering applications. Michael Heinz (Speech, Language, and Hearing Sciences & Biomedical Engineering, Purdue University, 500 Oval Drive, West Lafayette, IN 47907, mheinz@purdue.edu)

Psychological and physiological acoustics includes a wide range of multidisciplinary approaches and topics, ranging from basic science to clinical and engineering applications. Research in this area of acoustics is concerned with questions such as how sound is processed once it enters the auditory system (both in humans and other species), how sound is used by organisms to help them communicate and navigate their environment, and how experience and pathology can alter the signal processing of sounds through neural plasticity. Topics include the biomechanics of the middle and inner ear; the neuroscience of the auditory nerve, brainstem, and cortex (including both upward and downward connections); and behavioral and cognitive studies of auditory perception. This talk provides a brief overview of several current areas of research, ranging from basic questions about the neural codes that represent various features of sound in the peripheral and central auditory systems, to clinical applications including the development and improvement of cochlear, brainstem, and midbrain implants that bypass the peripheral auditory system to restore hearing to people with profound hearing loss.

2:35

1pID4. An introduction to current research in Speech Communication. Tessa Bent (Department of Speech and Hearing Sciences, Indiana University, 200 S. Jordan Ave., Bloomington, IN 47405, tbent@indiana.edu)

Speech is a highly complex acoustic signal yet most people can produce and understand speech rapidly and without error. Researchers in Speech Communication—including speech and hearing scientists, linguists, psychologists, and engineers—are deepening our understanding of this amazing process. Topics covered by the Speech Communication Technical Committee include speech production, perception, and acquisition; acoustic phonetics; speech and hearing disorders; neuroscience of speech production and perception; speech intelligibility; communicative aspects of singing; speaker classification and identity; audiovisual speech perception; and speech processing and technology. This presentation will provide a brief overview of some current research areas within Speech Communication including speech acquisition in first language, second language, and bilingual contexts; the impact of speech and hearing disorders on communication; imaging and modeling of speech production using new technologies; and adaptation to novel speech stimuli throughout the lifespan.

2:45

1pID5. Architectural acoustics—Space for sound, and you. Alex Case (Sound Recording Technology, University of Massachusetts Lowell, 35 Wilder St, Suite 3, Lowell, MA 01854, alex@fermata.biz)

The discipline of Architectural Acoustics consistently produces more than 100 papers across 6 or more special sessions, at each meeting of the ASA. Student paper awards, student design competitions, and Knudsen lectures augment these activities. Joint sessions, particularly with Noise, Musical Acoustics, Psychological and Physiological Acoustics, and Signal Processing in Acoustics, add more still to the architectural acoustics goings-on at every ASA conference. The sphere of influence is not limited to ASA alone, as TCAA members participate in the Green Construction Code of the International Code Council, Society of Motion Picture and Television Engineers Study Group: Movie Theater Sound System Measurement and Adjustment Techniques, Classroom Acoustics Standards, the American Institute of Architects Continuing Education System, and more. This busy committee also produces a steady stream of publications documenting recent work and deciphering standards for key stakeholders. Anyone with an interest in the field will find many opportunities to advance their own expertise, build a network of colleagues, friends and mentors, and contribute to the essential activities of the Technical Committee on Architectural Acoustics.

2:55

1pID6. Introduction to the Structural Acoustics and Vibration Technical Committee. James E. Phillips (Wilson, Ihrig & Associates, Inc., 6001 Shellmound St., Suite 400, Emeryville, CA 94608, jphillips@wiai.com)

The Structural Acoustics & Vibration Technical Committee (SAVTC) includes the study of motions and interactions of mechanical systems with their environments and the methods of their measurement, analysis, and control. This talk will provide a broad overview of the many research areas of interest to SAVTC. A few topics will be explored in more depth to provide background on some of the more common analysis methods used by members of the technical committee.

3:05–3:20 Break

3:20

1pID7. Noise and its impact on our world. Erica Ryherd (Mechanical Engineering, Georgia Institute of Technology, Mechanical Engineering, Atlanta, GA 30332-0405, erica.ryherd@me.gatech.edu)

Noise invades all aspects of our lives. The word noise is actually derived from the Latin word “nausea”, with one possible connection being that unpleasant sounds were made by seasick passengers or sailors in ancient times. In modern times, the demand for noise research and consulting has intensified in concert with rising population densities, growing industrialized societies, escalating demands from consumers, and increasingly common standards and legislation related to noise. The Acoustical Society of America Technical Committee on Noise (TC Noise) is concerned with all aspects of noise, ranging from noise generation and propagation, to active and passive methods of controlling noise, to the effects of noise on humans and animals. This talk will explore the broad topic of noise and its impact on our world.

3:30

1pID8. The Engineering Acoustics Technical Committee. Michael V. Scanlon (US Army Research Laboratory, 2800 Powder Mill Road, Adelphi, MD 20783-1197, michael.v.scanlon2.civ@mail.mil)

Engineering Acoustics Technical Committee (EATC) encompasses the theory and practice of creating tools for investigating acoustical phenomena and applying knowledge of acoustics to practical utility. This includes the design and modeling of acoustical and vibrational transducers, arrays, and transduction systems in all media and frequency ranges; instrumentation, metrology, and calibration; measurement and computational techniques as they relate to acoustical phenomena and their utility; and the engineering of materials and devices. EATC's recently sponsored special sessions attracted members from all areas and is an enabler for overlapping interests: single crystal piezoelectrics, transducer design, vector sensors, materials for high power sonar, micromachined silicon mics, multimedia, 3-D audio, pro-audio, parametric sources, speakers, transduction, projection, materials processing and manufacturing, piezocomposites, sensor fusion, signal processing hardware, data communication, condition-based monitoring of machinery and processes, solid-state sensors and actuators, hearing aids and ear impedance, thermoacoustic refrigerators and engines, wind turbines, energy harvesting, computer modeling methods, acoustic barriers & noise control, array applications, metamaterials, systems for underwater vehicles, mufflers & silencers, borehole acoustics, flow noise mitigation methods, and non-destructive testing with ultrasound & non-contact methods.

3:40

1pID9. Signal processing in acoustics: Why not get involved? R. L. Culver (ARL, Penn State University, PO Box 30, State College, PA 16804, rlc5@psu.edu)

The Signal Processing Technical Committee (SPTC) of the ASA provides a forum for discussion of signal processing techniques that transcend any one application. Signal processing research typically presented at ASA meetings includes techniques that show promise in one application - say underwater acoustics - but may also have application to other areas, for example, speech processing or room acoustics. There are two good reasons to get involved in the SP TC. First, since signal processing is an important aspect of many acoustic research areas, you will have the opportunity to better understand new and potentially useful tools. Second, we are a small TC and you can make an immediate contribution.

3:50

1pID10. An introduction to the Physical Acoustics Technical Committee activities. Steven L. Garrett (Grad. Prog. in Acoustics, Applied Research Lab, Penn State University, P.O. Box 30, State College, PA 16804, sxg185@psu.edu)

The primary activity of any ASA Technical Committee is to use collective wisdom of the Committee's membership to determine which research topics within its specialization area are most active and interesting. Based on that assessment, the Committee organizes special sessions at future meetings that will bring together experts from those areas, not necessarily limited to the Society members, who can share interesting results and provide guidance regarding the directions that will lead to further understanding. In Physical Acoustics, that is a particularly daunting challenge given the scope of topics that fall within its purview: use of sound to probe material properties, sound propagation and attenuation mechanisms on this planet and in other parts of the universe, and physical effects of sound and its interaction with other forms of radiation, all of which could also go well beyond the limitations of a linear acoustical theory. Needless to say, involvement in debates about "what's hot" is both interesting and educational. Other activities include proposals for Technical Initiatives that allocate ASA resources. Recently, PATC received funding to sponsor a demonstration session at the Physical Acoustics Summer School.

4:00

1pID11. Overview of Acoustical Oceanography Technical Committee. Aaron Thode (SIO, UCSD, 9500 Gilman Dr, MC 0238, La Jolla, CA 92093-0238, athode@ucsd.edu)

The Acoustical Oceanography (AO) technical committee focuses on the use of sound to study physical and biological processes in the ocean. The broad scope of the committee ensures that many of the research topics overlap those in Underwater Acoustics and Animal Bioacoustics. This presentation will review representative aspects of AO, including long range acoustic tomography, air-sea interactions via studying bubble plumes, fisheries acoustics, and marine mammal acoustic tracking.

4:10

1pID12. An introduction to the Underwater Acoustics Technical Committee. Marcia J. Isakson (Applied Research Laboratories, The University of Texas at Austin, 10000 Burnet Road, Austin, TX 78713, misakson@arlut.utexas.edu)

Acoustics is considered the best means of remote sensing in oceans, lakes, and estuaries due to the high attenuation of electromagnetic radiation in water. The members of the underwater acoustics technical committee are concerned with the generation and propagation of sound in an underwater environment as well as acoustic reflection and scattering from the seabed, sea surface and objects in the water column and on or beneath the seabed. In this talk, a short history of underwater acoustics will be followed by an overview of the current state of research in the field.

4:20

1pID13. An overview of the Musical Acoustics Technical Committee. Andrew Morrison (Joliet Junior College, 1215 Houbolt Rd, Natural Science Department, Joliet, IL 60431, amorrison@jjc.edu)

The technical committee on musical acoustics (TCMU) is concerned with the application of science and technology to the field of music. Many of the sessions organized by the TCMU focus on a particular family of musical instruments. At many Acoustical Society meetings the TCMU has arranged for musical performances related to one or more special sessions. The TCMU has also arranged for tours of sites in the community around past meeting locations. An overview of what students and relative newcomers to the society can expect from the TCMU in general will be presented as well as highlights of what to see at this meeting.

Session 1pMU

Musical Acoustics: Acoustics of the Pipe Organ

Uwe J. Hansen, Chair
Indiana State University, Terre Haute, IN 47803-2374

Invited Papers

1:00

1pMU1. The Research Organ at the Fraunhofer IBP in Stuttgart. Judit Angster (Acoustics, Fraunhofer IBP, Nobelstr 12, Stuttgart 70569, Germany, angster@ibp.fhg.de) and András Miklós (Applied Acoustics, Steinbeis Transfer Center, Stuttgart, Baden Wuerttemberg, Germany)

At the Fraunhofer IBP in Stuttgart a research organ has been built for scientists. Its transparency and unique design allows the demonstration of research results, the investigation of technical and sound problems in organ building as well as the audible testing of sound ideas. Some of the special design features are: The wind system can be switched from traditional to innovative design. Newly developed swell shutters which allow a better dynamic of the sound are mounted in the swell organ. The dimensioning of pipes and wind systems was conducted by means of scaling software developed within the context of European research projects. One wind chest of a division can be exchanged to allow the testing of valves and pipe layouts. In order to test newly designed stops a blind slider is available. There are several blind grooves to analyze the effect of wind flow, of resonances in the grooves and of different outlet holes on the pipe sound. The blowers are driven by a frequency converter for continuous adjustment of wind pressures. The motion of a beating and a free reed can be visualized by means of a stroboscope installed. Some of the research results will be demonstrated.

1:20

1pMU2. The challenge of orchestrating for the organ and the orchestra. Jason L. Raymond (Biomedical Engineering Program, College of Engineering and Applied Science, University of Cincinnati, CVC 3940, 231 Albert Sabin Way, Cincinnati, OH 45267-0586, raymonjl@mail.uc.edu), Christina Haan (College-Conservatory of Music, University of Cincinnati, Cincinnati, OH), and Christy K. Holland (Department of Internal Medicine, Division of Cardiovascular Diseases, College of Medicine, University of Cincinnati, Cincinnati, OH)

Hector Berlioz (1803-1869), though not an organist himself, included descriptions of organ stops, registration, pitch range, and use in orchestral compositions in his Grand Traité d'Instrumentation et d'Orchestration modernes (1855). When discussing the unsuitability of combining the organ with the orchestra, he stated, "…the even and uniform tones of the organ can never fuse completely with the extremely variable sounds of the orchestra…." The objective of our study was to use this statement as a hypothesis to be tested. The relative dissonance of selected organ stops in combination with four orchestral instruments was analyzed using quantitative frequency analysis techniques. Three organs were chosen for study, each built by a different organ company, and each in a different acoustic setting. Four orchestral instruments (violin, flute, oboe, and horn) were chosen for their contrast in timbre and method of sound production. The differences in pitch between the overtones of the organ and instrument were compared in order to quantify the relative dissonance produced by each combination as a function of critical bandwidth of the human ear. In general, the combinations with the oboe and flute resulted in frequency differences less than 2% of the critical band for each overtone, which were perceived as minimally dissonant. In some cases, the violin and horn overtones exceeded 2% and 4% of the critical band, respectively.

1:40

1pMU3. Scanning vibrometry studies of reed dynamics in reed organ pipes. Thomas M. Huber, Lucas Seewald (Physics, Gustavus Adolphus College, 800 W College Ave, Saint Peter, MN 56082, huber@gac.edu), and Charles Hendrickson (Hendrickson Organ Company, Saint Peter, MN)

Unlike most other wind instruments, in reed organ pipes it is not the length of the resonator tube that primarily determines the pitch, but the length of the vibrating reed. The reed, its fluid-structure interaction with the airflow, and feedback from the resonator form a very complicated dynamical system. By utilizing a Polytec PSV-400 scanning laser Doppler vibrometer, it is possible to monitor the operating deflection shapes of a vibrating reed, while using a microphone to monitor the sound production. In the current study, an experienced organ builder made adjustments to the reed/resonator/airflow parameters, both within a musically appropriate range, and for ranges outside of the norm. Results will be presented of the acoustical and vibrational spectral envelope, and the corresponding deflection shapes for each harmonic, for a range of different adjustments to the system. The vibrational results for the reed will be compared to measurements where the non-contact ultrasound radiation force is used to excite the natural resonance frequencies and deflection shapes of the reed in the absence of airflow. In addition to steady-state deflection shapes, results will be presented for the transient dynamics of the system as the airflow into the pipe is initiated.

2:00

1pMU4. Categorical sound characteristics of free-reed pipe-organ stops. Jonas Braasch (School of Architecture, Rensselaer Polytechnic Institute, 110 8th Street, Troy, NY 12180, braasj@rpi.edu)

Organ pipes with free reeds became very popular in parts of Europe at the end of the 18th century, but vanished about 100 years later following a critical discussion about their characteristic sound qualities. The research reported here is based on the measurement and analysis of 11 free-reed organ stops and 15 striking-reed organ stops, as well as 7 flue-pipe organ stops for comparison purposes. The results show that the sound characteristics between free-reed and striking-reed pipes are perceptually distinguishable. Both types of reed stops have their unique set of characteristics. In general, striking-reed pipes have a higher spectral centroid than free-reed pipes. While the overtone spectra of the latter can be fairly similar to those of flue pipes, their onset characteristics do not match the other two types of pipe organ stops. Their fundamental frequencies gradually increase by a semitone over the duration of approximately 60 ms. The frequency shift can be larger for striking-reed pipes, but the duration of the shift is less than half the value for free reeds. In contrast, flue pipes do not usually show such a characteristic frequency shift.

2:20

1pMU5. Aeolian-Skinner Opus 1309 in the Community of Christ Auditorium, Independence, Missouri, USA. Michael Quimby (Quimby Pipe Organs, Inc., PO Box 434, 208 Marshall Street, Warrensburg, MO 64093, qpo1@earthlink.net)

The 113-rank Auditorium organ located in Independence, Missouri, was built by the Aeolian-Skinner Organ Company of Boston, Mass. Immediately after its installation in 1959, the organ became - and remains - perhaps the most important example of the company's work from the period. The commanding display of exposed Great, Positiv, and Pedal pipework forms the visual centerpiece of the massive conference chamber which seats nearly 5,800 people. The main organ is framed by nineteen acoustical clouds suspended above and in front of it, and by choir seating and the large rostrum beneath it. The entire room is covered by a huge dome, culminating in an oculus rising some 100 feet above the floor. G. Donald Harrison, President and Tonal Director of Aeolian-Skinner and one of the twentieth century's most influential organ builders, was responsible for the organ's initial design and specification in the mid-1950s. Following Mr. Harrison's untimely death in 1956, Joseph Whiteford was appointed Tonal Director and, in collaboration with consultants Catharine Crozier and Harold Gleason, finalized the design and formulated the organ's pipe scales. The organ is a superb example of the "American Classic Organ," a concept and design developed by Aeolian-Skinner. (Text by Thomas Brown)

2:40

1pMU6. Acoustics of the pipe organ. Jan Kraybill (Community of Christ Headquarters, 1001 W Walnut St, Independence, KS 64050, jkraybill@CofChrist.org)

An organist's perspective on pipe organ acoustics. The range of frequencies produced by a large pipe organ covers 10 Hz to over 10,000 Hz. Three significant pipe organs in the Kansas City metro area will be discussed: the Julia Kauffman Casavant at the Kauffman Center for the Performing Arts in Kansas City (installation completed early 2012) and the two magnificent instruments at Community of Christ Headquarters in Independence, MO (installations in 1993 and 1959). The acoustic qualities of individual pipes, groups of pipes, and the rooms in which these instruments reside affect the approach which these organs' builders took in designing these one-of-a-kind pipe organs, and the approach each artist takes when making music with them.

Session 1pNS

Noise, Physical Acoustics, Animal Bioacoustics, and ASA Committee on Standards: Outdoor Sound Propagation

Siu-Kit Lau, Cochair
University of Nebraska-Lincoln, Omaha, NE 68182-0816

Kai Ming Li, Cochair
Mechanical Engineering, Purdue University, West Lafayette, IN 47907-2031

Invited Papers

1:00

1pNS1. Excess attenuation and effective impedance associated with rough hard ground. Keith Attenborough, Imran Bashir, and Shahram Taherzadeh (Design, Development, Environment and Materials, The Open University, Walton Hall, Milton Keynes, Buckinghamshire MK7 6AA, United Kingdom, k.attenborough@open.ac.uk)

Although ground effect has been studied widely and is an accepted component of outdoor sound prediction schemes exploitation of ground effect has been restricted to the development of porous road surfaces which influence traffic noise generation as well as propagation. Relatively little attention has been paid to the potential for exploiting the effectively finite impedance associated with roughness small compared with the incident wavelengths on an otherwise acoustically-hard ground or to the potential usefulness of the wide variation in soft ground effects that are available. Results of recent laboratory and field measurements on artificially rough hard surfaces including the comparative acoustical performances of randomly- and periodically-spaced roughness are presented. The laboratory data have been used to study the influences of roughness shape and spacing and surface wave formation. Practical outdoor realisations of artificially roughened hard surfaces have utilised low brick wall configurations and their relative merits have been studied through loudspeaker and car pass by measurements and Boundary Element calculations.

1:20

1pNS2. Estimation of blast noise sound fields over large regions using noise monitors and geostatistical models. Edward T. Nykaza, Michael J. White (US Army Corps of Engineers, Engineer Research and Development Center, 2902 Newmark Drive, Champaign, IL 61822, edward.t.nykaza@erdc.dren.mil), D. Keith Wilson (US Army Corps of Engineers, Engineer Research and Development Center, Hanover, NH), and Anthony A. Atchley (College of Engineering, The Pennsylvania State University, University Park, PA)

This study explores the feasibility of accurately estimating blast noise levels over a large region between and beyond noise monitoring stations using geostatistical models. The potential improvements over propagation modeling include faster computations, fewer assumptions, and improved accuracy. The estimation models explored include kriging, simple interpolation, and models that include meteorological and terrain parameters commonly incorporated into outdoor sound propagation models. The estimation models are evaluated using both experimentally measured and simulated noise monitor data gathered under various atmospheric conditions in several large regions (e.g., greater than 16 km^2). The performance of using geostatistical-based estimation models is discussed in terms of the uncertainty of sound pressure field estimates, sensitivity to atmospheric variability, sensor density and geometry configuration, and model validation.

1:40

1pNS3. Aircraft sound transmission in homes categorized by U.S. climate regions. Erica Ryherd and Nathan Firesheets (Mechanical Engineering, Georgia Institute of Technology, Atlanta, GA 30332-0405, erica.ryherd@me.gatech.edu)

Current aircraft noise guidelines are based primarily on outdoor sound levels. However, human perception is highly related to indoor response, particularly for residences. A research project is being conducted that provides insight into how typical residential dwelling envelopes affect indoor sound levels. A focus is being placed on non-sonic boom aircraft noise, using continuous noise signatures of commercial aircraft overflights. Typical construction types in various U.S. climate regions have been identified and used to develop model predictions of indoor noise levels. Further, the impacts of systematically altering construction variables such as construction material and window to wall ratio is being investigated. Results will be used to understand trends for expected noise reduction for typical construction types around the U.S.

2:00

1pNS4. Recent advances in sound propagation above a non-locally reacting ground. Kai Ming Li (Mechanical Engineering, Purdue University, 140 South Martin Jischke Drive, West Lafayette, IN 47907-2031, mmkmli@purdue.edu)

In the absence of atmospheric effects, the sound fields above a locally reacting ground can be accurately predicted by the Weyl-van der Pol formula. The solution is based on an asymptotic analysis to yield two terms: a direct and a ground reflected wave terms. The reflected wave term can be written as a product of a spherical wave reflection coefficient and the sound reflected from a rigid ground. In the contrary, it is more challenging to derive a similar formula for the sound fields above non-locally reacting grounds. In the past, an approximation in the same form as the Weyl-van der Pol formula has been used which becomes inadequate for layered grounds. In this presentation, a brief review of the asymptotic analysis will be discussed. An overview of the analytical and numerical approaches will be presented for obtaining accurate prediction of sound fields above the non-locally reacting ground. It will be further demonstrated that the reflection coefficient can be split exactly into two terms - a plane wave reflection coefficient and a ground wave term involving the boundary loss factor. The correlation between the numerical distance and the location of the surface wave pole will be examined.

2:20

1pNS5. A hybrid computational method for computing urban canyon sound fields exhibiting roughness. Carl Hart and Siu-Kit Lau (University of Nebraska - Lincoln, 1110 S 67th St, Omaha, NE 68182, carl.hart@huskers.unl.edu)

Predicting the three-dimensional sound field within an urban canyon is essential for urban noise assessment. Several analytical and computational methods exist to predict the canyon sound field. Generally building facades can be characterized as both geometrically reflecting and dispersive. The image source method is well suited to scenarios where surfaces are geometrically reflecting. Given dispersive surfaces the radiosity method predicts the sound field well. On the other hand a canyon exhibiting geometric and dispersive facades requires a computationally intensive technique such as the finite-element method (FEM) or the boundary-element method (BEM). Due to computational limitations neither the FEM nor BEM are well suited for computing large, unbounded, three-dimensional, urban canyon domains. A prediction method which synthesizes adaptive beam tracing and a secondary model for edge diffraction serves as an alternative technique for analyzing urban canyon acoustics, which contain façades exhibiting both geometric and dispersive surfaces. Advantages of the hybrid method include the ability to model unbounded domains simply, no requirement for discretizing geometric boundaries, and the ability to model sound propagation in the time domain. The magnitude of acoustic dispersion from a surface is related to surface roughness. The effect of surface roughness on the canyon sound field is investigated.

Contributed Papers

2:40

1pNS6. A single-bounce method for estimating impulse propagation and attenuation in a forest. Michelle E. Swearingen (US Army ERDC, Construction Engineering Research Laborartory, P.O. Box 9005, Champaign, IL 61826, michelle.e.swearingen@usace.army.mil) and Donald G. Albert (US Army ERDC, Hanover, NH)

There are numerous methods for determining the impact of interactions with multiple scattering objects on a propagating signal. Many of these methods assume that the signal is continuous in time, allowing one to neglect time dependence. Additionally, these methods make assumptions about the spatial distribution of scattering objects, such as lattice or random, and many assume that the scattering objects are all identical. Real forests often have trees of varying trunk diameters and may be arranged in a grid, in clusters, or random, and the assumptions of uniform size and particular spatial distributions introduce error into the assessments. A simple model, based on single bounces from trunks, is developed to begin estimating the propagation of an impulsive signal through this complicated multiple scattering environment. The scattering algorithm takes the frequency-dependent radial scattering pattern of a cylinder into account. Results are compared to data collected in a forest stand where the locations and diameters of trunks were carefully recorded. These comparisons provide insight into whether a single, discrete bounce method is sufficient for modeling impulse propagation in this complex environment, or whether multiple discrete bounces or some other method should be explored.

2:55

1pNS7. Investigations of measured temperature and wind effects on outdoor sound propagation. Lauren M. Ronsse, Dan Valente, Edward T. Nykaza, and Michael J. White (Construction Engineering Research Laboratory, US Army Engineer Research and Development Center, P.O. Box 9005, Champaign, IL 61826-9005, Lauren.Ronsse@erdc.dren.mil)

Temperature and wind effects on outdoor sound propagation have been well-studied in numerous theoretical investigations, leading to a number of commonly held beliefs about how weather affects outdoor propagation. For example, louder sound levels are expected when downwind propagation and temperature inversions are present, whereas lower levels are expected when upwind propagation and temperature lapses exist. However, the validity of such relationships has not been rigorously tested in the field for various terrains at long distances from an outdoor source. One is justified in questioning the validity of these relationships due to the difficulty of adequately modeling the dynamic atmosphere along the entire propagation path. This study examines some commonly held notions of outdoor sound propagation by experimentally investigating the effects of temperature gradients and wind speed/direction on sound propagation at long distances from a typical impulsive source. Temperature and wind conditions measured near the source and along the line of sound propagation are correlated with the received sound pressure levels recorded at distances up to 15 km from the source. The variability of peak sound pressure levels occurring under similar wind and temperature conditions is assessed, demonstrating that much complexity underlies these common aphorisms.

3:10–3:30 Break

3:30

1pNS8. A modified saddle point method for predicting sound penetration into a rigid-porous ground. Hongdan Tao and Kai M. Li (Purdue University, 140 S. Martin Jischke Drive, West Lafayette, IN 47907, htao@purdue.edu)

An approximate analytical formula has been derived for the prediction of sound penetration into a semi-infinite rigid porous ground due to a monopole source. The sound fields can be expressed in an integral form that is amenable to analytical and numerical analyses. A modified saddle point method is applied to evaluate the integral asymptotically that leads to a closed form expression. The validity of the asymptotic formula is confirmed by comparing with the numerical results computed by the fast field formulation and the direct evaluation of the integral. It has been demonstrated that the present analytical formula is sufficiently accurate to predict the penetration of sound into the semi-infinite rigid porous ground. Furthermore, the sound fields predicted by modified saddle point are compared with that

computed by the double saddle point method. It is found that these two asymptotic schemes give precise solutions at far fields but the modified saddle method is more accurate at the near field especially when both the source and receiver are close to the air/ground interface. [Research is partially funded by the China Research Scholarship Council.]

3:45

1pNS9. Wind noise reduction in a non-porous subsurface windscreen. Allan J. Zuckerwar (Analytical Services and Materials, 1052 Research Drive, Hampton, VA 23666-1340, ajzuckerwar@yahoo.com), Qamar A. Shams, and Keith Knight (NASA Langley Research Center, Hampton, VA)

Measurements of wind noise reduction were conducted on a box-shaped, subsurface windscreen made of closed cell polyurethane foam. The windscreen was installed in the ground with the lid flush with the ground surface. The wind was generated by means of a fan, situated on the ground, and the wind speed was measured at the center of the windscreen lid with an ultrasonic anemometer. The wind speed was controlled by moving the fan to selected distances from the windscreen. The wind noise was measured on a PCB Piezotronics 3" electret microphone. Wind noise spectra were measured with the microphone exposed directly to the wind (atop the windscreen lid) and with the microphone installed inside the windscreen. The difference between the two spectra comprises the wind noise reduction. At wind speeds of 3, 5, and 7 m/s, the wind noise reduction is typically 15 dB over the frequency range 0.1-20 Hz.

4:00

1pNS10. Measurements of acoustic transmission loss over a rough water surface. Cristina Tollefsen and Sean Pecknold (Defence Research and Development Canada - Atlantic, P.O. Box 1012, Dartmouth, NS B2Y 3Z7, Canada, cristina.tollefsen@gmail.com)

Recent interest in understanding acoustic propagation over rough water surfaces has been driven largely by the increasing presence of offshore wind turbines and concerns about the potential for community noise disturbance. In addition, there has been interest in evaluating directional acoustic hailing devices for use at sea, in determining potential environmental impact of naval gunfire exercises, and in understanding the in-air acoustic footprint of maritime-based military assets. Measurements of acoustic transmission loss over a rough water surface were made during the period of 3 Oct and 7 Dec 2011 near Halifax, Nova Scotia, Canada. The acoustic source was a propane cannon, firing four consecutive shots once per hour during daylight hours. A receiver was positioned at ranges of 2 km to 7.5 km from the source, with a clear line-of-sight across the water, for periods ranging from 5-21 days at each location. Temperature, wind velocity, relative humidity, and ocean surface wave height were acquired from a variety of sources, including point measurements, radiosonde profiles, and output from an atmospheric forecasting model (Environment Canada's Global Environmental Multiscale [GEM] model). The measured values of transmission loss are compared to results obtained with a parabolic equation-based atmospheric acoustic propagation model.

4:15

1pNS11. Noise exposure profiles for small-caliber firearms from 1.5 to 6 meters. William J. Murphy (Hearing Loss Prevention Team, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, 4676 Columbia Parkway, Mailstop C-27, Cincinnati, OH 45226-1998, wjm4@cdc.gov), Gregory A. Flamme (College of Health and Human Services, Western Michigan University, Kalamazoo, MI), Edward L. Zechmann, Caroline Dektas (Hearing Loss Prevention Team, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, Cincinnati, OH), Deanna K. Meinke (Audiology and Speech-Language Sciences, University of Northern Colorado, Greeley, CO), Michael Stewart (Communication Disorders Department, Central Michigan University, Mount Pleasant, MI), James E. Lankford (Allied Health and Communication Disorders, Northern Illinois University, DeKalb, IL), and Donald S. Finan (Audiology and Speech-Language Sciences, University of Northern Colorado, Greeley, CO)

Small caliber firearms (rifles, pistols and shotguns) are commonly used at outdoor firing ranges for training in shooting skills, job qualification and for recreation. Firearm noise from fifty-four weapons was measured at an outdoor range in the near field (6 meters and closer) of the weapons using a radial array of 18 microphones centered on the shooter's head. Each weapon was fired five times and the microphone array was sampled at 200 kHz with at least 16-bit resolution. Peak sound pressure levels and damage risk criteria (e.g. MIL-STD 1474D, 8-hour Equivalent A-weighted Level (LAeq8), and Auditory Hazard Assessment Algorithm for Humans (AHAAH)) were computed for each microphone and compared across weapon type, caliber and load. The acoustic propagation from the muzzle to the microphone was modeled using a simple image source over a reflecting plane. The impedance of the ground was estimated from the observed data and was used to compare the measured waveforms with the estimated waveforms. These data will be used to model the exposures for multiple shooters and observers standing at or behind the firing line.

4:30

1pNS12. Effects of inclusion shapes within rigid porous materials on acoustic performance. Hyun Hong and Siu-Kit Lau (Charles W. Durham School of Architectural Engineering and Construction, University of Nebraska-Lincoln, 1110 S. 67th Street, Omaha, NE 68182, slau3@unl.edu)

The present study investigates the influence of various shapes of inclusions having same volume embedded in a porous rigid material. Previous studies showed improvement of the broadband sound absorption with particular shapes of inclusions. However, different volumes of the inclusions have been considered; therefore, the bulk densities are not the same for comparison. The present study extends the investigations of inclusions in porous materials with same volume (or bulk density) to eliminate the influence by the change of bulk density. The effects of shape will be discussed. Finite element modeling will be used for this study. Total four different shapes: circle, square, ellipse, and triangle, have been studied at various orientations. It has been found that specific configurations can be able to improve the broadband sound absorption compared with reference (no inclusion). It is being expected that a better control of sound absorption of porous materials at desired frequency range can be achieved with the results of the present study.

Session 1pPA

Physical Acoustics and Biomedical Acoustics: Memorial Session for Wesley Nyborg

Lawrence A. Crum, Cochair
Applied Physics Laboratory, University of Washington, Seattle, WA 98105

Junru Wu, Cochair
Physics, University of Vermont, Burlington, VT 05405

Chair's Introduction—1:00

Invited Paper

1:05

1pPA1. Wesley Nyborg and bioacoustics at the University of Vermont. Junru Wu (Physics, University of Vermont, Cook Bldg, Burlington, VT 05405, jwu@uvm.edu)

Wesley Nyborg, Physics Professor Emeritus at the University of Vermont, passed away on September 24, 2011 after a full and wonderful life of 94 years. Wes came to the University of Vermont in 1960 where he did his most pioneering research in microstreaming, acoustic radiation pressure and bioeffects of ultrasound. He was considered as one of most influential pioneers by the international biomedical ultrasound community. Wesley Nyborg has developed an active bioacoustics and biomedical ultrasound research in the university. His research was continuously supported over 20 years by NIH. In this presentation, his research and life with the university will be reviewed.

Contributed Papers

1:25

1pPA2. Wes and Ed and the minus sign—A tale of two giants. Charles C. Church (NCPA, University of Mississippi, 1 Coliseum Drive, University, MS 38677, cchurch@olemiss.edu)

Once upon a time there was a young lad who liked to stroll through the Land of Bioacoustics. It was a pleasant land filled with many things that this fellow found very interesting indeed, but there were also giants. These giants had powerful names like Wes and Ed, and they understood many things that were hidden from the lad. One of these was how to calculate the force exerted by a traveling wave on an object in an acoustic field. With some trepidation, the fellow asked the giants to explain the proper way to make the calculation. "Certainly lad," said Wes, "Here's how to do it." "Oh," said Ed, "but what about this?" Each gave him a paper, and he studied them hard, turning them this way and that, and what did he find? The answers were the same. Well almost. One had a minus sign where the other did not. "I don't understand," said the lad, "How can this be?" "We're really not sure," said the giants, "We'll have to discuss it. We'll tell you tomorrow, or in a month or a year." To learn what they said finally, come to Kansas City to hear.

1:40

1pPA3. Acoustic and optical characterization of ultrasound contrast agents via flow cytometry. Camilo Perez, Andrew Brayman (Center for Industrial and Medical Ultrasound (CIMU), University of Washington Applied Physics Laboratory, 1013 NE 40th Street, Seattle, WA 98105-6698, camipiri@uw.edu), Juan Tu (Key Laboratory of Modern Acoustics, Nanjing University, Nanjing, Jiang Su, China), Jarred Swalwell, Hong Chen, and Tom Matula (Center for Industrial and Medical Ultrasound (CIMU), University of Washington Applied Physics Laboratory, Seattle, WA)

Characterizing ultrasound contrast agents (UCAs) involve measuring the size and population distribution. However, these instruments do not allow for characterization of shell properties, which are important for (1) stability to administration and circulation throughout the vasculature; (2) UCA response to ultrasound; and (3) conjugating ligands for molecular imaging. Thus it is critical to understand the physical and rheological properties of shells. We previously developed a light scattering technique to characterize the shell properties of UCAs [Guan and Matula, JASA, Vol 116(5), 2004; Tu, et al., IEEE Trans. Ultrason., Ferroelec., and Freq. Control, vol. 58(5), 2011]. The most recent manifestation involves a flow cytometer modified with a custom square quartz flow cell in place of the standard nozzle and fluid jet. Acoustic coupling to the carrier sheath fluid and UCA samples occurred through a PZT bonded to one side of the flow cell. The PZT-driven UCA oscillations were processed and fitted to the Marmottant UCA model. Shell properties for UCAs (including Definity, Optison, SonoVue, and even homemade bubbles) were determined. The focus of this talk will be on pressure calibration and additional measurements of unpublished data from Optison and homemade bubbles. (Funded in part by the Life Sciences Discovery Fund #3292512)

1:55

1pPA4. Gauging the likelihood of stable cavitation from ultrasound contrast agents. Kenneth B. Bader and Christy K. Holland (Internal Medicine, University of Cincinnati, 231 Albert Sabin Way, Cincinnati, OH 45267-0586, Kenneth.Bader@uc.edu)

Clinical ultrasound scanners use the Mechanical Index (MI) to gauge the potential for bioeffects due to inertial cavitation. However, the advent of ultrasound contrast agents (UCA) introduces nucleation mechanisms for bubble activity far different than that assumed in the development of the MI. Such exogenous agents promote bubble activity at substantially lower acoustic pressures than those required for inertial cavitation. The onset of this type of gentle bubble activity is within a stable cavitation regime. The minimum thresholds of both stable cavitation (as indicated by the onset of subharmonic oscillations) and the rupture of UCA were numerically calculated as a function of frequency. Both of these thresholds were found to depend linearly on frequency, and a "cavitation index" will be introduced. This index will be compared to the MI and compared to bioeffects studies in the literature. This cavitation index is not intended to replace the MI. Rather, it may be used to gauge the destruction of UCA, or promote bubble activity

to induce beneficial bioeffects mediated by stable cavitation. This work was supported by the National Institutes of Health, grant numbers NIH RO1 NS047603, NIH RO1 HL059586, and NIH RO1 HL74002.

2:10

1pPA5. Engineering tissues with ultrasound heating, radiation force, and cavitation. Diane Dalecki (Biomedical Engineering, University of Rochester, 310 Goergen Hall, P.O. Box 270168, Rochester, NY 14627, dalecki@bme.rochester.edu) and Denise C. Hocking (Pharmacology and Physiology, University of Rochester, Rochester, NY)

Wesley Nyborg was a pioneer in the field of biomedical ultrasound. His theoretical and experimental work forms the foundation for our understanding of the biological effects of ultrasound. He developed fundamental theories of the physical mechanisms of interaction of ultrasound with tissues, including heating, radiation force, and cavitation. In this presentation, we discuss our development of three ultrasound technologies that employ heating, radiation force, or cavitation to address important challenges in tissue engineering. One technology uses radiation forces developed in an ultrasound standing wave field to spatially pattern cells within engineered tissues. The resultant ultrasound-induced patterning can lead to extracellular matrix remodeling, collagen reorganization, and the rapid formation of a vascular network. A second technology uses ultrasound to control the microstructure of collagen within engineered tissues via a thermal mechanism. Through control of ultrasound heating, engineered tissues can be fabricated with spatial variations in collagen microstructures. The structure of extracellular matrix proteins directs cell behaviors important for tissue formation. In the third technology, ultrasound is used to alter the conformation of another extracellular matrix protein, fibronectin, likely through a cavitation mechanism. These studies highlight how fundamental principles of ultrasound-tissue interactions can be used to develop novel tools for tissue engineering.

2:25–3:10 Break

3:10

1pPA6. Nucleating and sustaining acoustic cavitation for biomedical applications. Tyrone M. Porter (Mechanical Engineering, Boston University, 110 Cummington St, Boston, MA 02215, tmp@bu.edu)

Wes Nyborg was a pioneer in the field of biomedical ultrasound. In particular, Nyborg conducted extensive studies that provided insight into how bubbles oscillating in liquids generated forces that could alter the anatomy and/or physiology of cells. While these studies demonstrated that acoustic cavitation is instrumental in a variety of bioeffects, nucleating and sustaining acoustic cavitation in a controlled manner has proven to be a challenge, particularly in vivo. Studies have shown that these challenges can be addressed with the use of novel materials, particles, and/or acoustic pulsing schemes. In particular, pH-sensitive polymers with varying hydrophobicity have been used to sustain cavitation/cell interactions and vaporizable perfluorocarbon nanoemulsions have been used to reduce the pressure threshold for cavitation nucleation. The impact of these materials and particles on cavitation-mediated bioeffects will be discussed.

3:25

1pPA7. Tracking the motion of cavitation bubbles using pulsed Doppler. E. C. Everbach (Engineering, Swarthmore College, 500 College Avenue, Swarthmore, PA 19081, ceverba1@swarthmore.edu)

Echo-contrast agent microbubbles in blood can sometimes penetrate a clot that is blocking bulk flow in the vessel. When ultrasound is applied for the purpose of sonothrombolysis, microbubbles can be forced by acoustic radiation force into the clot matrix. To monitor the extent of this penetration, a 20 MHz pulsed Doppler method was employed to measure both the position of the bubble front in the clot and its velocity. Correlations between clot dissolution and the location of the advancing microbubble front may be used to optimize cavitational activity and improve sonothrombolysis.

3:40

1pPA8. Recent advances concerning acoustic radiation forces and torques and Wes Nyborg's helpful discussion of acoustic streaming. Philip L. Marston, L. K. Zhang, and David B. Thiessen (Physics and Astronomy Dept., Washington State University, Pullman, WA 99164-2814, marston@wsu.edu)

Recent theoretical advances concerning the geometrical interpretation of acoustic radiation forces [L. K. Zhang and P. L. Marston, Phys. Rev. E 84, 035601R (2011); L. K. Zhang and P. L. Marston, J. Acoust. Soc. Am. 131, EL329-EL335 (2012)] and the scaling of acoustic radiation torques for symmetric objects in beams and in standing waves with increasing helicity [L. K. Zhang and P. L. Marston, Phys. Rev. E 84, 065601R (2011)] will be summarized. For spheres in beams it has been possible to find situations giving transversely stable radiation forces using finite elements. The predicted scaling properties of acoustic torques have been verified in an investigation by an independent group [C. E. M. Demore et al., Phys. Rev. Lett. 108, 194301 (2012); A. G. Smart, Physics Today 65 (6), 18-20 (2012)]. This work will be examined in the context of broader discussions with, and/or a few of the interests of, Wes Nyborg and his practical analysis of acoustic streaming [W. L. Nyborg, in Nonlinear Acoustics, edited by M. F. Hamilton and D. T. Blackstock (Academic Press, San Diego, CA, 1998)] pp. 207-231. [Marston and Thiessen were supported in part by ONR. Zhang was supported in part by NASA.]

3:55

1pPA9. Acoustic streaming in therapeutic ultrasound. Lawrence A. Crum (Applied Physics Laboratory, University of Washington, 1013 NE 40th Street, Seattle, WA 98105, lac@apl.washington.edu)

Wesley Nyborg's contributions to a theoretical description of acoustic streaming were pioneering, rigorous, and so thorough that little additional work has been published. Acoustic streaming has had many applications in acoustics, especially medical acoustics, in which it is difficult to avoid. In many cases, it can be used to enhance or accelerate a particular therapeutic effect. This presentation will provide a few examples of the role of acoustic streaming in therapeutic ultrasound as well as share a few warm memories of this kind and generous man. [Work supported in part by the NIH and NSBRI.]

4:10–4:40 Panel Discussion

Session 1pUW

Underwater Acoustics: Reverberation and Scattering

John R. Preston, Chair
ARL, Pennsylvania State Univ., State College, PA 16804

Contributed Papers

2:30

1pUW1. Planning for a reverberation field experiment. Dajun Tang, Brian T. Hefner, Kevin L. Williams, Jie Yang, and Eric I. Thorsos (Applied Physics Lab, Univ. of Washington, 1013 NE 40th St., Seattle, WA 98105, djtang@apl.washington.edu)

A basic research reverberation experiment, supported by the US Office of Naval Research, is planned for 2013. Measurement issues that arise when planning such an experiment are discussed. The fundamental requirement for this basic research experiment is that the environment is characterized in sufficient detail to allow accurate numerical modeling of the acoustical results based on the environmental description. The main goal is to measure mid-frequency shallow water reverberation with full companion environmental measurements so that model/data can be compared without ambiguity. Included in the goal is to make statistical estimates of the uncertainties associated with all the environmental conditions. The frequency range of interest is 1-10 kHz with emphasis at 3 kHz. A pilot field experiment was conducted off the coast of Panama City, Florida. Data from the pilot experiment will be discussed in light of the forthcoming main experiment, including simulations on both propagation/forward-scatter and reverberation for given noise background on both vertical and horizontal arrays which will be deployed in the main experiment.

2:45

1pUW2. Scattering enhancements for partially exposed cylinders at a free surface caused by Franz waves: Measurements and geometric model. Grant C. Eastland and Philip L. Marston (Physics and Astronomy Dept., Washington State University, Pullman, WA 99164-2814, marston@wsu.edu)

Creeping waves on solid cylinders having slightly subsonic phase velocities and large radiation damping are usually described as Franz waves because of their association with complex poles investigated by Franz. For free-field high frequency broadside backscattering in water, the associated echoes are weak due to the radiation damping. It is demonstrated here, however, that for partially exposed solid metal cylinders at a free surface viewed at grazing incidence, the Franz wave echo can be large relative to the specular echo even for ka above 20 when the grazing angle is sufficiently small. The reason is that at small grazing angles and small exposures, the Fresnel zone associated with the specular echo is occluded so that the specular echo is weak [K. Baik and P. L. Marston, IEEE J. Ocean. Eng. 33, 386 (2008)] while the Franz wave is partially reflected at the interface. This has been confirmed from the evolution of echo timing with cylinder exposure and by SAS imaging. In the experiment a solid cylinder was slowly lowered through the free surface into the water. In bistatic scattering a Franz echo can be present with small exposure without the Franz wave reflecting from the free surface. [Supported by ONR.]

3:00

1pUW3. Computation of backscattering enhancements by a half-exposed rigid cylinder at a free surface caused by Franz waves. Anthony R. Smith, Daniel S. Plotnick, Grant C. Eastland, and Philip L. Marston (Physics and Astronomy Dept., Washington State University, Pullman, WA 99164-2814, marston@wsu.edu)

Recent observations of the backscattering by partially-exposed solid aluminum cylinders in water viewed at grazing incidence at a free surface [G. C. Eastland, Ph.D. thesis, Wash. State Univ., 2012] indicate that the generation, propagation, and reflection of Franz-type creeping waves can be important. The present investigation gives additional support for this hypothesis by calculating the exact backscattering by a half-exposed infinitely long rigid cylinder viewed over a range of grazing angles. The calculation begins with the known frequency domain expression for the complex amplitude given in an Appendix of [K. Baik and P. L. Marston, IEEE J. Ocean. Eng. 33, 386 (2008)]. Numerical Fourier transforms were used to construct the time-domain response for various excitations and the evolution of that response was investigated as a function of the grazing angle. This procedure reveals from the timing of the computed features there is a significant delayed echo having the expected timing of a Franz wave partially reflected from the free surface. The timing of the Franz wave depends on grazing angle in agreement with a geometric model in Eastland's thesis. [Supported by ONR.]

3:15

1pUW4. Some initial findings from the very shallow water GulfEx12 reverberation experiments. John R. Preston (ARL, Penn State Univ., P.O. Box 30, MS3510, State College, PA 16804, jrp7@arl.psu.edu)

In April 2012, reverberation and clutter measurements were taken in very shallow water (~20 m) over a 40 hour period off Panama City, FL. This work describes the data from this recent sea trial called GULFEX12 designed to characterize reverberation and clutter from a very shallow water site in the 2500-5500 Hz band. The received data are taken from one aperture of the Five Octave Research Array (FORA) namely, the triplet sub-aperture. The array was fixed 2 m off the sea floor by mounting it to tripods using a clothes line and data were passed by cable to a nearby moored ship (the R/V Sharp). An ITC source transducer was located 3 m away from the array center. Data show a surprising amount of anisotropy. Five different pulses were used in this study. Matched filtered polar plots of the reverberation and clutter are presented using the FORA triplet beamformer to map out anisotropy. Some model data comparisons are made using the author?s normal mode based reverberation model. Help from D.J. Tang, T. Hefner and K. Williams of Applied Physics Lab at Univ. of Washington was crucial to this effort. [Work supported by ONR code 322OA.]

3:30

1pUW5. Scattering of low-frequency spherical waves by fluid and solid spheres. Oleg A. Godin (CIRES, Univ. of Colorado and NOAA Earth System Research Laboratory, Physical Sciences Div., Mail Code R/PSD99, 325 Broadway, Boulder, CO 80305-3328, oleg.godin@noaa.gov)

Acoustic Green's functions for a homogeneous fluid with an embedded spherical obstacle arise in analyses of sound scattering by air bubbles, scattering by objects on or near the seafloor, radiation by finite sources, sound attenuation in and scattering from clouds of suspended particles, etc. Here, radius of the obstacle is assumed to be small compared to the wavelength of sound. This regime is usually referred to as Rayleigh scattering. A new, elementary solution of the problem of diffraction of a spherical wave was recently obtained for small, soft obstacles [O. A. Godin, J. Acoust. Soc. Am. **37**, L13605 (2010)]. The solution is valid for arbitrary positions of the source and receiver relative to the obstacle. In this paper, the solution is extended to homogeneous and inhomogeneous fluid and solid spheres. Low-frequency scattering is found to be rather sensitive to boundary conditions on the surface of the obstacle. Resonance scattering of spherical waves by small spheres is investigated. [Work supported, in part, by ONR.]

3:45

1pUW6. Fast model for target scattering in a homogeneous waveguide. Steven G. Kargl, Kevin L. Williams, and Aubrey L. Espana (Applied Physics Laboratory, University of Washington, 1013 NE 40th St, Seattle, WA 98105, kargl@apl.washington.edu)

A fast ray model for propagation in a homogenous water column tracks time-of-flight wavepackets from sources to targets and then to receivers. The model uses image sources and receivers to account for interactions with the water column boundaries, where the layer of water lies between an upper semi-infinite halfspace of air and a lower semi-infinite halfspace of a homogenous sediment. The sediment can be either an attenuating fluid with a frequency-independent loss parameter or a fluid consistent with an effective density fluid model (i.e., a fluid limit to Biot's model for a fluid-saturated poroelastic medium). The target scattering process is computed via convolution of a free-field scattering form function with the spectrum of an incident acoustic field at the target location. A simulated or measured scattered free-field pressure from a complicate target can be reduced to a scattering form function, and this form function then can be used within model via interpolation. The fast ray-based model permits the generation of sets of realistic pings suitable for synthetic aperture sonar processing for proud and partially buried target. Results from simulations are compared to measurements where the targets are an inert unexploded ordnance and aluminum cylinder. [Research supported by SERDP and ONR.]

4:00

1pUW7. Supervised machine learning for classification of underwater target geometry from sampled scattered acoustic fields in the presence of rough bottom interference. Erin M. Fischell and Henrik Schmidt (Mechanical Engineering, MIT, 77 Massachusetts Ave., Cambridge, MA 02139, emf43@mit.edu)

An increasingly important mission for Autonomous Underwater Vehicles (AUVs) is the identification and classification of potentially hazardous targets in harbors. A process is demonstrated in simulation that would allow AUV in-flight classification of spherical and cylindrical targets using only scattered acoustic amplitudes collected at waypoints. Target and bottom roughness scattered fields are simulated using OASES and SCATT, then combined and sampled into independent training and testing examples for a Support Vector Machine (SVM). The feature space and parameters for the SVM are selected using a design of experiments grid search. By processing the model using a feature reduction algorithm, it is possible to identify the regions in the scattered field that are the most critical for classification. To make use of the resulting models and critical features, a vehicle in the field would be loaded with pre-generated models for bottom and target classification. Upon target localization, the vehicle would begin visiting the critical waypoints until a confident classification is achieved using the SVM models. The resulting in-flight classification, based only on amplitude data collected by a hydrophone along the vehicle's path, could be used as the basis for further action on the target. [Work supported by ONR and NSF GRFP.]

4:15

1pUW8. Simulating coherent backscatter enhancement from aggregations of underwater scatterers. Adaleena Mookerjee and David R. Dowling (Mechanical Engineering, University of Michigan, Ann Arbor, MI 48105, adaleena@umich.edu)

Remote classification of scatterers is an enduring priority in active sonar applications. For aggregations of marine life, typically schools or shoals of fish, remote classification may be possible when there is coherent backscattering enhancement (CBE) from the aggregation. CBE is a multiple scattering phenomenon that occurs in optics and acoustics when wave propagation paths within the aggregation are likely to be traversed in both directions. For a plane wave illuminating a half-space of randomly-placed, omnidirectional scatterers, CBE may lead to a doubling of the scattered field intensity in the direction opposite that of the incident wave (Akkermans et al. 1986). This presentation describes acoustic CBE simulations for finite-size spherical aggregations of point scatterers. The results are developed from the classical multiple-scattering equations of Foldy (1945), and are checked to ensure appropriate rotational symmetries and acoustic energy conservation when scatterer locations are random and when they are structured. Variations in the magnitude of the CBE peak and its angular width are presented for different frequencies, aggregation sizes, scatterer densities, and scatterer properties. Extension of these results to sonar-pulse scattering from schools of fish will be discussed. [Supported by the Office of Naval Research.]

4:30

1pUW9. Frequency response of ordnance replicas across multiple scales. Christopher Dudley, Jermaine Kennedy, Kwang Lee, and David Malphurs (Naval Surface Warfare Center, Panama City Division, 110 Vernon Ave, Panama City, FL 32407, mhhd@hotmail.com)

Broad-band, multi-aspect backscatter data obtained using small-scaled and full-scaled replicas of Unexploded Ordnance (UXO) are reported. Data were collected using either linear or circular rail systems. The experiments were performed in: (1) NSWC PCD's small scale test bed (less than 1/16 scaled) which has a simulated bottom, (2) NSWC PCD's Facility 383 9-million gallon fresh water test pool which has a 5-ft sand bottom, and (3) the Gulf of Mexico during GULFEX12 off Panama City, Florida. Data were processed using linear and circular synthetic aperture sonar techniques to generate both images and plots of target strength as functions of frequency and aspect angle. The results from all three experiments are compared to each other and with predictions from Finite-element (FE) analysis. These comparisons are used to assess the utility of alternative methods for generating sonar data from bottom targets of sufficient fidelity to study scattering phenomena and support development of automated target recognition. [Work supported by ONR Code 32 and SERDP.]

Payment of additional registration fee required to attend. See page A?

MONDAY EVENING, 22 OCTOBER 2012 COLONIAL, 7:00 P.M. TO 9:00 P.M.

Session 1eID

Interdisciplinary: Tutorial Lecture on the Acoustics of Pianos

James P. Cottingham, Chair
Physics, Coe College, Cedar Rapids, IA 52402

Chair's Introduction—7:00

Invited Paper

7:05

1eID1. The acoustics of pianos. Antoine J. Chaigne (ENSTA, UME, Chemin de la Huniere, Palaiseau, 91761, France, antoine.chaigne@ensta-paristech.fr)

The manufacturing of pianos remains largely empirical, with numerous trial-and-error procedures and fine adjustments at each step of the building process. The "skeleton" of the instrument obeys fundamental principles of vibrations, acoustics, and material science. An abundance of literature is available on its different constitutive parts. However, scientific studies based on a global model of the instrument that connects all of these constitutive parts together are more recent. Such modeling sheds useful light on the essential coupling properties between elements and, in particular, on the string-soundboard coupling at the bridge, and on the radiation of the soundboard. Fine analysis of piano tones also shows that in most cases, a nonlinear model of the strings is necessary to account for perceptually significant features such as precursors in the time-domain and the so-called "phantom partials" in the spectrum. This nonlinearity is based on the coupling between transverse and longitudinal waves in the string. In this lecture, a time-domain model of a complete piano is presented that couples together nonlinear strings, soundboard vibrations, and radiation in air. It highlights the transmission of both transverse and longitudinal string forces to the soundboard, and the influence of rib design and bridge on soundboard mobility and radiation patterns. Comparisons between the results of the model and measurements made on real pianos will be discussed.