Technical Committee Report: Committee on Engineering Acoustics

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Editor's Note: This is the final report in the *Acoustics Today* series on the contributions of Technical Committees to the Acoustical Society of America. In addition to being in the pages of the magazine, this report will be added to all of the technical committee reports in "*AT* Collections" at bit.ly/AT-Collections.

The Technical Committee on Engineering Acoustics (TCEA) of the Acoustical Society of America (ASA) is concerned with the evolution and improvement of acoustical techniques and apparatus, and with the promotion of new applications of acoustics for useful purposes.

The TCEA includes scientists and engineers with a very wide range of interests and expertise. Indeed, the area of engineering acoustics is highly cross-disciplinary, encompassing the theory and practice of creating tools to generate and investigate acoustical phenomena and then to apply the knowledge of acoustics to practical utility. This includes the modeling, design, and fabrication of acoustical and vibrational transducers, arrays, and transduction systems in all media and frequency ranges. Engineering acoustics is further concerned with the design of acoustical instrumentation, metrology, and calibration of acoustical systems as well as the associated aspects of fabrication and computational techniques as they relate to the generation and sensing of acoustical phenomena.

Accordingly, members of the TCEA have highly diverse technical backgrounds and virtually all members are very active in at least one other ASA technical committee, primarily Noise, Physical Acoustics, Signal Processing, Structural Acoustics and Vibration, or Underwater Acoustics. Due to the practical bent of a large numbers of our membership, the TCEA also has significant representation in the ASA Committee on Standards, which develops new standardization projects, revises existing standards and technical reports, and reaffirms globally disseminated and widely used standards in acoustics and vibrations (see bit.ly/AT-Struck).

As implied from the description above, the research topics in the TCEA are incredibly varied. A representative, but not exhaustive, set of topics include (1) detailed studies on the fundamental physical principles of materials used to sense, generate, absorb, and otherwise control acoustic fields; (2) the design of sensor arrays and processing techniques for the detection and identification of sound sources or to perform nondestructive evaluation of structures and materials; (3) the design and characterization of electroacoustic devices for scientific, industrial, or entertainment purposes; and (4) the development of standards to ensure that measurement methods and devices are uniformly employed across all domains in acoustics.

The technical disciplines of engineering acoustics are applied every day across an extremely broad spectrum of applications in the academic, governmental, and industrial workforces. Indeed, one of the primary animating principles of members in TCEA is the desire to translate fundamental research into practice. Some of the earliest examples of this type include research on piezoelectricity to generate underwater sound by the physicist Langevin (CNRS, 1950) and the fundamental works of Mason (1930) and Firestone (1933) on the representation of acoustical elements and electromechanical systems, respectively, using equivalent circuits. Together, those works greatly facilitated the design of acoustic transducers and their integration into acoustical systems for a wide range of applications in acoustics.

Other notable early examples include the transition of fundamental science to applications in the design of sonar systems that were central to the militaries of the world during World Wars I and II (Muir and Bradley, 2016) and the creation of the electret microphone by Sessler and West (1966), a technological contribution that led to the development of low-cost and high-quality sound measurement for a wide range of applications (Busch-Vishniac and Elko, 2021). Somewhat more recent historical examples include the use of pressure-induced changes to the optical index of

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the refraction of glass to create fiber-optic, mandrel-based hydrophones that are currently employed for underwater sensing used by the military and the oil and gas exploration industry (Bucaro et al., 1977; Cole et al., 1977) as well as microelectromechanical (MEMS) acoustic microphones that are now widely used in nearly every device that measures sound (Hohm and Sessler, 1983).

As evidenced by the seminal contributions listed above, the nature of the research conducted by members of the TCEA is inherently cross-disciplinary. Indeed, the TCEA embodies this from both technical and professional standpoints, bringing together groups of scientists and engineers from a wide range of backgrounds, training, expertise, and interests. The TCEA membership list includes people in large research universities and small liberal arts colleges, private industry, and the military, each bringing their individual experience and training to bear on emerging technical and scientific challenges in acoustics. Although this breadth of expertise and interests is generally valuable, it also represents a challenge because many members are also active in more specialized organizations or may work on topics that can be difficult to share with the scientific community due to intellectual property restrictions. The TCEA has recently been trying to bring these communities back to the ASA through the organization of special sessions and extending speaking invitations to prominent researchers.

The wide range of interests in the TCEA community makes it hard to identify a subset of recent works that have been especially impactful. Instead, I have selected a few representative recent contributions to *The Journal of the Acoustical Society of America* (*JASA*) to provide a window into the quality and breadth of research that falls under the umbrella of engineering acoustics.

The first is recent work by Cheer et al. (2019) who investigated the concurrent use of reference microphones in both the left and right ears to improve the performance of headphones with active noise control. Their results showed that the strategy of using dual reference signals requires an increased computational demand but affords a significant control advantage for noise sources originating from the side of the user while maintaining performance for noises originating from the front or back.

Another recent work by researchers at ETH Zurich used experiments and numerical modeling to investigate the use of a novel signal-processing approach known as multidimensional deconvolution to postprocess data from acoustic-scattering experiments to remove reflections from the laboratory boundaries, leaving only the Green's functions of a scattering object (Li et al., 2021). This approach is highly valuable to acoustics research across application areas and may ultimately help enable researchers to "embed" physical experiments in computational domains to study the interaction of targets with arbitrary environments using a single experimental apparatus (Becker et al., 2018).

The final highlighted work is recent experimental and computational research by Jeon et al. (2021) that used X-ray computed tomography (CT) scans combined with convolutional neural networks (CNNs) to estimate the transport parameters of fibrous materials used as acoustic absorbers. The transport parameters and sound absorption coefficients of the fibrous volume predicted by the CT-informed CNN models showed good agreement with the measured values, which demonstrates the valuable integration of advanced measurement technology and analysis using novel computational methods to predict, and ultimately design, materials to absorb acoustic energy.

Although many of the examples provided above are in the area of acoustic transduction, transducer systems, and classic acoustical materials, several emerging areas of research that have gained significant attention across the acoustics community have relevance to the TCEA. The first is the area of acoustic metamaterials, which has been the subject of special issues of *JASA* in 2012 and 2016 and featured in *Acoustics Today* (Haberman and Norris, 2016). Researchers in the TCEA have provided fundamental and applied contributions to this research area and are well-suited to help transition fundamental concepts to new technologies.

Another active area of engineering acoustics research is on the development of new electroacoustic transduction materials. This topic spans ongoing research on single crystal relaxor ferroelectric materials and textured piezoelectric ceramics to improve sonar and biomedical imaging systems as well as carbon nanotube and graphene-based thermoacoustic transducers (Mayo, 2018) and bio-inspired sensing mechanisms and signal-processing techniques.

The rapid expansion of voice-interactive consumer electronic devices has prompted researchers in the TCEA and numerous other technical committees to investigate

the acoustical human-machine interface, the subject of a special session organized by Gary Elko at the 181st meeting of the ASA. Finally, researchers in the TCEA and other technical committees have begun investigating the utility and opportunities that additive manufacturing technology offers the field of acoustics. I have helped organize a special issue of *JASA* with Christina Naify of the Applied Research Laboratories at The University of Texas at Austin and Kathryn Matlack at The University of Illinois Urbana-Champaign, which will provide a representative snapshot of current research and perspectives on the ways that advanced manufacturing may enable a new generation of acoustic materials and devices.

The historical contributions of engineering acoustics paired with the broad-based, high-quality nature of current and emerging research conducted by members and affiliates of the TCEA shows that the technical committee continues to contribute to the ASA and the field of acoustics more broadly. Although the science of sound is the passion that brings members of the TCEA to the ASA, I would be remiss to not mention the culture of the TCEA and the ASA as a whole. The recent past has thrown significant obstacles at everyone and resulted in a complete disruption of one of the aspects of the ASA that most members truly enjoy: our regular in-person interactions at the biannual meetings of the ASA. We genuinely enjoy interacting with our colleagues because it provides us with an opportunity to learn from each other and to advance the technical and scientific objectives of the TCEA and the ASA as a whole. The ASA fosters a welcoming and supportive culture that extends from the most senior members to graduate and undergraduate students who are encouraged to engage in TCEA activities and to present their research to a constructive audience. The members of the TCEA and the ASA will strive to maintain this culture to continually improve our understanding of sound by creating the tools and technology of acoustics.

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