Technical Specialty Group Report: Computational Acoustics

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At the spring 2018 meeting of the Acoustical Society of America (ASA) in Minneapolis, MN, the Executive Council approved the formation of a new Technical Specialty Group (TSG) in Computational Acoustics (CA). The CA TSG will hold its first official meeting at the fall 2018 meeting in Vancouver, BC, Canada. As indicated in the ASA Rules (Sect. 18), "Technical Specialty Groups are established to organize technical sessions at meetings of the Society in new or evolving acoustical areas not within the scopes of the existing Technical Committees…" Although a TSG functions similarly to a technical committee (TC) in that it organizes sessions, undertakes technical initiatives, and is represented on the ASA Technical Council, it does have significant limitations relative to a full TC, for example, it does not confer awards and medals. After an initial period of three years, the TSG may be renewed, disestablished, or converted into a TC.

Computational acoustics is a well-established yet still rapidly expanding area of acoustics that attracts a broad range of researchers across the spectrum of the current TCs. The effort to establish a CA TSG began in earnest at the Honolulu (HI) meeting in December 2016, when Amanda Hanford (of the Pennsylvania State University Applied Research Laboratory, University Park) and I first circulated a petition and collected signatures. The requisite 50 signatures to form a TSG were eventually gathered before the spring 2018 meeting in Minneapolis. The signatories to the petition listed 10 different TCs as their primary affiliations, with Physical Acoustics, Structural Acoustics and Vibration, and Underwater Acoustics being the most frequently represented.

Along the way to forming the TSG, Amanda and I received encouragement and valuable support from a great many ASA colleagues, whom we will not attempt to list here. Many stimulating discussions helped to sharpen our thoughts about the purpose of a CA TSG and its relationship to the current TC structure. In my view, the primary positive rationale for forming a new CA TSG is well captured by the following quote, which was brought to my attention by Elaine Moran (Director of Operations of the ASA).

> "We also try to seek out groups who are working in some area of acoustics and try to show them the Society will be of value to them. Over the years there has been a lot of discussion about what should be the scope of the Acoustical Society. I choose to take the position that acoustics and the scope of our Society should include whatever those who call themselves acoustical scientists are doing, which they regard as acoustics."
> *Wallace Waterfall (ASA founding member, 1st Secretary, 1st Editor-in-Chief, 8th Treasurer), Address to the Narragansett Regional Chapter, 1966.*

Because the ASA exists primarily to serve the professional interests of its members, if it can better serve a substantial segment of the membership through the

formation of a new TSG, that would be a suitable and sufficient justification for forming one. Given the increasingly computational nature of acoustics and the sciences in general, and the interest of many members of the ASA in recent developments in this area, it is important that the ASA deepen its support for CA-related activities. Particularly worth noting is that many of the signatories of the TSG petition were relatively young ASA members, which likely reflects the emphasis of their research projects and employment interests. Hence the CA TSG should help the ASA to encourage and retain younger members. Many petition signatories also hail from countries other than the United States and Canada; thus the TSG can help expand the reach of the ASA to researchers in other countries.

Although most of the feedback we received regarding formation of a CA TSG was enthusiastic, some thoughtful arguments were also made against the idea. The most frequent was that computational acoustics is a *tool* that should be discussed within the scope of the existing TCs rather than a proper *research topic* warranting focused discussions in a separate, specialized group. In response, it can be argued that computer science is now widely accepted as a legitimate academic discipline, and in many other fields (e.g., fluid dynamics, physics, and biology), computational techniques are regarded as an important and rapidly expanding area of inquiry, distinct enough to be the subject of specialized groups, meetings, and journals. Thus the formation of a CA TSG is really just a recognition of the important status of computation across the spectrum of modern science.

Currently, CA topics are often discussed independently within many of the TCs. This lack of interaction can be a detriment to scientific progress because many computational approaches have multiple applications. One pertinent example is the formulation of computational methods for sound refraction and scattering, such as the parabolic equation, that have applications both underwater (e.g., Jensen et al., 2011) and in the atmosphere (e.g., Salomons, 2012). Another example is finite-element methods for calculating sound fields in interior spaces, which are important in structural, engineering, and architectural acoustics (Thompson, 2006; Marburg and Nolte, 2008; Vorländer, 2013). The CA TSG thus provides a forum for researchers to discuss recent advances in these and other topics crossing the existing TC boundaries.

The technical scope envisioned for the TSG includes the following topics:

- Numerical methods for acoustic wave propagation, scattering, interactions with structures and boundaries, radiation, and other acoustically related phenomena
- Practical utilization of acoustical computations for engineering and noise control, and integration into other simulations
- Optimization, parallelization, and acceleration of computational algorithms
- Validation, benchmarking, and uncertainty analysis in computational models
- Computational learning methods, data analytics, and visualization

The first of these topics includes various numerical methods for solving differential and integral equations, for example, finite-difference methods, boundary-element methods, finite-element methods, parabolic equations, wavenumber integration, and ray tracing. It lies at the heart of how most researchers view computational acoustics. Some particular problems that have received strong interest in recent years include methods to efficiently handle complex boundaries and irregular meshes (e.g., Thompson, 2006; Marburg and Nolte, 2008), time-domain formulations for attenuation and impedance (e.g., Tam and Auriault, 1996), three-dimensional solutions for sound propagating in the ocean and atmosphere (e.g., Castor and Sturm, 2008), wave propagation and scattering in moving and inhomogeneous media (e.g., Ostashev and Wilson, 2016), and nonlinear wave propagation (sonic booms and explosions; e.g., Blanc-Benon et al., 2002).

Regarding the practical utilization of acoustical computations for engineering and noise control, a vital research area is how to efficiently capture complex physical phenomena with limited computational resources. A prime example is modeling noise in complex urban environments where phenomena such as reflections, shadowing by buildings, scattering and absorption from facades and balconies, and distributed sound sources are all important for accurate sound-level prediction. Modeling of such phenomena in large urban spaces through direct numerical methods (e.g., finite differences or boundary elements) can be prohibitive even with supercomputers, although such models can be used to calibrate less intensive empirical and heuristic models.

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The remaining topics in the preceding list might be regarded as activities that support, enhance, or leverage development of conventional numerical methods. The TSG can play a valuable role, for example, by promoting technical exchange between researchers on computational methods and best practices. This may involve holding special sessions and workshops on recent advances in computational techniques, websites to facilitate code exchange and crowd-based development, formulation of benchmarks (Hornikx et al., 2015), and sharing of experiences with new software tools.

The CA TSG looks forward to fostering interactions with other ASA TCs. For example, in the rapidly growing field of machine learning (data-driven) computational methods, there is a natural overlap with the Signal Processing in Acoustics TC. We also look forward to interactions with other societies that have already established groups in computational acoustics, such as the European Acoustics Association. We hope to encourage a stronger ASA presence at international conferences on computational acoustics and perhaps to play a role in organizing future conferences on computational topics.

Whether computational acoustics is a primary interest or a secondary one, please join us for a meeting of the TSG and consider participating in our activities in this exciting and growing area of acoustical research!

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