

THE PRESIDENT'S PERSPECTIVE ON SCIENTIFIC DIVERSITY IN THE ACOUSTICAL SOCIETY OF AMERICA

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Diversity—a popular word in our day and time. Be it racial diversity, biodiversity, economic diversity, or gender diversity, the word is commonly used in many different contexts. In the Acoustical Society of America (ASA) we are fortunate to have diversity in the scientific disciplines that are a major part of our Society. We can loosely divide our Society into two groups having different scientific backgrounds, that of the physical sciences and that of the life sciences. Members who have backgrounds in engineering, physics, and mathematics are in the physical sciences group and those with backgrounds in psychology, physiology, music, and biology are in the life sciences. The percentages of ASA members in each group is depicted in Fig. 1 based upon the most recent available data.



The Acoustical Society of America was formally established in 1929 and during its early years, most members were from engineering, physics, and mathematics backgrounds. Today, the society has evolved to the point that the two largest technical committees are Speech Communication (SC) and Psychological and Physiological Acoustics (P&P), a reflection of our movement towards more diversity. This characteristic of our scientific society is good and brings strength in many ways. To use an old cliché, there is strength in numbers. This is especially true for an organization like ours. The impact of our society, the amount of services, the number of awards, the kinds of meetings, and the different types of projects that are part of the ASA, comes from having our strength in numbers. A critical mass of dedicated members is essential in order to have the type of organization that we do. Hopefully, as we grow in membership, more and better services can be provided.

Scientific diversity also brings richness to our society. I always find it satisfying when I see those in the life sciences “rubbing elbows” with those in the physical sciences and taking part in deep discussions on a variety of

issues affecting our country, universities, and companies. It is always good to get a different perspective on things, especially if we only interact with colleagues of similar background in our work places. I also see the value of having different perspectives when addressing scientific and technical issues, especially those that cross the various boundaries. I highly recommend that we, as members of this rich society of ours, reach out to others in different disciplines, especially at our semi-annual meetings.

The variety of disciplines in our society is also a source of strength. There is nothing better than to know someone in a different discipline who you can approach and ask some of the most elementary questions that may be far from elementary in the discipline from which we come. I know I have benefited by knowing who to approach for advice and assistance. I am always graciously received without having to feel inadequate or uninformed. It is also helpful that we are able to direct colleagues to others in our society who are much better informed and have experiences that are outside our specific discipline. I know this first hand as I have had to point someone to experts in other fields. The world and our country are changing at an unprecedented rate in history and this rate of change will continue or even accelerate with time. What society deems as important and the issues that arise are continuously changing. We as part of a professional scientific society must also continuously change. Some of us may find that the kinds of work and the skills we have developed are not in strong demand any longer, which means that we have to do some mid-career adjustment and broaden our scope. Knowing individuals in different disciplines could be very helpful to the process of career adjustment and in the development of new and more cross-discipline collaborative efforts.

My intention in writing this article is to focus on our scientific diversity but there are two other areas of concern

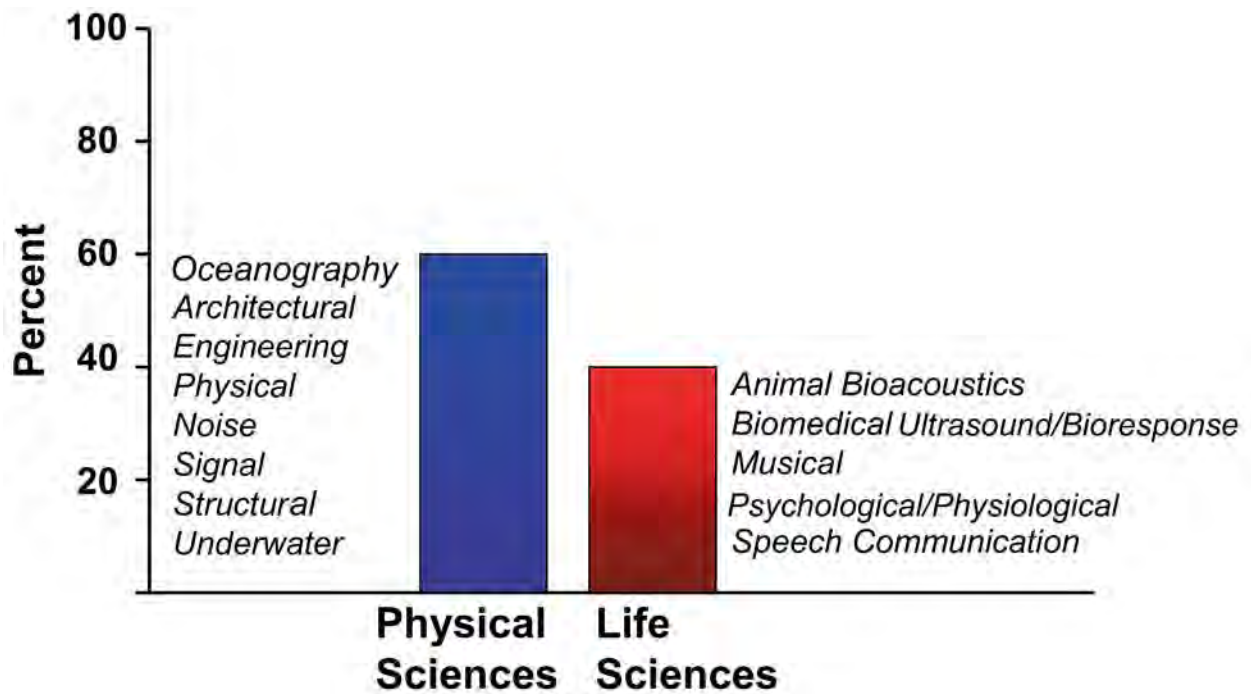


Fig. 1. Percentages of ASA members in physical sciences and life sciences.

that I should bring up. The first is gender diversity and the second is racial diversity. In my opinion and experience, the ASA is making good progress on both fronts. In the past decade, three women (Patricia Kuhl, Kathryn Harris, and Ilene Busch-Vishniac) were elected President and three women were elected Vice President (Janet Weisenberger, Donna Neff and Diane Kewley-Port). The make up of the Executive Council in the past decade has always included a good representation of women. Of the present six Executive Council elective positions, two are held by women. We also have a vibrant Women in Acoustics Committee. In the area of unrepresented minorities, progress is slower but there is a committed ad hoc committee addressing this area. The election of James West, an African-American, as President for 1998-99 and myself, an Asian-American, is a reflection of progress in this area. James West was also awarded the prestigious Gold Medal in 2006. I was awarded the Animal Bioacoustics Silver Medal in 1998. Lilly Wang, an Asian-American, was awarded the R. Bruce Lindsay Award in 2005, Purnima Ratilal, an Asian-American in 2006, and Tyrone Porter, an African-American, in 2008. Again a reflection of how our society judges people by their accomplishments rather than by any other standards.

My main motivation for writing this article is to share with both those not in the ASA and with members who are not as aware as they should be about how diverse a professional and scientific society we are. The scope and depth of science represented by the members of our society are indeed broad and deep and provide a richness from which we can all profit and enjoy. My second motivation is to encourage all of us to think in terms of cross-discipline collaborations and approaches where the inherent strength of our membership can be realized. I understand that many problems and projects do not lend themselves to a cross-discipline approach, but when those that do appear, we should be eager to pounce on them. Words like bioacoustics, biomimeics, biomechanical, and so on have popped up in our lexicon during recent decades, reflecting the thrust by some toward a more integrated and collaborative approach to some fields of science. We should be a part of this general thrust. Finally, with acoustics as our common field, I encourage all members to devote some time during each meeting to go to see what the other folks are doing. Who knows, you may be pleasantly surprised by the quality of science done in the different disciplines and perhaps such experiences may stimulate new ideas to pop into your minds.

RICHMOND OLYMPIC OVAL

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The Richmond Olympic Oval in Vancouver, Canada is the largest structure built for the 2010 Olympic Winter Games. Dramatically located beside the Fraser River, with expansive views north to the Coast Mountains, this monumental building stretches to a length of five football fields laid side by side. It will host the long track speed skating events along with the 8000 expected fans. This distinctive structure, shown in Fig. 1, will be the architectural symbol of these games.

The City of Richmond wanted an iconic building that could accommodate multiple uses and also attract public attention and development to the area. They selected a wooden structure designed to highlight the local wood industry and give the main hall a warm ambiance. From the outset, the building was intended for adaptive reuse after the Olympic

“The final result was a ceiling structure of stunning beauty and great practicality.”

Games. The Oval will be converted into a multi-use sports facility for the citizens of Vancouver, with two ice rinks, racquet courts, a 200 meter track, rubberized turf area and even a high performance workout area.

The design team consisted of Fast & Epp Structural Engineers, Cannon Design Architects, design-builder StructureCraft Builders, and Marshall Long Acoustics Acoustical Engineers. George Third & Son, Ltd. Steel Contractor and twenty-four other firms also contributed to the construction.

The visually spectacular six-acre free span roof had to provide not only the structural capacity, but also had to meet stringent acoustical requirements. The structural system had never before been built, so extensive modeling and testing was required. Shown under construction in Fig. 2, it is shaped like a turtle’s back with upturned sides.

The roof is supported by massive curved wood and steel composite beams spanning 330 feet from end to end across the structure. Between the beams are striking vee-shaped WoodWave© panels constructed from Pine Beetle-killed trees that were sawn into 2x4s and bolted together in undulating sections to create a rippled effect. These shapes create an impressive visual appearance, giving the ceiling its signature look. The Main Hall is shown in Fig. 3.

Virtually all rooms of this size are hampered by long reverberation times and poor speech intelligibility. This is particularly troubling for public gatherings and sporting events where communication is essential. With a conventional hard roof the reverberation time (the time it takes for a sound to die out in a room) would have been many seconds, making speech nearly impossible to understand. The solution to excess reverberation is to install large amounts of



Fig. 1. Exterior view of the main entrance to the Richmond Olympic Oval at night (Photo by Kam Lau <http://kamlau.com>).



Fig. 2. Curved rooftop under construction with view of the Fraser River and Coast Mountains (Photo by Ziggy Welsch, George Third & Son Ltd., ziggy@third.com Courtesy Wood WORKS! BC).

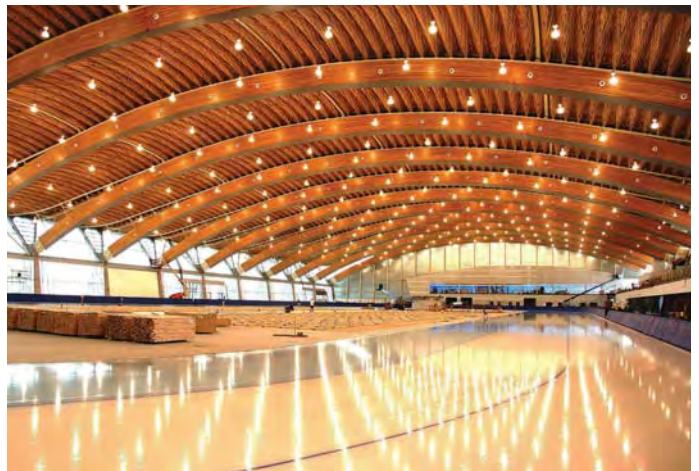


Fig. 3. Main Hall with massive curved beams and WoodWave© panels (Courtesy Fast & Epp Structural Engineers and Wood WORKS! BC).

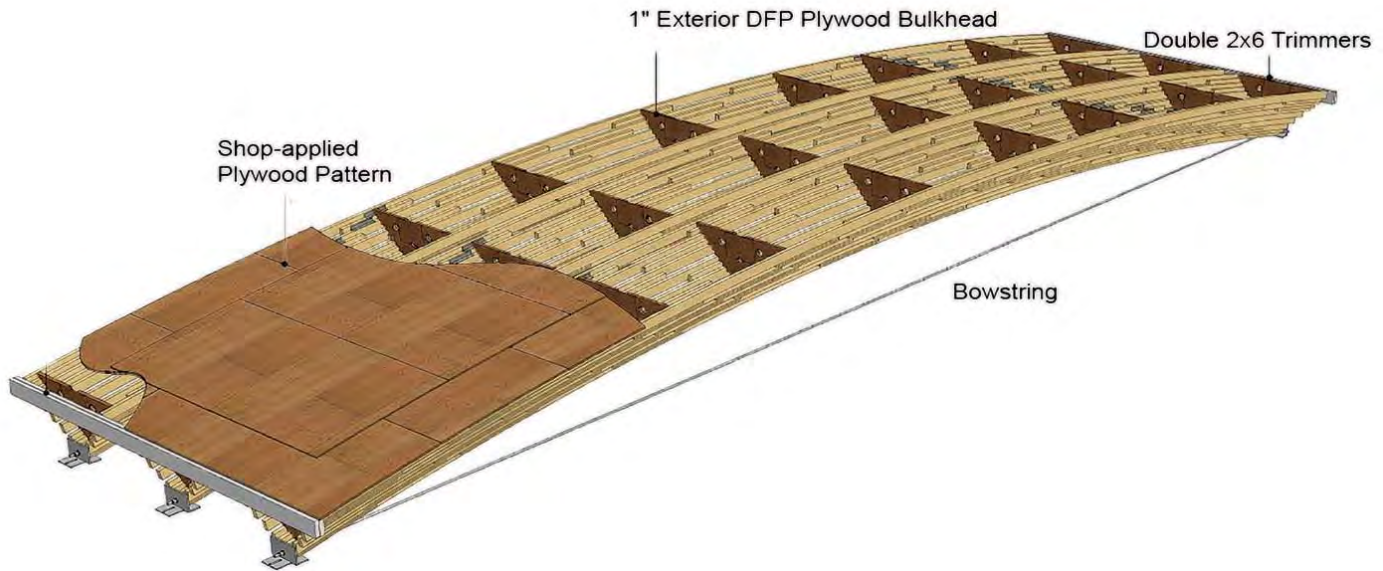


Fig. 4. Rendered WoodWave© panel with bulkheads, stressed skin, and bowstring (Courtesy StructureCraft Builders).

absorptive materials. The largest space available for locating this material is in the ceiling. Local engineers hired by the City of Richmond set the required absorption coefficient (the fraction of the incident sound energy absorbed by a surface) to 1.0.

The absorption is characterized by its Noise Reduction Coefficient (NRC) rating. The NRC is the arithmetic average of the sound absorption coefficients measured at the 250 Hz, 500 Hz, 1000 Hz, and 2000 Hz third octave bands rounded to the nearest 0.05, measured in accordance with the ASTM C 423 testing standard. The test is performed by laying the material of interest on the floor of the test chamber with its absorbing surface facing upward, exposed to the sound field. The chamber is a rectangular room with hard concrete surfaces that is ensounded with band limited pink noise. The sound source is interrupted and the rate of decay of the sound in the chamber is measured with and without the presence of the sample under test. Using the rate of decay under the two conditions, an absorption coefficient can be obtained for the material.

When we were first involved with the project, the engineers at StructureCraft wanted to use a vee-shaped wood structure that could be built out of 2x4s. The normal approach to a covered acoustical absorber is to leave the surface with at least a 20% open area. When the openings are round holes, they must have a diameter greater than the thickness of the panel to minimize tube resonances. The holes have to be arranged so that there are several within the dimension of a wavelength otherwise the absorption will revert to the value of the open percentage multiplied by the effective area of the panel. Thus at high frequencies the absorption can be expected to drop as the wavelength decreases.

The WoodWave© panels provided an opportunity to achieve a lightweight structure with the necessary structural strength, acoustical absorption, and desired visual appearance. Their acoustical requirements dictated openings in the surface of the vees with a thick absorptive material behind.

Early in the design I suggested a 20% open area with a 2 inch thick black fiberglass liner, held in place with wood battens. Their first design was about 27% open, which was later reduced to about 24%. Because the slots were primarily on the bottom of the vees, not on the face of the panel, I was concerned that it might reduce the amount of the exposed area. Because most of the sound would be coming from under-



Fig. 5. Interior of vee-shaped WoodWave© structure during construction (Courtesy StructureCraft Builders).

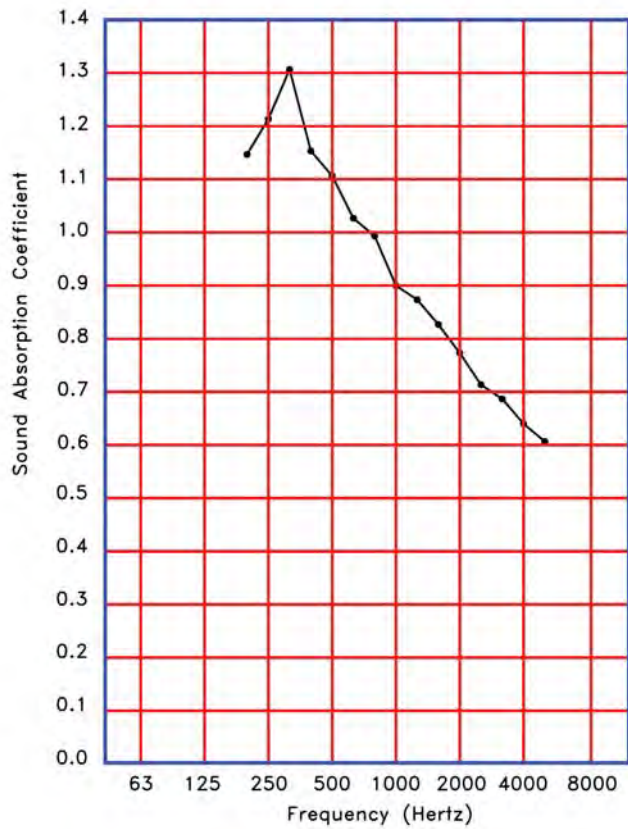


Fig. 6. Final result of absorption test.

neath the panels, I thought the opening location would probably work.

The WoodWave© panel design is shown in Fig. 4. StructureCraft lined the inside of the vees with a black cloth and 2.5 inch thick mineral wool that helped meet the fire code requirements. The 2x4s surfaces are positioned and held in place by means of plywood bulkheads. These also support the sprinkler pipes and give the panels their shape. The panels are formed in a curve, much like an archer's bow. A steel cable bowstring added additional structural strength.

The panels were constructed in StructureCraft's shop. The process is shown in Fig. 5 with the black cloth in place. The interior plywood bulkheads are notched to secure the 2x4s in their proper locations. Conduit for the lighting is also placed in the hollow panels.

Because of the added area provided by the saw tooth surface, I predicted an NRC of about 1.2 and suggested that they mock up a sample and have it tested. In early 2006 a sample was built and sent to the Western Electro-Acoustic Laboratories (WEAL) in Los Angeles. The first test yielded an NRC of about 0.85, much less than I had calculated. At the time I was quite puzzled by the result. The reason, as it turned out, was that the absorptive material had not been properly secured and was jostled during the transport from Vancouver. It had fallen to the bottom (roof side) of the test sample. Since there was a black cloth between the wood and the mineral wool, this displacement could not be seen from the outside.

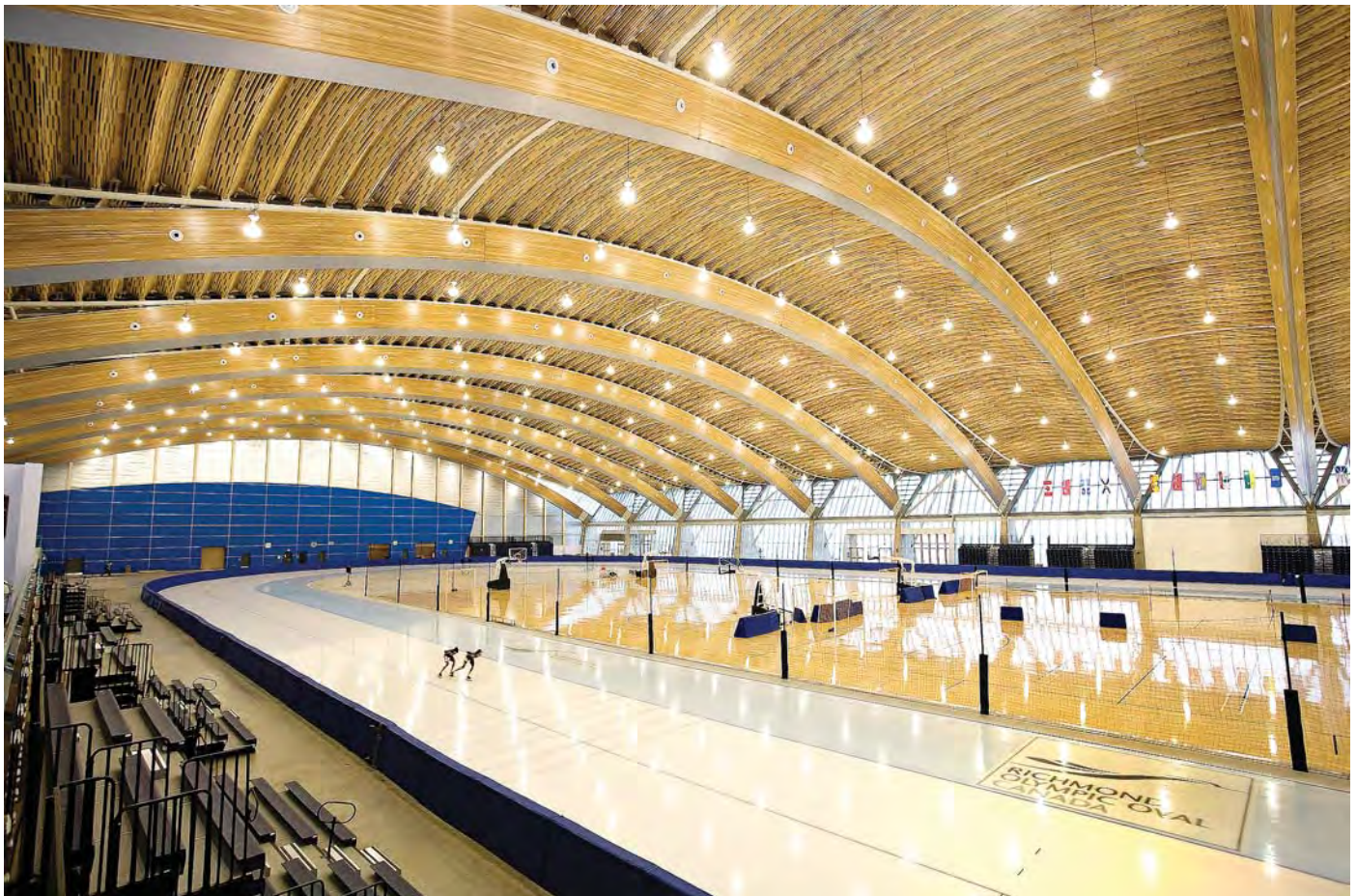


Fig. 7. Main Hall and rink with skaters (Photo by Stephanie Tracey www.photographywest.ca Courtesy Wood WORKS! BC).

StructureCraft sent an engineer down to Los Angeles, who took the sample apart, discovered the problem, and rearranged the mineral wool. At the suggestion of Rick Talaske, another acoustical engineer on the project, StructureCraft also added additional 1 inch thick mineral fiber material on the inside faces of the plywood bulkheads. The sample was retested and the result, shown in Fig. 6, met the design criteria.

It is interesting that at the low frequencies the tests yielded the absorption coefficient value of 1.2 that I had predicted. At the higher frequencies the shorter wavelengths caused the sound to interact with the solid portion of the vee rather than spanning open portions of the slotted surface, thereby reducing the absorption. The absorption values greater than 1.0 are due to the additional area from the angled surface compared to the flat ceiling area used in the ASTM test standard.

The final result, shown in Fig. 7, was a ceiling structure of stunning beauty and great practicality. The acoustical absorption was what the City of Richmond had requested. As Rick Talaske pointed out in the final report, not only was the absorption on target, the lack of high frequency absorption from the ceiling was offset by the high frequency absorption provided by the air contained in the large room volume. The saw tooth shape of the vees also provided helpful diffusion to reduce focusing and echoes.

The building, with its ingenious roof structure, has attracted worldwide attention and received several prestigious awards. These include an Award of Excellence for Innovation in Architecture, in the Science category, from the Royal Architectural Institute of Canada, and the 2009 Award for Sports or Leisure Structures, from the Institution of Structural Engineers, UK.[AT](#)



Marshall Long received a BSE degree from Princeton University in 1965, attended the University of Grenoble in France and the University of Madrid in Spain in 1966. He received M.S. and Ph.D. degrees in engineering from UCLA in 1971. While still a graduate student, he founded his own acoustical consulting firm, now in its 38th year. Marshall Long Acoustics specializes in architectural acoustics, audio visual design, noise and vibration control, and other technical areas related to acoustics. He enjoys sailing, judo, soccer, reading, and writing, and is living with his family in Sherman Oaks, California. He is a Fellow of the Acoustical Society of America.