BIOGRAPHICAL SKETCH

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NAME:	Ronald N. Miles
eRA COMMONS USER NAME:	RMILES
POSITION TITLE:	Distinguished Professor

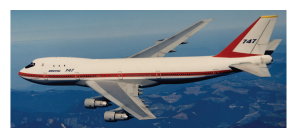
EDUCATION/TRAINING (Begin with baccalaureate or other initial professional education, such as nursing, and include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)

INSTITUTION AND LOCATION	DEGREE (if applicable)	Completion Date MM/YYYY	FIELD OF STUDY
University of California, Berkeley, USA	BSEE	1976	Electrical Engineering
University of Washington, Seattle, Washington	MSE	1985	Mechanical Engineering
University of Washington, Seattle, Washington	Ph.D.	1987	Mechanical Engineering

A. Personal Statement

I have nearly 40 years of experience in acoustics. My interest in sound, hearing, and audio devices began while I was in grade school and has continued since then without interruption. As an undergraduate at Berkeley, I performed independent research on electroacoustics and room acoustics with Prof. Michael Carroll. I obtained a solution to a Fredholm integral equation for room acoustics that he had recently derived, which led to my first journal publication in 1978. This gave me a practical and exciting introduction to integral equations, Laplace transform methods, and eigenvalue problems that would not have normally been part of undergraduate coursework in my major, electrical engineering.

After receiving my BSEE degree, I landed at Boeing in Seattle and began learning about structural acoustics, more specifically, the random excitation due to turbulent flow on periodically stiffened fuselage structures and the subsequent sound radiation into the airplane interior. Along with getting a very practical education on the mathematical methods for studying vibrational waves on periodically stiffened shells, I also learned about the use of viscoelastic materials and constrained layer damping to reduce resonant vibration and radiated noise. This is a highly effective means of reducing structural vibration and noise radiation without the addition of mass, which is extremely important in aerospace vehicles. My vibration damping invention (and 1984 patent) resulted in a very substantial weight savings on the Boeing 747 along with nearly $1M annual savings in manufacturing costs. I accomplished this through a combination of mathematical analysis, prototype design and fabrication, laboratory testing and flight testing (which I directed).



After encouragement from my supervisor at Boeing, I began graduate studies in mechanical engineering at the University of Washington in Seattle under supervision by my mentor, Prof. Per Reinhall. This greatly enhanced my analysis skills in acoustics and random vibrations and introduced me to the study of nonlinear dynamics and vibrations. I learned methods for studying the statistics of nonlinear structures driven by random excitations and discovered a mathematical method of explaining how nonlinear stiffness can result in the broadening of resonant peaks in the response power spectral density. My experience with the high-level, nonlinear response of complicated structures equipped me to participate in the random fatigue of aerospace structures, a topic of interest to NASA. This led to a summer faculty fellowship at NASA Langley in the summer of 1988 and subsequent research grants when I started my faculty position at SUNY Binghamton (aka Binghamton University).

Through a personal connection (my wife, Dr. Carol Miles) I was introduced to Prof. Ron Hoy and Daniel Robert at Cornell while I was a fairly new faculty member. This introduced me to the biophysics of hearing in insects, which was a topic for which my structural acoustics background equipped me well. Through a combination of laser vibrometry, mathematical modeling, and behavioral experiments, we discovered a new method for achieving directional hearing in small animals, specifically, the parasitoid fly, *Ormia ochracea*. For a very small animal to be able to localize a sound source, it must be able to detect extremely minute differences in pressure at two closely spaced points. We discovered that this difference in pressure could be detected extremely well if the animal's two ears are coupled together with a carefully designed connecting structure. This discovery received significant attention and was the subject of many dozens of media releases in print and video in over 100 countries.

Since my core discipline is engineering (rather than science), I sought to design a device that utilizes the essential ideas behind Ormia's directional ears. With funding from NIDCD, I have succeeded in developing miniature MEMS microphones that achieve unprecedented directionality over the audible range and, because they are extraordinarily capable of detecting pressure differences, they achieve lower noise floors than can be achieved with the best low-noise hearing aid microphones, particularly at low frequencies. Low frequency noise is a significant problem for existing directional microphones since the difference signal becomes buried in noise as the frequency is reduced. We are the only group that has published noise performance for Ormia-inspired microphones.[2,4]

Our work on the Ormia ear has been the basis of a number of well-funded and talented research groups at prestigious universities both in this country and abroad, including a large recent award in the UK. At least three NSF grant awards (including a CAREER award) have been made to others based on our work along with research grant awards from NIH and DOD. Over 20 patents have been awarded to me and nearly as many have been awarded to others based on our discovery. These patents have been awarded to large companies (such as Intel) and small start-ups along with universities here and abroad. There are currently several ongoing efforts to commercialize designs based on our work. At least one start-up company is pursuing this and discussions are underway between at least one hearing aid company and a major miniature microphone supplier. As recently as the end of September 2016, a major audio company and one large, well-funded startup company has had discussions on this topic with the Binghamton University Technology Transfer Office. Having demonstrated the feasibility of this new microphone design approach,[2,4] I believe the engineering development and commercialization is best left to others. The present proposal is an attempt to create the next generation of miniature directional microphone technology, which I believe will be even more exciting than our work on Ormia.

More recently, I have published a note on how to realize much of the essential operating principles of the Ormia-microphones simply by properly packaging existing nondirectional microphones.[3] This new report provides a method of dramatically improving the performance of existing directional microphone arrays with essentially no additional development or manufacturing cost.

In addition to the development of new microphone technologies, we have contributed to methods for analysis and design of miniature microphone packages. Because modern miniature microphones are extremely small, it is important to account for the effects of fluid viscosity and heat conduction when examining the effects of placing them in a small, protective package. We have published the first successful analysis of the effects of this package.[1]

Because much of our work involves acoustic measurements, I have been primarily responsible for the design and management of a state of the art acoustic testing facility at Binghamton, shown in figure (1). This facility was designed to achieve extremely low ambient noise; measurements show that the ambient noise of the chamber is approximately zero dBA, likely the best of any university facility. This facility will be central to the proposed research.

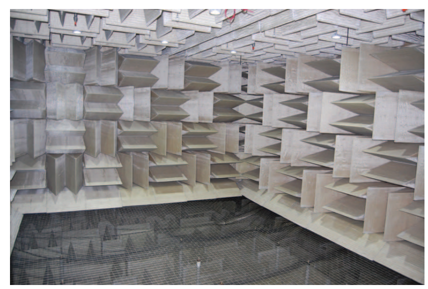


Figure 1: The Binghamton University anechoic chamber facility.

1. D Homentcovschi, RN Miles, PV Loeppert, and AJ Zuckerwar. A microacoustic analysis including viscosity and thermal conductivity to model the effect of the protective cap on the acoustic response of a mems microphone. *Microsystem technologies*, 20(2):265–272, 2014.

2. R. N. Miles, Q. Su, W. Cui, M. Shetye, F. L. Degertekin, B. Bicen, C. Garcia, S. Jones, and N. Hall. A low-noise differential microphone inspired by the ears of the parasitoid fly Ormia ochracea. *Journal of the Acoustical Society of America*, 125(4, Part 1):2013–2026, APR 2009.

3. RN Miles. Acoustically coupled microphone arrays. *ASME Journal of Vibration and Acoustics*, 138(6):064503, 2016.

4. Ronald N Miles, Weili Cui, Quang T Su, and Dorel Homentcovschi. A mems low-noise sound pressure gradient microphone with capacitive sensing. *Journal of Microelectromechanical Systems*, 24(1):241–248, 2015.

B. Positions and Honors

Positions and Employment

8/14 – present	Chairman, Department of Mechanical Engineering, Thomas J. Watson School of Engineering and Applied Science, State University of New York, Binghamton
4/15 – present	Associate Editor, ASME Journal of Vibration and Acoustics
10/09 – 8/14	Associate Dean for Research, Thomas J. Watson School of Engineering and Applied Science, State University of New York, Binghamton
5/11–present	Distinguished Professor, Department of Mechanical Engineering, Thomas J. Watson School of Engineering and Applied Science, State University of New York, Binghamton
9/06–5/11	Professor, Department of Mechanical Engineering, Thomas J. Watson School of Engineering and Applied Science, State University of New York, Binghamton
9/05–9/06	Professor & Director Undergraduate Studies, Department of Mechanical Engineering, Thomas J. Watson School of Engineering and Applied Science, State University of New York, Binghamton
7/02-9/05	Professor, Department of Mechanical Engineering, Thomas J. Watson School of Engineering and Applied Science, State University of New York, Binghamton
9/98–7/02	Professor and Chairman, Department of Mechanical Engineering, Thomas J. Watson School of Engineering and Applied Science, State University of New York, Binghamton
6/98–8/98	Associate Professor and Chairman, Department of Mechanical Engineering, Thomas J. Watson School of Engineering and Applied Science, State University of New York, Binghamton
3/98–6/98	Associate Professor, Vice Chairman, and Director of Graduate Studies, Department of Mechanical Engineering, Thomas J. Watson School of Engineering and Applied Science, State University of New York, Binghamton
9/96–3/98	Associate Professor and Director of Graduate Studies, Department of Mechanical Engineering, Thomas J. Watson School of Engineering and Applied Science, State University of New York, Binghamton
1/95–8/96	Associate Professor, Department of Mechanical Engineering, Thomas J. Watson School of Engineering and Applied Science, State University of New York, Binghamton
1/89–12/94	Assistant Professor, Department of Mechanical and Industrial Engineering, Thomas J. Watson School of Engineering and Applied Science, State University of New York, Binghamton
Summer 1988	Summer Faculty Fellow, Structural Acoustics Branch, NASA Langley Research Center
1/87–12/88	Assistant Research Engineer and Lecturer, Department of Mechanical Engineering, University of California at Berkeley. Vibration and sound transmission through orthogonally stiffened shells subjected to convected turbulent flow
1/77–12/84	Engineer, Acoustics Staff, Boeing Commercial Airplane Company, Seattle, Washington

Principal Investigator on over $17M total research grant awards.

Graduate Student Advisees: 17 graduated PhD and 46 graduated MS thesis advisees.

20 Patents, 41 Invited Lectures

Society Memberships: Acoustical Society of America, American Society of Engineering Education, Institute of Electrical and Electronic Engineers, American Society of Mechanical Engineers, International Society for Neuroethology

Honors

2011	Named Distinguished Professor, State University of New York
2005	Award for First Patent, Research Foundation State University of New York
2005	Innovation, Creation & Discovery Award, Research Foundation State University of New York
2001	Outstanding Inventor, Research Foundation State University of New York
1997	Chancellor's Award for Excellence in Teaching, State University of New York
1997	University Award for Excellence in Teaching, State University of New York

C. Contribution to Science

Directional microphones for hearing aids: A primary research interest of mine for over a dozen years has been on the development of miniature microphones that are capable of detecting pressure gradients over a broad range of frequencies and with a minimum of added noise. This effort has primarily been based on my discovery (described below) of the mechanism used in the directional ears of the parasitoid fly, *Ormia ochracea*. This work involved the design, fabrication and testing of MEMS microphones where the diaphragm was carefully designed to respond to pressure gradients. As discussed above, these novel microphone diaphragm designs are described in numerous publications and about 20 issued patents. In addition to the creation of an entirely new way to design a microphone diaphragm, we also made significant contributions to the problem of converting the diaphragm motion into an electronic signal, admittedly, the most difficult part of making a microphone. In 2 and 3 below, we describe the use of optical sensing to achieve an extremely low noise floor along with describing the first use of active damping to improve

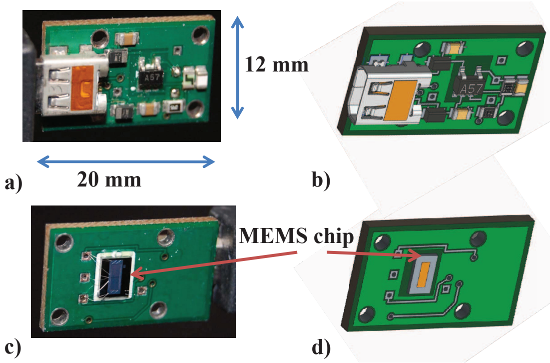


Figure 2: *Ormia ochracea*-inspired directional microphone

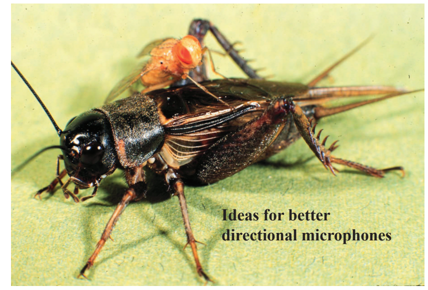


Figure 3: *Ormia ochracea* and its host cricket.

microphone performance. In addition to optical sensing, we also have demonstrated (and patented) a new way to achieve high performance in this microphone using capacitive sensing (in ref 1 below). Figure (2) shows the prototype microphone including the MEMS chip and capacitive sensing electronics that we designed and fabricated.

1. Miles, Ronald N and Cui, Weili and Su, Quang T and Homentcovschi, Dorel A MEMS low-noise sound pressure gradient microphone with capacitive sensing in *IEEE Journal of Microelectromechanical Systems* 24(1):241–248, 2015.

2. Bicen, Baris and Jolly, Sunny and Jeelani, Kamran and Garcia, Caesar T. and Hall, Neal A. and Degertekin, F. Levent and Su, Quang and Cui, Weili and Miles, Ronald N. Integrated Optical Displacement Detection and Electrostatic Actuation for Directional Optical Microphones With Micromachined Biomimetic Diaphragms. *IEEE Sensors Journal* 9(12):1933–1941, 2009.

3. Miles, R. N. and Su, Q. and Cui, W. and Shetye, M. and Degertekin, F. L. and Bicen, B. and Garcia, C. and Jones, S. and Hall, N. A low-noise differential microphone inspired by the ears of the parasitoid fly *Ormia ochracea Journal of the Acoustical Society of America*, 125(4):2013–2026, 2009.

4. R. N. Miles Acoustically coupled microphone arrays *ASME Journal of Vibration and Acoustics* 138(6), 2016.

Mechanisms for sound and vibration sensing in insects: As discussed above, I have made significant contributions to our understanding of sound and vibration sensing in insects. Our discovery of the mechanism for directional hearing in the fly *Ormia ochracea* shown in figure(3) as well as *Emblemasoma* has had a marked influence on the research of a number of groups (references 1 and 2). In addition to the sensing of air-borne sound, I have contributed to our understanding of substrate-borne vibrational communication which has been reported to be employed by 150,000 species. One recent contribution is in reference 3 in which I examine wave motion on a plant stem by considering coupled partial and ordinary differential equations to account for the interaction between an insect's body and a thin stem. My most recent publication (4) is the first report of airborne hearing by a jumping spider. This study is part of the inspiration for the proposed effort because these spiders detect sound using extremely thin hairs, which are driven by viscous forces in the air, much like the nanoscale fibers discussed here.

1. Miles, RN and Robert, D and Hoy, RR. Mechanically coupled ears for directional hearing in the parasitoid fly *Ormia ochracea* in *The Journal of the Acoustical Society of America* 98(6):3059–3070, 1995.

2. Robert, D and Miles, RN and Hoy, RR Tympanal hearing in the sarcophagid parasitoid fly *Emblemasoma* sp.: the biomechanics of directional hearing in *Journal of Experimental Biology* 202(14):1865–1876, 1999.

3. R.N. Miles An analytical model for the propagation of bending waves on a plant stem due to vibration of an attached insect *Heliyon* 2(3) March 2016, Article e00086.

4. Shamble, Paul S and Menda, Gil and Golden, James and Nitzany, Eyal and Walden, Katherine and Beatus, Tsevi and Elias, Damian O and Cohen, Itai and Miles, Ronald N and Hoy, Ronald R Airborne Acoustic Perception by a Jumping Spider *Current Biology* http://dx.doi.org/10.1016/j.cub.2016.08.041, October 2016.

Noise, vibration control and acoustics: While working toward my BSEE at Berkeley, I obtained a solution to a Fredholm integral equation for room acoustics which resulted in references 1 and 2 below. After graduating with my BSEE, I became an acoustical engineer at Boeing in Seattle. A significant contribution from this period consisted of inventing and developing a method of damping the vibration of structures. This invention was put into production on the Boeing 747, resulting in a 220 pound weight savings and $1M/year cost savings(3). This results in a fleet fuel savings on the order of 1 million gallons/year. An analytical study of this design is described in (4). This publication with Prof. Per Reinhall while I was a graduate student at the University of Washington has been the basis of the 'Miles–Reinhall' element developed by others for analyzing laminated structures in the finite element method.

1. MM Carroll, RN Miles Steady-state sound in an enclosure with diffusely reflecting boundary *The Journal of the Acoustical Society of America* 64 (5), 1424-1428 1978.

2. Miles, RN Sound field in a rectangular enclosure with diffusely reflecting boundaries *Journal of Sound and Vibration*, 92 (2), 203–226 1984.

3. Miles, Ronald N. Beam dampers for damping the vibrations of the skin of reinforced structures US Patent 4,425,980 1984

4. Miles, Ronald Neal and Reinhall, Per G. An analytical model for the vibration of laminated beams including the effects of both shear and thickness deformation in the adhesive layer in *ASME Journal of vibration, acoustics, stress, and reliability in design* 108(1):55–64, 1986.

Random vibration: In my work at Boeing and later as a graduate student at the University of Washington, I encountered numerous practical problems where the excitation and response of a complex structure is random. Published experimental results on the random response of nonlinear structures showed that as the excitation level increases, resonant peaks that are evident when the frequency dependence of the response is viewed as the power spectral density, become more broad. This was attributed to nonlinear damping since damping is known to influence the width of resonant peaks. I proved that this effect was the result of random fluctuations in the system's stiffness (and resonant frequency) rather than nonlinear damping. I created a mathematical method of explaining how nonlinear stiffness can result in the broadening of resonant peaks in the response power spectral density. The result is shown in references 1 and 2.

Reference 3 describes an analysis of the effect of adding vibration dampers (as described above) on the random response of a plate. Reference 4 examines a beam undergoing intense random motion with clamped ends that are able to slip when the large deflection causes sufficient axial forces. In this study, we presented a method of estimating the rate at which slipping events occur.

1. Miles, RN. An approximate solution for the spectral response of Duffing's oscillator with random input in *Journal of Sound and Vibration* 132 (1), 43-49 1989.

2. Miles, RN. Spectral response of a bilinear oscillator in *Journal of Sound and Vibration* 163 (2), 319-326 1993.

3. Garrison, MR and Miles, RN and Sun, JQ and Bao, W Random response of a plate partially covered by a constrained layer damper *Journal of Sound and Vibration*, 172(2):231–245, 1984.

4. RN Miles, and SP Bigelow. Random vibration of a beam with a stick-slip end condition *Journal of Sound and Vibration* 169(4):445–457, 1994.

D. Research Support

Ongoing Research Support

NSF Grant 1608692 Date: 9/1/16–8/31/2019
A New Approach to Capacitive Sensing: Repulsive Sensors
Role: Co-PI
This research aims to devise a new approach to capacitive sensing and to demonstrate its effectiveness in MEMS microphones. The approach utilizes a new capacitive sensing mechanism that is able to create a repulsive force that, unlike conventional capacitive sensors, does not suffer instabilities that arise due to the use of excessive bias voltages. This allows the use of significantly increased bias voltages that will substantially improve the signal-to-noise ratio and electrical sensitivity of microphones, accelerometers, and any other capacitive sensors. While this research is in its early stages, it is my hope that we will discover a method of using capacitive sensing on sensing electrodes that have essentially zero stiffness, such as the nanoscale fibers discussed here. This could have a revolutionary impact on microphone design.