NOISE/NEWS INTERNATIONAL

Volume 16, Number 3
2008 September

A quarterly news magazine with an Internet supplement published by I-INCE and INCE/USA

NOISE-CON 08
Report

SPECIAL ISSUE
Noise Control Engineering Education in the United States

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Features

Departments

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I-INCE

The International Institute of Noise Control Engineering (I-INCE) is a worldwide consortium of societies concerned with noise control and acoustics. I-INCE, chartered in Zürich, Switzerland, is the sponsor of the INTER-NOISE Series of International Congresses on Noise Control Engineering, and, with the Institute of Noise Control Engineering of the USA, publishes this quarterly magazine and its Internet supplement. I-INCE has an active program of technical initiatives, which are described in the Internet supplement to NNI. I-INCE currently has 46 Member Societies in 39 countries.

INCE/USA

The Institute of Noise Control Engineering of the USA (INCE/USA) is a non-profit professional organization incorporated in Washington, D.C., USA. The primary purpose of the Institute is to promote engineering solutions to environmental noise problems. INCE/USA publishes the technical journal, *Noise Control Engineering Journal*, and, with I-INCE publishes this quarterly magazine and its Internet supplement. INCE/USA sponsors the NOISE-CON series of national conferences on noise control engineering and the INTER-NOISE Congress when it is held in North America. INCE/USA Members are professionals in the field of noise control engineering, and many offer consulting services in noise control. Any persons interested in noise control may become an Associate of INCE/USA and receive both this magazine and *Noise Control Engineering Journal.*

NNI Internet Supplement

www.noisenewsinternational.net

- Links to the home pages of I-INCE and INCE/USA
- Abstracts of feature articles in the printed version
- Directory of the Member Societies of I-INCE with links, where available, to the Member Society Profiles and home pages
- Links to I-INCE Technical Initiatives
- Calendar of meetings related to noise—worldwide
- Links, where available, to NNI advertisers
- Links to news related to the development of standards
- Link to an article "Surf the 'Net for News on Noise," which contains links to noise-related sites—worldwide

Current Activities of I-INCE

I have served as I-INCE President for nearly five years, and this is my last President's Column. In this article, I would like to briefly introduce the current activities of I-INCE.

I-INCE was founded in 1974, and is now in its 34th year. As of today, the Institute has 41 Member Societies in 33 countries, 8 Sustaining members, and 10 Institutional members in the world. Its financial condition is sound owing to the member dues and fees from INTER-NOISE congresses.

The main activities of I-INCE are (1) planning of annual INTER-NOISE congress series in various cities in the world, (2) promotion of the international exchange of information related to noise control engineering, (3) definition of long-range global noise-control policy goals, and (4) encouragement of the development of education on noise control engineering.

As for the first item, INTER-NOISE congress has been held every year from 1972. INTER-NOISE 2008, which will be held in Shanghai in this October, is the 37th congress. The venue of each congress is decided at the I-INCE General Assembly based on the recommendation by the Congress Selection Committee and the Board of Directors. The selection procedure starts five years before the congress, in which the the venue is chosen from the three geographical regions, Europe-Africa, Pan-America and Asia-Pacific in turn. As the future congresses, the following schedule has been approved: 2009 in Ottawa, Canada, 2010 in Lisbon, Portugal, and 2011 in Asia-Pacific region, and 2012 in the Pan-American region.

I-INCE is also active on other continuing programs. To promote the second to fourth items mentioned above, the Technical Study Groups (TSGs) have been established in I-INCE. Currently, the following TSGs are active.

- "Noise of Recreational Activities in Outdoor Areas" (TSG 1),
- "Assessment of the Effectiveness of Noise Policies and Regulations" (TSG 3),
- "Environmental Noise Impact Assessment and Mitigation" (TSG 6),
- "Harmonization and Implementation of Global Noise Policies" (TSG 7),

In addition, TSGs for "Noise Control Engineering Education Worldwide" and "Noise and Reverberation Control for Schoolrooms" will be established in the near future.

The reports prepared by the TSGs are published in this magazine and, in one case, in ***Noise Control Engineering Journal***. They are also published on the I-INCE web site. These reports will be very useful not only for noise control researchers/engineers but also for policy makers in charge of environmental noise issues in each country in the world.

Another unique activity of I-INCE is the "Technical Divisions," in which currently important research topics are discussed among the congress participants, and proposals are made for Technical Sessions in future congresses. Although there have been discussions at each congress for the past few years, the results have not been as good as was anticipated when the Divisions were established. One reason is because the time for discussion was limited to very short time in the lunch breaks. Recently, the I-INCE Board of Directors has discussed this problem and decided to propose a new system provisionally named "Future Congress Technical Planners" which will be planned in parallel with the regular congress technical sessions—with enough time for discussion.

Another activity is the publication, with INCE/USA, of this quarterly magazine. Issues are distributed to the Member Societies of I-INCE, and provide regular communication of I-INCE activities as they develop.

Lack of space prevents me from introducing other activities of I-INCE here. I-INCE still has various tasks; not only the development and exchange of noise/vibration control engineering but also appeal of its importance to the general public.

Hideki Tachibana
President, International INCE

Education and the Noise Control Engineer

Marion Burgess

Asia-Pacific Editor

It seems like *education* is a hot topic for consideration at conferences and meetings for acoustics. At the There is a forum planned for INTER-NOISE 08 in October on "Asia-Pacific Education in Noise Control Engineering." At the Australian Acoustical Society Conference in November there will be a workshop on sustainability of acoustics education. In the June *NNI* Presidents Column, Patricia Davies referred to outcomes from a INCE/USA forum focused on education *(See the feature article in this issue.—Ed.)*

Perhaps one of the drivers for this concern about acoustics education is the strength of the noise control engineering industry. From the job advertisements, it can be seen that there is a demand in many countries for staff to work for consultancies and agencies specializing in acoustics and primarily in noise control. For the right person with the right skills there are clearly good opportunities for a career as a noise control engineer in private industry, or as an acoustics specialist in government or semi-government agencies. This is just as much the case in Asia as elsewhere in the world.

Employers would ideally like to offer positions to graduates who also have a good understanding of acoustics. A degree in science, engineering, or building is generally the basic qualification required for most new personnel wishing to enter the field. However the opportunity for the students to undertake, within their undergraduate program, courses on noise control depends,to a great extent, on academic staff who are knowledgeable and enthusiastic about the subject at the university they attend. Usually, this is only the case if acoustics and vibration is a research strength within the institution.

So, having employed an engineering or science graduate, the employer has the task to develop and refine the appropriate skills of the new staff. Options for undertaking post graduate study in acoustics on a part time basis are not always available in a convenient location. If they are, the problem is to fit the attendance at classes with the work demands. Short courses are another way to develop skills and knowledge but these may not be offered at a suitable time or location. Some larger firms can provide in-house training but this is rarely balanced and consistent due to changes in personnel and work pressures.

The acoustics consulting profession in Australia faced this problem and identified their needs were for a fully flexible distance learning program. This has been established and follows somewhat the structure of the United Kingdom Institute of Acoustics Diploma program. Two changes in the approach of the Australian program are that it is run via a short course program of a University (as opposed to the formal academic programs of study), and that it uses the expertise in the consultancies to provide the tutoring and supervision of the experimental sessions and the tests. Consequently, the students do not have to attend a central location at any time during the program.

This flexible approach has been very successful so far. The senior consultants know how important it is for their staff to work through a structured educational package and provide the support necessary. The flexibility of the distance learning program is a strength, as it allows the student to defer when work pressures increase, but it is also a weakness in that some students continually extend due to the lack of firm deadlines.

The success of this program highlights the benefits of having the industry involved with both the development of a program of study that meets their needs while maintaining educational rigor.

Managing editor's note: This issue contains a feature on noise control engineering education in the USA. Future articles will cover noise control engineering education in Europe and in the Asia-Pacific region.

Noise Control Engineering Education in the USA

Janet Moss, Noise Control Foundation, Poughkeepsie, New York, USA

Introduction

The third National Noise Policy Workshop was held during NOISE-CON 2007 in Reno, Nevada, USA, on 2007 October 23. The theme of the workshop was "U.S. Education in Noise Control Engineering." The implementation of noise policy depends on the education of noise control engineers in America. The purpose of the workshop was to consider the current capacity to educate technologists and to recognize the challenges within academe to place greater emphasis on noise control education.

Many universities have one or more professors teaching courses in noise control engineering. There is evidence that current demand for trained professionals in this field may exceed the supply and that industry and government are now hiring people from other fields to perform noise control engineering work—aerodynamicists, crash-worthiness engineers, physicists, mechanical engineers, vibration specialists, electrical engineers, and others. To be fully effective as a noise control engineer, many educators stress that graduate training leading to a degree is needed in this field. The objectives of the Reno workshop were to determine the current demand for noise control engineers in the public and private sectors, assess the ability of higher education to supply these specialists, examine the current academic curricula available to meet this demand, and define the topics of major importance to the education of noise control engineers.

The workshop featured morning and afternoon sessions with presentations by panelists from academe and industry. In Sessions 1 and 2 panelists addressed questions on noise control engineering education at their universities. The focus of Session 3 was on the needs of industry for noise control engineers.

The panelists from academe described the course offerings and research at their institutions and the current demand for noise control engineers in the public and private sectors. They assessed the capability of higher education to supply these specialists. The panelists from industry described their role in reducing noise, the educational requirements for a successful industrial career, and industry demand for noise control engineers.

Executive Summary

In Sessions 1 and 2 panelists addressed questions on noise control engineering education at their universities. Much of the subject matter in these presentations concerned the extent of the noise control engineering education offered at the panelist's university and whether it was adequate to supply industry's need for qualified engineers. The panelists covered the number of courses, faculty, and students in such a program as well as the number of requests from industry for trained graduates. If no specific program in noise control engineering was offered, they indicated the other program areas (e.g. mechanical engineering) where some acoustics courses could be found

The scope of noise control engineering education varied greatly with each university. The focus of engineering programs at each university had much to do with funding from industry to support the particular need they had. Hiring of faculty was also based on who was supporting the program.

During the discussion, in addition to the questions from the audience, the panelists in Sessions 1 and 2 were asked to answer the following three questions:

1. If you had your choice of teaching a course related to acoustics and noise control which is not being taught now, and you were not constrained by money or management approval, is there any course that you would like to teach that you're not teaching now?
2. If INCE/USA were to have a program to define, for the benefit of employers, what a noise control engineer should know and ask the universities if they would agree on that subject, what would the response be?
3. If students thought that it would be beneficial to them to have some sort of certification from INCE/USA that they had knowledge of the key courses of noise control engineering, what would be the response from the academic world?

The subject of INCE/USA involvement with universities in several areas was a topic of much discussion. The bottom line, though, seemed to be that this was a bit of a gray area and at this time not well enough developed to make a major contribution to the field.

Regarding the off-campus training available, some panelists covered what

their universities offered in this area. Cooperation with industry provided benefits to both the university and industry. Also, it was mentioned that some industries approached the students long before they were ready to graduate to support their studies in the areas most needed by that industry.

The focus of Session 3 was on the needs of industry for noise control engineers. Panelists spoke on the source of their noise control engineers (e.g. other disciplines but with additional training in NCE subjects). The conclusion was that there were not enough properly trained noise control engineers to supply the needs of industry. Additional training and the availability of publications to supplement the knowledge of those practicing noise control engineering in industry was discussed, but the individual must want to further pursue his training.

There was some discussion on whether chapters of INCE/USA and other professional societies should be founded at the universities. ASA has done just this. Some from industry mentioned that the noise control engineers in their company were not even aware of INCE/USA. (A recurring topic it seems is to get more publicity on and activity from INCE/USA.) There was a great deal discussion on the activities and roles of other related professional organizations.

A brief but important point was brought up and agreed on by both those in academe and industry regarding communication. Apparently writing and communication skills are offered in the universities but not taken seriously by many of the students. However, once in the corporate world, the need for these skills becomes apparent and important if these engineers are to communicate the problems and solutions either verbally or in print.

Session 1 – University Programs

Panelists

Robert Bernhard
University of Notre Dame

Scott Sommerfeldt
Brigham Young University

Kenneth Cunefare
Georgia Institute of Technology

Rajendra Singh
Ohio State University

Presentations

Noise control engineering education

Robert J. Bernhard, University of Notre Dame

There is need for technologists in noise control engineering. Currently there is no comprehensive survey of the need for noise control technologists across the broad applications, but there is anecdotal information through inquiries that have found their way to the Herrick Labs and the profiles of current practitioners. For the past decade Herrick Labs has had 60 to 100 inquires per year from the automotive companies and their head hunters and consultants in the mechanical and architectural fields (a limited set of the need). Follow-up inquiries show that many of these positions were not filled. It is a seller's market—significant mobility occurs in the field.

Our current pool of noise control technologists has been recruited from many fields—aerodynamicists, crash-worthiness engineers, physicists, mechanical engineers, vibration specialists, electrical engineers, systems engineers, and others. There are three languages in the noise control field—waves, modes, and dBese. Few practitioners are trilingual.

A review of data from the Acoustical Society of America's *DIRECTORY OF GRADUATE EDUCATION IN ACOUSTICS* and participation in ASME, ASA, SAE, AIAA, TRB, Noise-Con, INTER-NOISE, and ASHRAE conferences show that there are few universities with a critical mass in "noise and noise control." Some that offer such curricula are: Penn State, Purdue, Georgia Tech, Virginia Polytech, M.I.T., Stanford, Michigan Tech, Ohio State, Iowa State, Texas Austin, Cincinnati, and Brigham Young. Other universities may have one faculty member with a noise control engineering background.

There are approximately 30 to 50 engineering graduates per year with an MS or PhD in the noise field and 150 to 250 engineering and architecture BS graduates who have taken one noise control class. The demand for these graduates far exceeds the supply. To compensate for the shortage, some businesses assign noise

control practitioners to corporate labs rather than disperse them to operations units where noise characteristics will be incorporated into the product. Some offer continuing education for current employees through a limited number of university programs, vendor and customer courses, peer mentoring, and conferences; but their depth of understanding is often limited.

Many issues impact the response of universities to this situation. These include Accreditation Board for Engineering and Technology (ABET) accreditation, national priorities and global challenges, the potential for research funding, and hiring practices. The issue is to find a home for noise control within the academic departments.

In Architectural Engineering, the program must demonstrate that graduates have proficiency in mathematics through differential equations, probability and statistics, calculus-based physics, and general chemistry; proficiency in statistics, strength of materials, thermodynamics, fluid mechanics, electric circuits, and engineering economics; proficiency . . . in structures, building mechanical and electrical systems, and construction management; engineering design capabilities in . . . architectural engineering. . . In Mechanical Engineering, the program must demonstrate that graduates have knowledge of chemistry and calculus-based physics with depth in at least one; the ability to apply advanced mathematics through multivariate calculus and differential equations; familiarity with statistics and linear algebra; the ability to work professionally. [1] These requirements drive curriculum which drives faculty hires.

The U.S. Government's Office of Science and Technology Policy instructs agencies to assess the priorities for and stewardship of Federal scientific collections, which play an important role in public health and safety, homeland security, trade and economic development, medical research, and environmental monitoring. [2] These priorities drive universities which drive faculty hiring and new facilities.

Acoustics, dynamics, and vibrations are part of the National Science Foundation (NSF) FY2006 engineering budget. In addition to NSF's "core" research and educational activities, NSF supports four major research initiatives, or "priority areas." These are: nanoscale science and engineering, mathematical sciences, human and social dynamics, and biocomplexity in the environment.

Funding drives much of the discretionary effort of a university and may come from graduate student support, facilities, and faculty interest. During the Cold War, the need for underwater signature reduction dominated funding in noise control; but today there are no significant funding priorities aligned with noise control. At Purdue the funding metric is $400K per year per faculty member. Making the case to hire new faculty in noise control requires a proposal based on teaching, research funding, and national and global priorities for the long term. Depending on the administration it is possible to be squeezed between or to take advantage of the "old school" (one-for-one replacement for attrition) or the "new school" (inter-disciplinary initiatives aligned with global challenges).

Noise control does not have a leading federal agency to advocate for a quieter America. The budgets for noise control among the several federal agencies involved are small. Noise is not mainstream environmental engineering but crosses academic disciplines and agency departmental organizations.

In summary, there is a large unfilled need for well-educated noise control technologists. A graduate degree is the entry-level degree required to practice in this field. Continuing education offerings (informal post-graduate educational experiences) are not sufficient to fill the demand for noise control technologists. We should develop a noise control curriculum with accreditation standards and integrate noise control concepts throughout existing curricula to develop high-quality noise control practitioners. And we need to increase faculty hiring, which requires building a case for noise control engineering

1. ABET Criteria for Accrediting Engineering Programs, 11/1/2004
2. Office of Science and Technology Policy, Excerpts from FY 2007 Administration Research and Development Budget Priorities

Acoustics and noise control engineering at Brigham Young University

Scott D. Sommerfeldt, Brigham Young University

At Brigham Young University (BYU), acoustics was historically housed in physics, due to Harvey Fletcher and Carl Eyring, who were both in the physics department. This program has been strengthened over the past decade with a focus on also being interdisciplinary (primarily with Mechanical Engineering). There are now three full-time and one part-time faculty members in physics and three full-time faculty members in mechanical engineering. To better understand the acoustics program at BYU, it is important to recognize that BYU's primary emphasis is on undergraduate education. However, the university also seeks strong graduate programs in support of that mission. Thus, in building the acoustics program, we have sought to develop a strong graduate program in acoustics along with significant involvement of undergraduate students

The acoustics and noise control curriculum at BYU consists of "core" courses that require math preparation through (partial) differential equations, which usually

happens by the junior year. The following "core" courses are for graduate students, but are also taken by seniors or well-prepared juniors:

- Physics/ME 561 – Fundamentals of Acoustics: waves in fluids and solids, source radiation, reflection/transmission, sound in pipes, acoustic filters, community noise, basic noise control, nonlinear acoustics;
- ME 535 – Mechanical Vibrations: mass-spring systems, strings, membranes, rods, beams, plates, shells;
- Physics 660/ME 562 – Analysis of Acoustic Systems: equivalent circuit analysis, acoustic filters, arrays, directivity, transducers, duct acoustics, general spherical/cylindrical waves, scattering, energy-based acoustics;
- Physics 661 – Acoustics of Music, Speech, Architecture, and Audio: Room acoustics, audio, music/speech; and
- Physics 662 – Interaction of Sound Fields and Vibrating Structures: structural radiation, fluid loading, transmission and transmission loss, active noise and vibration control.

There are approximately 40 additional supporting courses related to acoustics. Some more closely aligned with noise control engineering are: ME 609 – Spectral Analysis of Dynamic Systems; ME 312/512 – Fluid Mechanics/Dynamics; ME 363 – Instrumentation; ME 431 – Design of Control Systems (classical control theory); EE 541 – Active and Passive Filter Design; and Physics 167 – Descriptive Acoustics of Music and Speech. At the junior/senior level, a future course is planned (Fall 2008) which will focus on fundamental acoustics with a strong emphasis on noise control and community noise.

A BS degree in physics or mechanical engineering typically takes 4 to 5 years. A popular degree for acoustics is a BS Applied Physics – Selected Options, which allows a student to have about four elective courses focused on acoustics as part of his/her curriculum. An MS in Physics or Mechanical Engineering with an emphasis in acoustics typically takes 2 to 2½ additional years while a PhD in Physics or Mechanical Engineering with an emphasis in acoustics takes 4 to 6 years beyond the BS level. At BYU, flexibility now exists for graduate students to tailor their curriculum to meet their professional needs or interests. This is particularly attractive for the PhD program.

BYU offers a research program which typically involves approximately 12 to 14 graduate students (mostly MS), along with about 20 undergraduate students. We typically graduate 4 to 5 graduate students per year. Currently, we receive more inquiries from potential employers than the number of students we have to fill positions. Physics requires a senior thesis or capstone project for undergraduate majors (usually 3 to 6 per year). There are weekly Acoustics Research Group (ARG) meetings which cover numerous subjects related to acoustics and noise control and are typically attended by approximately 35 to 40 students. There are also a number of additional smaller group meetings for various research projects that usually meet weekly.

The research program has access to large (8.71 x 5.66 x 5.74 m) and small (3.00 x 2.38 x 2.80 m) anechoic chambers, a variable acoustics chamber, large (210 m^3) and small (65 m^3) reverberation chambers, as well as computer controlled scanning systems in most of those facilities The equipment available to students in this program includes at least six multi-channel (2-56 channels) analyzers, more than 70 Type 1 microphones, 3 Larson Davis Type 1 sound level meters, a Polytec Scanning Laser Doppler Vibrometer, a Larson Davis intensity probe, about 20 PCB accelerometers, a PCB impact hammer kit, shakers and speakers, filters and amplifiers. Also available is software such as Matlab, Maple, SysNoise, ANSYS, FLUENT, CATT Acoustics, and ADA EASE.

Over the past 5 years, the ARG faculty has had over $400k per year in research funding. About 45 percent of that has been industry funding, and the rest has been government (federal/state) funding. At this time, the ARG supports research projects in active noise control (axial fan noise, cab noise, and transmission loss), use of energy density measurements to measure acoustic power and absorption, nonlinear jet noise, nearfield acoustic holography (NAH), and throat microphones for high ambient noise environments

The demand for BYU graduates with noise control training is strong and recent industry placements have included major corporations such as Caterpillar, EAR Acoustics, Apple Computer, Starkey Labs, National Instruments, and many more. Many of our BS and MS graduates are pursuing further graduate work at some of the best schools in the country.

The limiting factor for BYU's noise program seems to be time available for faculty members who mentor graduate students. (Those faculty members typically have about 3 graduate students which, when coupled with undergraduate student involvement and teaching assignments, makes it difficult to increase that number.) We are currently receiving more applications from qualified graduate students than we can admit. They also tend to be weighted more to the MS level, and we would like to attract a higher ratio of PhD to MS students. BYU is also looking at the possibility of developing an interdisciplinary bachelor's program in acoustics that would focus on preparing students who do not plan to go on to graduate school. The program would have a strong emphasis on community noise and noise control topics.

In conclusion, from our perspective there appears to be significant interest among students, as well as demand from potential employers, to support acoustics and noise control training.

The challenge of noise control education at a major engineering research university

Ken Cunefare, Georgia Institute of Technology

There is no formal "noise control engineering" program, certificate, or degree at Georgia Institute of Technology (GIT). However, there is a graduate program in acoustics and dynamics with faculty, students, graduate program courses, and facilities. The research interests of Georgia Tech faculty members include topics under acoustics, vibration, wave propagation, and other similar noise-related subjects.

During the past three years, 90 percent of the GIT students were from out of state. Of the new students, there were 12 with a primary interest in noise and 24 whose interest in noise was secondary. At present the population in acoustics-related programs includes 16 MS and 23 PhD students. The curriculum requires at least two years for an MS degree and at least 5 years for a PhD. During the past three years 12 MS and 9 PhD students with an acoustics major graduated. Most GIT students are supported by grants, contracts, or fellowships. After graduation, many are placed in academe, government laboratories, and industry with a small number entering the consulting field.

There are two core noise control courses:

- ME 4760: Engineering Acoustics and Noise Control which is a senior undergraduate technical elective taught every fall. There are thirty or more students in this course, and they are taught at the level of C. Hansen's "Noise Control."
- ME 6762: Applied Acoustics which is a graduate class taught every spring. There are usually at least 10 students per year, and they are taught at the level of D. Bies and C. Hansen's "Engineering Noise Control" plus extensive supplementary material.

In addition, two new courses are planned—Human Response to Sound and Vibration and Architectural Acoustics.

The main facility devoted to the noise curriculum is the Integrated Acoustics Laboratory (IAL) which was developed as a campus resource to support education and research in acoustics and vibration. This facility was primarily funded by the Ford Motor Company and has three acoustic test chambers and an active control laboratory. The initial development of IAL began in 1996; and during the following three years, a fully-anechoic chamber, instrumentation backbone, sensors, and a laser vibrometer were installed. During the years from 1999 through 2004, a hemi-anechoic chamber, a reverberation chamber, additional instrumentation backbone items, and sensors were added.

The graduate program in acoustics and dynamics faces several challenges. The research that is undertaken determines the subjects to be taught, and faculty recruiting follows the dollars. Recently recruiting has heavily emphasized microelectromechanical systems (MEMs), biomedical engineering, and advanced nanotechnology (Nano-X). The faculty perception of fields of acoustics and noise control are too applied and there is a dearth of funding to support research. This mold was recently broken with two new acoustics courses and one new dynamics course.

As far as funding challenges are concerned, the keyword is "noise control." From the National Institutes of Health there have been no grants; however, from the National Science Foundation 13 grants have been received between the years of 1997 and 2007, 9 involving active noise control and 4 involving passive noise control. Grants have also been received from NASA for modeling, exterior noise control, and optimal active and passive control. Funding has also been received from American Society of Heating, Refrigerating and Air-Conditioning Engineers; is anticipated from DOT; and there are several industry sources.

In conclusion, GIT intends to develop a healthy graduate program with new faculty specializing in noise issues. Although the goal would be to produce graduates who have in-depth knowledge of acoustics and vibrations, they would not necessarily be considered noise control engineers. As the curriculum is determined by outside (industry) research interests and funding for these interests, new and creative funding opportunities are needed.

Practice and science track courses in noise and vibration control

Rajendra Singh, The Ohio State University

Regular and Short Courses

The science track courses offered by the Mechanical Engineering Department at The Ohio State University (OSU) are Engineering Acoustics, Wave Dynamics in Fluids, Digital Signal Analysis, Vibrations of Discrete Systems, and Vibrations of Continuous Systems. Graduate specialization in "Dynamics, Vibration and Acoustics" is available as part of the MS degree in Mechanical Engineering. However, few students have shown an interest.

Courses and research opportunities for undergraduate students include Vibrations of Mechanical Systems and Acoustic Problems in Engineering. Undergraduate honors students can work on research projects leading to a thesis. Five undergraduates have received INCE/USA undergraduate awards. One student won the best student paper award at ACTIVE 2004. His paper appeared in *Noise Control Engineering Journal*.

Practice track courses are offered as part of a graduate course sequence in automotive Noise, Vibration and Harshness (NVH) control. The sequence consists of 3 courses based on an innovative case study approach patterned on what has been done

in business, law, and medical schools. This sequence has been developed in close collaboration with General Motors and is taught once every 2 years. The objectives are to enhance critical thinking skills and relate NVH issues to design, manufacturing, materials, performance, and economic considerations; and to integrate concepts of mechanical vibrations, acoustics, digital signal processing, and machinery dynamics into a cohesive graduate course sequence.

Several short courses are offered. Basic Gear Noise (3 days) has been taught for more than 28 years to more than 1300 engineers from over 310 companies. Advanced Gear Noise (2 days) is offered once every other year. Rubber and Hydraulic Mounts (3 days) has been taught at more than 6 companies with an attendance of over 300 engineers. Driveline NVH (3 days) has been taught at 4 companies with over 150 engineers attending.

A certificate in Automotive Noise and Vibration Control (CNVH) has been offered by OSU in collaboration with KAIST (Korea) and General Motors since 2006. It requires the completion of 2 graduate courses in NVH and 4 self-paced seminars on contemporary topics.

OSU Research Labs

Education in noise and vibration control and related topics is research-based at four OSU research laboratories. The Acoustics and Dynamics Laboratory is combined with the Center for Automotive Research and the Smart Vehicle Concepts Center. This laboratory is supported by a new consortium of 12 companies. It focuses on noise and vibration sources in machine elements including non-linear sources, modeling and control of structure-borne noise paths, and the inclusion of smart materials. Applications are to automotive NVH and gear noise for helicopters, consumer products, etc.

The Flow, Engine, and Acoustics Research Laboratories that are part of the Center for Automotive Research are studying flow noise and its suppression in engine induction systems, engine simulation codes, and 3D frequency domain coupling for hybrid silencers for engines and turbo-charger silencers.

The Gear Dynamics and Gear Noise Research Laboratory is supported by a consortium of 47 companies and is studying gear noise excitation models, the relationship between gear noise and dynamic stress factors, and wear interactions in gear systems.

The Dynamics and Vibrations Laboratory is studying planetary and multi-mesh gear vibrations, belt dynamics, and experimental gear vibrations. The Gas Dynamics and Turbulence Laboratory is studying jet noise, flow control, aero-acoustics, and turbulence.

During 2002-2007 research-based education at OSU has graduated researchers with 14 PhD degrees, 35 MS degrees, and 5 BS honors degrees. Currently there are 16 PhD candidates, 10 MS candidates, and 2 BS honors candidates. There are 5 members of faculty, all in Mechanical Engineering. The graduate researchers and staff number approximately 30, and the grants and contracts for the laboratories are about $1.5M per year. For each graduate researcher, an average of $50K per year is needed for support from external sources.

Summary

The practice track graduate course sequence and short courses have been motivated by the needs of the automotive industry. The research focus has been on noise sources and transmission paths and their relationship to design, processing, and manufacturing. The research has been supported by more than 75 companies and government agencies.

The results of the research have been published in technical journals and publications; over the last five years nearly 100 articles have been published. Fourteen OSU students have won best student paper awards at SAE, ASME, INCE and ASA conferences. The faculty has received the Outstanding Distance Learning Faculty Award from General Motors, the Excellence in the Education of Noise Control Engineers from INCE/USA, and the George Westinghouse Award for "Distinguished contributions to the teaching of engineering" from the American Society for Engineering Education.

Session 1 - Discussion

Noise Control in Buildings

Question to the panel: Is the question of education related to the criteria for noise control and community noise, for example, methods, surveys, and that sort of thing? When I was young, there was a WADC report; Ken Stevens was involved in community noise studies, criteria for office noise and that sort of thing. So if you could talk about the building acoustics—noise control in buildings—and the question of criteria for noise control engineering.

Comment: My experience interacting with the civil engineers for work on noise control in buildings hasn't borne much fruit. Civil engineering departments are a consortium of about seven different sub-departments. Building acoustics just doesn't fall in their area of interest. I see a lot of potential for the future in the area of community research work and doing a better job of community-based data collection, but the current practitioners in these areas need to become more interested in interdisciplinary approaches. Elsewhere, the connections between engineering and social sciences have increased dramatically, and I believe now that dialog can bring social sciences onto our community noise

teams to help us understand how to do some of the things that we may have done poorly in the past. I believe that we may even be able to feed back some of the research on things that are being done in those disciplines for our purposes.

Comment: My perspective on noise control in buildings is that we do have some parts of our curricula where we look at what may be called architectural acoustics, but it is fairly general, talking about absorption, reverberation, and transmission loss and not some of the nitty-gritty practical things. The challenge we face simply is time to be able to fit it into the courses. That's a challenge we face at BYU. The environment at BYU is such that if we want to add something, the very first question asked is: That's fine, what are you taking away? It's really a net gain of zero game that we're playing. So we struggle to cover everything. Community noise is the other issue and is somewhat similar. We have built community noise in to some extent, but to cover it more extensively gets us into the same game—what are you going to take away now?

Comment: In the program at Georgia Tech there is very little communication in civil engineering with the architectural program. There's an ingrained, stove-piping academic structure arguing against us. We do cover aspects of building systems and noise control in our courses. As far as criteria and community noise, we cover those extensively in the undergraduate and graduate courses. There may be opportunities in the Atlanta area that will permit some social interaction where the city of Atlanta may some day do a city-wide noise map. If they do that, it is probably something that will come through our group.

Comment: I don't think that there is much collaboration between civil engineering and mechanical engineering in the region of noise control. In the engineering acoustics class there is standard room acoustics theory taught, but there is not a lot taught in the area of architectural acoustics. The mechanical engineering program is more directed towards automotive engineers and they get away from areas like noise control.

Core Curriculum in Noise Control

Question to the panel: The next question has to do with professionals in the field. When people hire in industry it's usually electrical engineers, mechanical engineers, mining engineers, and not necessarily noise control engineers. That situation may not change in industry and the university. But if INCE/USA were to try to get the universities together to define what courses constitute a reasonable curriculum in noise control engineering that could be agreed upon within universities, do you think there would be any probability of success for some sort of agreement on what courses a student should have taken as part of a degree program? If a person has an MS or PhD and has specialized in noise control and an employer were to come to INCE/USA and ask what he should expect this person to know, could there be any agreement within the university community on a series of core courses in noise control that one could list that contain material that would be expected?

Comment: As long as the list of courses doesn't get too long, I think people would be interested to hear what that list would be. If INCE/USA were to put out a list and say that they believe that these three or four courses probably represent the core of the noise control engineering curriculum, and then we would typically expect options to go along certain lines. I think there would be a willingness to look at such a document. But I do not believe such a curriculum would be taught in a department of its own. I believe the noise control engineering faculty would be teaching this curriculum to our students. We probably wouldn't want to take this through a university's approval process.

Comment: I think on basic concepts you might get some agreement, but various institutions have things that they're emphasizing. Ohio State has automotive noise, for example. Depending on what your specialty is you're going to focus on some areas much more heavily. So I think you have to stay with fairly basic concepts to get widespread agreement on what should be targeted for noise control engineering education. Taken to an institutional level, it would be very difficult because they're not going to care what INCE/USA does or doesn't think about this. They think about this from purely the institutional perspective.

Comment: My point of view is different because I'm a graduate student. I'm graduating next March, and I'm looking for a job in acoustics myself. My feeling is that some courses are of more interest to employers seeking to hire noise control engineers. Some courses at the university are necessary especially the more practical courses where we have projects.

Question to the panel: This has to do with whether we could design some sort of core curriculum of a few courses of noise control. If INCE/USA were to say that we would like to offer a certificate from INCE/USA to students who would take an examination, not like our fundamentals or professional exams, but some sort of an exam that might cover some of the core subjects and also maybe some of the things that different universities would be interested in, do you think that the universities would be receptive to INCE/USA offering some sort of certificate to students after they pass an examination prepared by INCE/USA?

Comment: I don't think the universities would have a role there. I think it would be either the faculty or research groups who would be supportive of noise control education. That said, what is your market to induce students to take this when you already have it in INCE/USA in the

fundamentals and professional exams? I'm wondering about the value of this.

Comment: I agree completely with Ken; I don't think the university would care. I think the students will take it if they perceive a benefit to it. I think the benefit is going to have to come from industry. If this idea were to fly, students would take it because they would have a perception that they have a better shot at getting hired if they have this certification through INCE. I'm somewhat neutral on the idea, but if we want to build it in INCE/USA, I think it has to be built at the industry level to have them say that they want somebody with INCE/USA certification in noise control engineering. Then the students I think will be interested in taking it.

ABET Requirements

Question to Bob Bernhard: You mentioned in your talk that the ABET requirements have changed and evidently become much more general now than they were some years ago, at least in mechanical engineering. Is there any way that we could influence the accreditation by including something more on noise control than we have now? How can we get a little more visibility for noise control engineering?

Answer: I believe currently the ABET committees are resistant to people talking about a disciplinary curriculum. At this point the accrediting agencies are talking about students being able to solve open-ended problems, being able to communicate, and being able to do design. I think noise control is actually a great disciplinary area to fit the current ABET requirements. So if you look at what they're asking engineers to do now, in fact noise control is very good. It's interdisciplinary, it's team oriented, and it's pragmatic. I think the strategy could be that we could look at the requirements and start to help the faculty to build a better case that noise control fits ABET requirements.

Industry Demand

Question to the panel: I'd like to address the question that Bob Bernhard asked about anecdotal evidence and the hiring and demand for people. We talked a bit about the supply. Tell us about how difficult or easy it is for students in this field to get a job. What's your perception of the demand?

Comment: All of our students who wanted a job in acoustics or noise control have been able to find one with reasonable ease. As a faculty member, we're getting more inquiries per year than we can provide students to fill all the positions.

Comment: Georgia Institute of Technology students aren't having any difficulty finding positions unless they impose unreasonable geographical constraints on where they wish to work. A common problem is when industry is looking for people with a narrow skill set which matches up with the population and the student interest. So the students are more successful in finding positions than industry is in finding students for the positions.

Course you would like to teach

Question to the panel: If you had your choice of teaching a course related to acoustics and noise control and for some reason it's not being taught now, is there any course that you would really like to be teaching that you're not teaching now?

Comment: When I had to give up my favorite course in undergraduate noise control, I took over an internal combustion engines class.

Comment: If it's not acoustics, my favorite would be to teach one of the introductory physics courses dealing with waves and optics and things like that.

Comment: When I was still active teaching, I had the perfect teaching assignment. I was teaching a sophomore class in mechanical engineering design which was an introductory project-based course where we taught teaming, creativity, oral communication, and we exposed these students to stress analysis and fluid mechanics and material they didn't know yet but they had to learn. Then I taught a graduate class for finite element analysis with a dozen highly motivated PhD graduate students. It was great fun to teach in these two environments.

Comment: As a retired professor from Penn State, I'd like to teach basic noise control technology to associate degree students. I'm actively pursuing such a position in one of the branch campuses of Penn State which is called the Pennsylvania College of Technology; they offer two-year (associate) technology degrees. That's where I'm trying to direct my energy so that these individuals who come out as technologists know something about noise and noise control.

Comment: I'd like to comment on Bob Bernhard's remark about the synergy created by combining the hard sciences that encompass noise control with certain social sciences. We've found at Virginia Tech that a significant number of noise-related research applications can benefit from combining acoustics with behavioral science techniques that involve operational performance effectiveness measures, speech intelligibility measures, metrics of noise-induced annoyance, and so forth. Faculty who have ergonomics and similar backgrounds can team on noise research proposals to strengthen them. My other comment relates to the speakers' remarks about the lack of civil engineers taking classes in noise control. It's been my experience at Virginia Tech that civil engineering students don't typically take our classes. But when they enter practice, particularly in small firms in small cities, it's often the civil engineers that are asked to do the traffic noise studies or noise impact studies and then interpret the data

for zoning decisions. Without a basic background in noise measurement and impact, their input can be lacking. If that occurs, additional consultants have to be retained. So, certainly civil engineering students could benefit from an overview-level background in noise, if we could get it into their class work. But the reality is that discipline-specific engineering curricula are already packed, and there may not be time for adding the noise content for civil engineers, even though it is probably needed.

Comment: A comment on this historic thing about NSF not doing acoustics and noise control. This is because in the funding agency division, acoustics was always handled by the Office of Naval Research. The end of the Cold War made an impact in that area because the NSF still has this historical division. When NSF was set up, the Office of Naval Research existed and NSF was modeled after ONR; so there was a close association from the beginning. When I was at ONR, I was on a committee that helped establish a joint program with NSF. I'm not sure if everybody is aware of this joint program, but it may be a way to generate some graduate student support for acoustics and noise control. Under the program if you're an NSF Principal Investigator, you can set up collaboration with a Navy laboratory; the Chief of Naval Research will fully fund a PhD or Master's student if that student works a summer in the Navy lab on a Navy project. There's a commitment to go work in the Navy Lab for one year or more. This is because the U.S. Navy sees a big problem in the retiring work force from their Navy labs and they don't have qualified people coming in. The only caveat is that one usually needs to be a U.S. citizen to be able to work in the Navy labs. It is still an active program.

Comment: To follow-up on the comment about civil engineers, and how we like to get acoustics into their curriculum. At IIT I'm in civil, architectural, and environmental engineering. When I was at Colorado it was civil, environmental, and architectural engineering. As much as I tried as a young faculty member to develop a course, there was no way to get it into the civil engineering curriculum because of ABET, the accreditation board. With the number of free credits available and what has to be covered there is no room in the curriculum. As things change and maybe some programs go to five years (At IIT we're looking at certificate programs that engineers may want to take.), there's a chance to get acoustics added in. But in a four-year civil engineering curriculum, there is almost no chance to add acoustics, even as a part of another course. So as much as we want to add acoustics, it's going to be a while before that is possible unless we can get the ABET board to recognize acoustics.

Highlights of the discussion

1. The scope of noise control engineering education varies greatly with each university. Much of the focus on the engineering programs in each university has to do with funding from industry to support the particular needs they have. Hiring of faculty is based on who is supporting what program.
2. There are not enough properly trained noise control engineers—those with graduate degrees—to supply the needs of industry. Students are more successful in finding positions than industry is in finding students for the positions.
3. Noise control is a great field to fit the current ABET requirements. It's interdisciplinary, it's team oriented, and it's pragmatic.
4. Civil engineering students could benefit from an overview course in noise. But the reality is that discipline-specific engineering curricula are already packed, and there may not be time for adding a noise course for civil engineers.

Session 2 – University Programs

Panelists

Patricia Davies
Purdue University

Anthony Atchley
Pennsylvania State University

David Holger
Iowa State University

Presentations

How can we fulfill the demand of industry and academia for engineers with expertise in acoustics, vibration and noise control?

Patricia Davies, Purdue University

The ideal acoustics and vibrations graduate would have a good grounding in the fundamentals in those areas. A graduate-level degree with emphasis in noise and vibration should include experimental and signal analysis skills, simulation and computational skills, and analytical and modeling skills. These graduates should have the ability to embrace new problems and to apply their fundamental understanding of acoustics and vibrations to real-world problems. To achieve this they must have had meaningful project experiences with actively participating sponsors. Such participation would include face-to-face discussions, other means of communication, technology transfer, and an understanding of industry needs.

The output of graduates from a university program is given by a simple equation. The output equals the number of faculty members multiplied by the number of graduate students per faculty member. This number varies between five and eight. Hence, to produce graduates in acoustics and vibrations funding is required for 5 to 8 graduate students per faculty member. The funded projects must have a publishable research component. Experience

demonstrates if funding is available for research, universities will hire faculty in that area. The number of courses offered in an acoustics and vibrations curriculum at the undergraduate and graduate level depends on the number of faculty in that technical area and the number of students interested in acoustics, noise, and vibration. At this time Purdue has over 50 faculty members involved in acoustics-related fields.

The following degrees are offered by Purdue with specializations in acoustics and vibrations. A bachelors of Engineering degree in acoustical engineering, which is a program under the Interdisciplinary Engineering program, includes courses in engineering, fine arts (music), speech language and hearing sciences, and physics. Technical electives are taken at the undergraduate level (400 level) and at the introductory graduate level (500 level).

Plans of study for graduate degrees with concentration in acoustics and vibrations tend to include mostly engineering classes in noise and vibration related subjects, as well as the two mathematics class requirement, but do occasionally also include classes offered in speech language and hearing sciences, physics, psychology, health sciences, and biological sciences. For a thesis-based Master of Science degree, seven courses and a research project with a thesis are required. For a PhD in acoustics and vibrations, the number of courses beyond the masters varies but typically is around seven courses, and, of course, a research project with a thesis are required.

What are the sources of financial support for students and for the research projects they carry out under Purdue faculty supervision? The graduate research projects are funded by industry, government (DOD and other agencies), fellowships or teaching assistantships. Support is provided through individual research projects, by two or more research projects and by consortia. However, there are more interested students than there is funding to support them.

For those noise control practitioners without formal training in noise control engineering or with a need for additional training, Purdue offers professional development opportunities including short courses and distance learning. Engineering professional education for off-campus students is done by streaming video. Individual faculty members teach short courses on noise control at various levels on acoustical materials, nonlinear vibrations, sound quality, and prognostics and diagnostics.

In conclusion, a few observations are appropriate. If industry wants to hire graduates with acoustics and vibrations experience, they will need to sponsor research projects in those areas. Students need to eat so they will choose projects that are funded. If industry is sponsoring a project, its participation in the project by, for example, doing a component of the research and interacting strongly in regular technical discussions on the research as it progresses is a key element to its success. By tackling a problem as a team, splitting the components into industry components and university components facilitates deeper and more meaningful technology transfer.

To be an effective noise control technologist, there is no substitute for an in-depth knowledge of fundamentals. One needs to learn how to swim to survive in turbulent waters! Intuition is borne out of a deep understanding of what is right and what is wrong gained from immersion in a topic. A lack of or no education in acoustics and vibrations will not provide this intuition. Those graduates with a good grounding in the field will be able to learn new techniques and new areas quickly and will be able to understand what they are doing and the reason for doing so.

Is noise control engineering education a sustainable resource?

Anthony Atchley, Pennsylvania State University

Framing the Issue

In the same way that raw materials go to the manufacturer who then processes them into products marketed for consumer use, prospective students attend a university where they are trained as noise control engineers to be hired into industry after graduation. The consumer/employer needs the "product" and expects a large supply; but is reluctant to support the production process. Is this a sustainable product? Using the source-path-receiver model so familiar in acoustics, the student is the source, the university the path, and the employer the receiver. The students are those interested in acoustics technology. The universities providing the link between source and receiver are challenged to sustain this link. The receiver is the demand of potential employers in industry, government labs, and agencies. The demand for graduates within academe is comparatively weak.

The challenge to education in noise control engineering from the graduate education perspective is that it must be competitive to students, faculty, and institutions. Students want a curriculum that is intellectually stimulating and financially viable with competitive graduate assistantship/fellowship support and yielding good jobs at competitive salaries. Faculty also demands a curriculum that is intellectually stimulating and financially viable. Financial viability is provided by research support that is both sufficient and sustainable. Career development for faculty requires respect among peers both internal and external as well as research productivity with publications authored with PhD students. From the institutional standpoint, whether a department, an interdepartmental program, a college, or a university, the curriculum must support the institutional mission and preserve or strengthen its reputation.

There are several aspects to be considered in sustaining the competitive resource. The role of graduate education is to educate students, advance the forefronts of knowledge, and support the mission of the institution. It is a major challenge to maintain programs in mature fields at research universities. To maintain a curriculum in noise control engineering requires a coordinated approach.

Graduate Program in Acoustics at Penn State

The Graduate Program in Acoustics (GPA) is one of Penn State's inter-college graduate degree programs administratively based in the College of Engineering and closely associated with the Applied Research Laboratory (ARL). The program was established in 1965 as the result of a request by the US Navy for an academic program in acoustics and its applications. In 1983 a summer program was established to provide educational opportunities for those who cannot attend graduate school as full-time students at University Park. In 1987, a distance education program was established in partnership with ARL to further extend educational opportunities for those who cannot attend graduate school as full-time students at University Park.

Although Penn State does not have a noise control engineering curriculum as such, it does offer research opportunities in the field. Forty-three members of the graduate faculty contribute to instruction and research in acoustics. Four are in the Graduate Program in Acoustics and twenty-two in the Applied Research Laboratory. The remaining faculty members are in the following departments: aerospace engineering (5), bioengineering (1), communication disorders (1), geosciences (2), engineering science and mechanics (2), mechanical engineering (4), meteorology (1), and physics (1).

Educational opportunities in acoustics are offered with residence education, distance education, and short courses. At the main campus (University Park) the following three degree opportunities are offered in the residence program: Master of Engineering in Acoustics, Master of Science in Acoustics, and Ph.D. in Acoustics.

The distance education program offers a Master of Engineering in Acoustics as well as individual courses that can be taken without degree credit and related engineering courses offered as electives. Short courses are offered at University Park and at other locations as requested by industrial firms and government agencies.

There were 95 students enrolled in the academic year 2006-2007. The distribution of candidates was as follows: Master of Science in Acoustics – 14, Master of Engineering (residence education) – 6, Master of Engineering (distance education) – 34, and PhD in Acoustics – 41.

To obtain a graduate degree in acoustics from Penn State, students are required to complete six courses in vibrations and acoustics of solids, acoustics of fluids, digital signal processing, transducers, advanced acoustics, and data measurement and analysis. In addition they must participate in a colloquium. Once graduated, these students have easily found employment with major corporations, government research laboratories and agencies, and universities.

Technology of the day dictates the methodology for course delivery in the distance education program. At present several delivery methods are used. Blended classes are offered where resident and distance education students get the same lectures and complete the same coursework. Students may view lectures live or archived (on demand) via high-speed internet. Students may use live chat rooms, telephones, computer microphones, and webcams to ask questions during lectures. Live office hours and recitation sections are held using internet webcams and microphones.

Noise control engineering education for specialists and generalists

David Holger, Iowa State University

Iowa State has never had as large a program in the area of acoustics and noise control as has Penn State and Purdue, but it's a more typical environment for engineering colleges, and many of the large public universities where, instead of having fifty faculty involved in acoustics and noise control, we have about fifteen, and not many of them are focused on noise control engineering. At Iowa State we have about three faculty members now who are truly focused on noise control engineering. There are probably about a dozen others who teach things related to ultrasonics or other elements of acoustics.

It's important that we exploit leverage in schools like Iowa State. For example, mechanical engineering is now the primary home for noise control engineering acoustics at Iowa State, and it's not a very big player. This fall there were 1003 undergraduate students in the mechanical engineering department, and 30 or 40 of them may be interested in noise control or acoustics. Thus when the department chair and the dean are considering replacing faculty, they'll not think to hire someone for this area. Recently there was a good candidate available who was of interest to the mechanical engineering department because of his background in control systems. He also happened to do research in active noise control. So the leverage is there for those interested in noise control engineering. When such opportunities come along, we try to get candidates in the pipeline that could contribute to the noise control engineering part of the program. When I came to Iowa State I was part of that leverage because my background was in aerodynamic sound generation and mechanics. They were looking for someone primarily in engineering mechanics and partly because they were interested in noise control engineering. So the idea of leverage is important.

The environment at Iowa State is typical of other public universities that don't have a large program in acoustics and noise control engineering. Iowa State is a research university with 26,000 students and 5,000 graduate students of which 4,600 are engineering undergrads and another 1,000 are graduate students in engineering. Not only is it an issue to interest those engineering students in noise control engineering, but it's an issue to interest young people in any type of engineering, science, technology, and math in general. Sometimes we have an advantage in noise control engineering because people come in with some sense that they enjoy I-pods, the musical aspects of acoustics, or things that don't directly relate to noise control engineering but generate some interest on their part. Interest them in the course, and then it's possible to interest them in noise control engineering.

The research agenda tends to drive the priorities of a research university. If there isn't good funding, there won't be enough people to offer critical mass courses in areas like noise control engineering. Thus most large technology engineering programs are now trying to build clusters of excellence. The thrust is that we want to have a large group that is doing things at the cutting edge. Usually that large group doesn't end up being noise control as we all, unfortunately, know. So again there are some opportunities occasionally for leverage, and the leverage isn't so much that you can make noise control engineering part of that major thrust; but we can sometimes hire faculty who are related to that thrust and thus get some funding for students who are part of that thrust and complement the primary cluster priority.

At Iowa State in the early 1970s, noise control engineering was a specific course at the undergrad level primarily aimed at mechanical engineers and people in engineering science and mechanics, aerospace engineering, electrical engineering, and other areas of engineering. It was housed at that time in engineering science and mechanics which meant that there was leverage with courses like vibrations and mechanical signal processing. Many of the students who took courses would take an introductory noise control acoustics course as mechanical engineers who did not intend to be specialists. That's where the generalist versus specialist came in. Many engineers can benefit from having a solid disciplinary background in noise control engineering, noise control acoustics, vibrations, and signal processing. It fits with a general engineering background, and for someone seeking a Bachelor's degree, that's the best path for them to take. The best of them may decide that this is a good thing to study further at the graduate level. But at the undergraduate level there probably won't be very many universities that can sustain an undergraduate program that's primarily noise control engineering or acoustics or a combination.

In the 1980s there was a sub-specialty at Iowa State in engineering science that was not quite a major in acoustics and noise control but it was pretty strong in that area. This program involved some opportunities for undergrad experience in research in noise control engineering. That was a good way to stimulate interest. It gets more leverage.

The greatest demand for specialists now is at the Master's level and is from industry and government agencies, but this doesn't optimize publications and research productivity. It means building on industrial collaborative activity. The ideal experience at a Master's level is to have a program that includes experimental analysis and numerical methods. Both the undergraduate and graduate noise control engineering courses at Iowa State have always had integral labs so the student gains experience in measurement techniques, signal processing, and experiencing what can go wrong that really shouldn't go wrong. Part of our research is influenced by the needs of those industries that fund us such as projects in HVAC systems, consumer product noise, agricultural equipment noise, and transportation noise.

Of the 20 to 30 students a year taking noise control engineering, most will also be taking vibration and signal processing courses. In the mid-1980s there were about twice that many. We're not training huge numbers of students in these disciplines. Right now that means the supply of graduates with that background isn't enough to meet the demand, certainly not industry demands. That's true across the board for engineering graduates. This fall Iowa State had a large engineering career fair. Over 300 employers came to attract students, even those at the freshman level, because they want to recruit them early.

Regarding the distance educational elements of professional development, we've had a set-up for quite a while that allows the instruction of on-campus courses in a studio classroom to be transmitted to or recorded for off-campus audiences. We were first to do this with courses that had integral lab components. We thought it might be a problem, but people in industry had better lab facilities than we had on campus, so they just did the lab work wherever they were working. That demand is certainly stable and maybe even growing because of people who have seen the need for continual professional development. One of our strongest interest areas is a Master's degree in mechanical engineering for people working in industry, and it's natural for them to be interested in noise control engineering and acoustics.

Discussion – Session 2

Supporting industrial and societal needs

Question for Anthony Atchley: How does Penn State support industrial and societal needs?

Answer: Penn State is a land grant institution whose mission is to help the development of the Commonwealth of Pennsylvania. And certainly industry is a big part of that. One aspect of this support is graduate education.

Comment: At Purdue—discovery, learning, and engagement. Engagement is the transfer of research knowledge to industry. Purdue is also a state university with a strong interest in research, and part of its mission is to help the state, the country, and the world. Students want to be involved in exciting research projects. They would love to see their research making a difference in the world. Many students in acoustics are concerned about the impacts of noise on communities. Others are interested in musical acoustics including the design of auditoria. They are very engaged in making life better for people. They want an exciting research project; they want to do well, and they want to publish. They also want to make a difference in people's lives with what they do.

Comment: Let me discuss societal needs. All three of our universities are land-grant universities that at one point received funding from our respective states to benefit society directly. That funding has eroded to the point where we're only moderately state-assisted universities. Less than a third of our revenue comes from state funds. Universities are forced to re-evaluate their priorities, and funding is no longer provided to address societal needs. At the same time today's students are perhaps more interested than they've ever been in societal needs. There's some evidence that one way we could recruit more engineering students into the pipeline is by showing them how engineers help people and solve society's problems. The tough part isn't if our programs address the needs of industry, it's how to find ways to address the needs of society for which funding isn't provided anymore. The expectation is that those with expertise will help solve those problems.

Comment: In principle it would be great to support society if students want to, but someone's got to pay for it.

Comment: At Herrick Labs we're doing research to specifically benefit industry, and that is part of our mission although we still have a lot funding from government bodies. The problems we're solving directly benefit industry. Our best industrially-sponsored projects are the most valuable form of education for our students because they take available problems and they learn how to reapply what they know to solve them. As I said in my talk, when it's a real dialog with the people in industry students see an implementation of that research on a real product and all the challenges that are faced. The student meets academic needs to be published and makes the products better.

Comment: Apart from industry there are none who are going to fund the students' experience. There has to be feedback. Industry projects are a great education, pushing forward the frontiers of knowledge because grappling with difficult problems is something that's really useful. But our department head does not say that industry has these needs, so here is a few million dollars to support some research projects because clearly noise is an important societal issue and an issue of industrial competitiveness. There's nobody setting aside money like that—the state isn't—so we have to understand if we want to undertake research for the benefit to industry, industry has to feed money into this research. Nobody else is going to fund it. And do I think it's valuable? I think it's enormously valuable.

Supply of noise control engineers

Question for the panel: Bob Bernhard gave anecdotal evidence that the demand for people in this field exceeds the supply. That was a question for the Session 1 panelists, and they all agreed with the statement. So do you think that the demand for people in this field exceeds the supply?

Answer: Yes, based on the number of inquiries we get from employers looking for people with expertise in this area. There certainly is a demand for students studying noise control problems.

Comment: Absolutely. I think we could place two or three times the number of students based on inquiries we receive.

Comment: I think it's true at the Bachelor's and Master's level, but maybe not as clear at the Doctorate level.

An INCE/USA curriculum?

Question for the panel: If INCE/USA were to have a program to define, for the benefit of employers, what a noise control engineer should know and ask the universities if they would agree on that subject, what would the response be? Earlier the response was that one could define a core of noise control engineering topics that everyone should know, but there may be peripheral areas that not everybody needs to know. Would you agree with that statement?

Comment: I'd agree with it. But I feel that some topic definition has already occurred in an ad hoc way. If you look at the noise control engineering acoustics course at the senior or introductory graduate level, the topics covered are going to be similar among institutions.

Comment: I teach a graduate class in signal processing and numerical methods. At the university they benchmark every now and then to find out what other instructors are teaching and are there courses we could change. I just did it in the signal processing area. In introductory graduate-level signal processing classes we were teaching mostly the same things. In basic noise control and acoustics, there would be a commonality with differences on the edge depending on the

research interests of the faculty who teach those classes. That's where you'd find diversification. The core stuff would be very similar.

Comment: What is the definition of a noise control engineer? I think it's extremely involved. We don't have a noise control engineering curriculum, per se, at Penn State. We have a broad curriculum that includes noise control engineering topics.

Question for the panel: If students thought that it would be beneficial to them to have some sort of certification from INCE/USA that they had knowledge of the key core of noise control engineering, what would be the response from the academic world?

Answer: You have Board certification for practicing engineers, and I think that's a very good thing to have. I can't answer whether this would be a good thing or not because it's almost as if our programs were being rated. I'm not sure we should get into that.

Course you would like to teach

Question to the panel: This is a question of teaching. If you were not constrained by money or approval from the boss and you had something related to acoustics that you would really like to teach, what would it be?

David: Early in my career I felt I had that opportunity. I was asked to develop a noise control engineering course for seniors in engineering. I felt if I was going to do that a lab would need to be an integral part of it. I developed such a course, taught it, and really enjoyed it. Later I wanted to do the same thing with a course we call signal processing and mechanics that is mostly acoustics and noise control. I'd like to do it again.

Patricia: For sound quality work, I've collaborated with people in speech, language, and hearing sciences and also in psychological sciences. We often talk about doing joint projects in that area. There is some psycho-acoustics in our undergraduate noise control class, but it is very rushed. Doing an engineering version of psycho-acoustics—sound quality, sound perception—and also incorporating things like health factors of noise would be a great class to have in engineering.

Anthony: One of the things we didn't say we had lots of is time. I see a great opportunity to teach more courses that are accessible to a wider range of undergraduates. Acoustics and music is a great draw. Almost every student who comes to the university has some experience in that area. We need to do a better job in this country, not necessarily bringing people into noise control engineering, but in technology in general. There is a need at the lower undergraduate level to try to show students the exciting things about acoustics and wave technologies.

Funding and the future of NCE education

Comment: This particular part of the session seems to be sort of doom and gloom from the university point of view in terms of sustaining graduate programs in acoustics. It shows the need to fund research programs. How do we go forward with this? If we don't get more money for research programs, what do you see as the future of noise control engineering education?

Comment: I'm going to be more pessimistic. If funding doesn't come through, you're looking at the death of the program within a generation.

Comment: Eighty percent of the graduate programs at Iowa State are in a similar situation as far as their sub-disciplines are concerned. Mature disciplines are at a disadvantage now because of the clustering of funding in really hot, cutting-edge areas. I'm not as pessimistic as Ken because I think we are not going to do away with all of the graduate programs that aren't in hot areas because that's part of the overall graduate program. The graduate programs I see, especially the ones that are mature and somewhat interdisciplinary so they aren't part of the core of a traditional department, are doing creative things to leverage their efforts and to attract faculty who can bridge more than one sub-discipline.

Comment: At the major research institutions when we hire into cutting-edge areas, faculty comes in that doesn't have the ability to teach core engineering courses. The design of gears, cams, and linkages used to be a part of a mechanical engineering curriculum. How many schools still teach those subjects? How many faculty in our institutions could even try to teach those courses? At Georgia Tech we don't because we can't. We don't have the faculty. We're not challenged in our thermal sciences area because our hiring has been in leading-edge areas where these folks can't teach thermal sciences. What will happen in noise control and acoustics? We will be forced by our reward structure, by our administrations, to pursue research areas outside the discipline of noise control; and sooner or later we will have professors who can't teach it because they don't have the background.

Highlights of the discussion

1. More engineering students could be recruited by showing them how noise control engineers help people and solve society's problems.
2. Industrially-sponsored projects are a valuable form of education for our students because they are given available problems and learn how to apply what they know to solve them.
3. Funding for education in noise control engineering is becoming more and more difficult.
4. The demand for trained noise control

engineers exceeds the supply.

5. An INCE/USA-defined curriculum is not necessary as the differences in curricula at the universities are not significant.
6. Mature and interdisciplinary graduate programs not part of a traditional department are leveraging their efforts to attract faculty that can bridge more than one sub-discipline.

Session 3 – Industry/ Consultants Needs

Panelists

Michael Lucas
Ingersoll-Rand

Dan Kato
Cummins Engine

Paul Donovan
Consultant

Eric Wood
Acentech

Evan Davis
Boeing Aircraft

Courtney Burroughs
Consultant

Presentations

Engineering skills required to design low-noise products

Michael Lucas, Ingersoll-Rand Company

The Ingersoll-Rand Company (IR), founded in 1906, is a large organization with 43,000 employees and 38 domestic plants plus 55 plants overseas even before its recent acquisition of the Trane Company. Its current product line includes stationary air compressors, pneumatic tools, golf carts, and truck refrigeration units. Before the recent sale of three equipment lines, Ingersoll-Rand had five noise controls specialists, four of whom had received university training.

In developing the noise level specifications for a new product, IR typically follows these steps. The marketing department conducts a voice of the customer survey and then develops the specifications for a new product. The engineering department designs a new product to meet these specifications. The marketing department makes a determination if the product noise level is acceptable for sale. It is the responsibility of the noise control engineer to meet the product noise specification.

Noise control specialists at IR are responsible for educating engineers on the principles of noise control. They support new product development teams by developing noise control features such as enclosures, mufflers, silencers, and baffles. They support the sales team and marketing department. And they are responsible for conducting non-routine noise and vibration measurements and developing and maintaining measurement systems for routine noise and vibration measurements.

Engineers are encouraged to receive annual training and most attend one-week seminars in an engineering specialty. Some engineers receive advanced degrees through distant learning, while others go back to school part-time. Engineers are also encouraged to attend technical conferences and to participate in the activities of technical societies. Other engineers choose to publish technical papers on their work at IR.

Historically IR has used technical consultants in many fields of engineering. Consultants are targeted to bring into our design environment the very best in engineering. IR has used in the past NVH specialists representing private consultants and universities. Proprietary information and product secrecy are always factors we consider when working with outside specialists.

There are specific skills needed by noise control specialists to design low-noise products at IR and other companies in the industry. They must know how to use commercial engineering computer programs such as FEA, BEM, CFD, Modal Analysis, and Rotor Dynamics. They must also know how to program using C++, C#, Visual Basic, MatLab, or LabView, as well as how to use CAD software. When designing a new product, they must know how to use the instrumentation and be able to predict noise and vibration levels. Such skills as the design of an isolation system, muffler, silencer, and enclosure are essential as is the ability to size a cooling fan.

The noise specialists at IR have access to transducers such as microphones, intensity probes, accelerometers, dynamic pressure transducers, proximity probes, and strain gauges. They are also trained to use an oscilloscope, a sound level meter, the PULSE data acquisition system, and Bently Nevada—Adrea.

The textbooks used for additional training include "Acoustics of Ducts and Mufflers" by M. L. Munjal, "Noise and Vibration Control Engineering" by L. Beranek and I. Ver, and "Acoustics" by L. Beranek. Computer software available to the noise specialists are PROE, ANSYS, SYSNOISE, CF Design, CFX, and Fluent.

In summary it is the responsibility of the noise control specialist to support all issues as they relate to noise in a design and product support function. Noise control of our compressor products is an important topic at IR and as a result we take noise control very seriously at IR.

Industry needs for noise control engineers

Daniel Kato, Cummins Engine

In the power generation industry, product sociability is a key company value. Pleasant-sounding, low-noise generators reflect positive product attributes to a public that is becoming increasingly environmentally aware. Driving this awareness has been the increase in population density as well as the increase

in generator set power density so that more people are affected than ever before. The public has been sensitized to environmental concerns by the media and they know that in many cases they have legal recourse if their neighborhood is not quiet. As the economy becomes more global, countries around the world are adopting noise regulations that never had them before. Consumer products are expected to be of high quality, and a pleasant sound is an expected indicator. Furthermore, some consumers expect to use their generators in extremely low-noise backgrounds, often encountered in wilderness areas, without having an impact on the background.

The demand for companies to provide low-noise products has been established and one would expect that companies need qualified experts to serve that demand. Industries can be somewhat lagging in obtaining the resources they need to fill this demand and often jump into new market opportunities before the supporting resources are in place. There is evidence in the marketplace that some vendors supplying acoustical products understand the principles and applications very well. However, others have minimal knowledge of sound and vibration and are offering only a "here-it-is-can-you-use-it" approach to their products. Recent high demand for acoustical enclosures has, for example, pushed some metal box fabricators into a market where they otherwise would not be. Finally, hiring managers are also resource constrained by their superiors and must first show that hiring highly trained specialists provides a return on investment higher than an individual with a more general background who can produce additional products. It is difficult to quantify the savings that a specialist will provide in increased market share or consumer satisfaction.

Nevertheless, specialists in noise and vibration are needed for companies that want to maintain a comparative advantage in their products otherwise they will not survive in those markets during difficult times. What is required are individuals with advanced degrees, strong backgrounds in acoustics and engineering mechanics, and the ability to acquire and process data using many channels. Knowledge of how products relate to the human interface is particularly important, employing basic principles of psychophysics. In addition to technical skills, there is the requirement to work with, influence, and sometimes lead design teams in order to teach and sell new concepts otherwise products will continue to be made the same old way. Fundamental to this effort is superior communication skills, both verbal and written.

Education and the sustainability of noise control engineering

Paul Donovan, Consultant (formerly General Motors)

In the past, noise control engineering was not recognized as a discipline. Now, however, noise control engineering has become a mature discipline with need for noise control practitioners at all levels. Research opportunities in the field, however, remain limited at the present time.

Important issues to be considered are the maturing work force and the unsatisfied demand for engineers with training somewhat above the "entry" level with Bachelor's or Master's degrees plus some noise control experience in academe or industry. This demand is not large at present.

Noise control engineers are found in two different workplaces—in large corporations with noise and vibration groups and in consulting companies. In large corporations internal training opportunities may be available and management may recruit employees with little or no noise and vibration background. But additional training requires a longer-term commitment for both the employee and the company. In consulting companies, internal training is often prohibitively expensive, and consultancies are almost always looking for experienced or trained candidates.

A noise control engineer should have one or more courses on noise control engineering or acoustics, good communications skills, a career interest in the field, and other assets such as laboratory or field experience and computer application skills. There should also be a willingness to relocate if necessary.

The ideal candidate for employment is an engineer with one or two senior-level or beginning graduate-level courses in noise control. These are usually elective courses and the students may be from different engineering and physical science departments spread throughout the university at its main campus and distant locations. Alternatively, the candidate should have been taught by a faculty member with an interest in noise control engineering, but may not necessarily have been involved in an academic research program.

Summer internships in consulting and industry provide good opportunities for evaluating a candidate to fill a noise control engineering assignment. Senior projects also provide good opportunities for recruiting. In-house seminars on noise control engineering by practicing engineers are another important avenue for training.

There are several possible roles that INCE/USA could play in the education field. Existing university programs could be catalogued with listings of noise control engineering courses offered and faculty members teaching them. A "support group" or "homeroom" could be established within INCE/USA that would provide a linkage between academe and industry. INCE/USA members could volunteer to "adopt a school" and serve

as advisors in noise control engineering education to the university they adopted. All of these roles would require considerable volunteer effort and an organizational structure to maintain them.

Education for noise and vibration control engineering and architectural acoustics

Eric W. Wood, Acentech

The parent company of Acentech, Bolt Beranek and Newman, was founded in 1948 as an architectural acoustics consulting practice. Today the Acentech staff consults in and teaches architectural acoustics, building noise and vibration control, industrial and environmental acoustics, product sound quality, and audiovisual/sound system design. They provide these services to architects, engineers, developers, building owners, facility managers, and agencies.

Acentech also helps guide the University of Nebraska Architectural Engineering Program to graduate engineering students that understand acoustics issues in building systems and architectural construction.

Most buildings have acoustical qualities. The architect, engineer, contractor, vendor, and owner all share the responsibility for the acoustics of a building. Therefore, it is important to teach acoustics to the building engineers and architects so that they are aware of the importance of acoustics, can recognize potential problems at an early stage of the design, and know when an expert is needed.

Engineers need a high degree of proficiency in the technical aspects of acoustics and noise control, whereas the architects should have at least a familiarity with the basic concepts. If architects and engineers are taught to avoid the following ten "most-common problems," buildings with good acoustics will follow:

- Not understanding the difference between sound absorption and sound transmission loss, and the need to consider both.
- Inadequate sound isolation between spaces due to leaks and light-weight construction.
- Low-directivity speakers in large spaces with too much sound radiated in unneeded directions exciting the reverberant sound field.
- Excessive background sound in spaces with live sound-reinforcement systems that leads to masking and/or system feedback
- "Noisy" open-plan offices which can be corrected with high-quality ceilings and partitions, proper layout, and sound masking
- Fan systems with excess capacity. Flow/pressure should be matched with requirements, fan speeds reduced, and dampers avoided as they do not reduce excessive noise.
- Fan noise travels upstream and downstream, therefore, attenuation is needed in the supply and return.
- Better space planning is needed in order to separate noise sources from sensitive receivers
- Not understanding the difference between airborne and structure-borne noise and that the means for attenuating each are not the same.
- Restaurants and cafeterias need great chefs and delightful food; they also need sound absorption.

In conclusion, if architects and engineers are taught to understand potential noise and vibration problems, the reward will be buildings designed with good acoustics.

Noise control education to support aerospace noise control needs

Evan B. Davis, Boeing Aircraft

Boeing Aircraft employs approximately 150 engineers, of which 100 are BCA, for work in noise control engineering. Currently this number meets the company's needs. Of these employees, very few have formal education in noise control engineering; and those that do are more recent hires. The other noise control specialists have backgrounds in mechanical and aerospace engineering and physics.

For the specialists without formal training in noise control engineering, Boeing provides supplemental education in the form of SAE and vendor short courses, in-house classes taught by both internal and external experts, and user teams for ckey-software-based processes. The noise control specialists at Boeing are not adequately prepared by short courses or distance learning exclusively but are expected to read and teach themselves with guidance from our technical fellowship as well as peer-to-peer training.

Control of the noise is required inside and outside the aircraft, while the aircraft is in the air and on the ramp. The noises of concern are combinations of steady-state sounds, long transients, short transients, bangs, buzzes, and rattles. Elements of the noise control design for an aircraft are the following:

- Blankets (fiberglass, bagging materials, mass septum, foams, over blankets)
- Acoustic absorption (seats and surfaces, floor coverings, acoustic panels)
- Structural damping (constrained layer, flow resistance, particle)
- Isolation mounts (ECS/equipment/tie rods, flight control actuators, engines/APU, tuned vibration absorbers)
- Fluids in pipes (clean and dirty water, hydraulics)
- Active noise/vibration control (engines/EVRN, ANC zonal/headsets, smart phones, fluid wallpaper)

The following systems and units require noise control:

- Trim system (trim panels, floors, stow-bins, monuments)
- ECS system (reactive/resistive mufflers, flow rates/pipe sizes, diffusers/flow restrictors, fans and powered equipment, air-return grille, ramp noise)

- APU (ramp noise)
- Doors, hatches, and latches

Engines require inlet linings (to control buzz-saw noise), nozzle/chevrons (for the shock-cells), and balance/vibration for the EVRN.

Boeing employs four different types of noise control engineers—interior noise engineers, test engineers, acoustic fatigue engineers, and community noise engineers.

The interior noise engineers are responsible for prediction and noise control for the interior of the aircraft. This entails assessment of the noise exposure/sound quality, consideration of the aircraft as a flying building from the architectural and engineering acoustics viewpoints, characterization of the exterior surface pressure field, and structural acoustic elements (cylinders and pressurization equipment).

Test engineers are responsible for data gathering, processing, and interpretation using in-flow microphones and accelerometers for gathering data as well as sound intensity probes and near-field acoustic holography techniques. Signal processing algorithms are used in the data processing.

Acoustic fatigue engineers are responsible for prediction of the integrity of the structural design involving characterization of the exterior surface pressure field, the structural response, and the sound transmission. Community noise engineers predict and determine the noise control requirements by assessing the impact of take-off and landing noise (EPNL), engine noise (turbo machinery and jet noise), and airframe noise (landing gear and wing-flow noise).

The source modeling process is common for measurements dealing with community noise, acoustic fatigue, and interior noise. Raw data sets that are the outputs of the measurement systems used to evaluate the three different noise sources are normalized and compared to prediction curves. The comparisons provide the engineers responsible for the three different noise sources with quantitative data for determining whether design criteria are satisfied or whether additional engineering actions are necessary. The increase in the uncertainty over the measurement uncertainty is due to limitations of the scaling rules used to normalize the basic data. Scaling rules are required to apply the data to new situations.

The work of Boeing noise control engineers involves many aspects of architectural acoustics. State-of-the-art knowledge of sound fields in large rooms is used to distinguish between reverberant and diffuse fields, to identify direct fields and the directivity of correlated and uncorrelated sources. The physics related to sound absorption and reverberation time provides important tools. Exposure metrics are used for noise design purposes. For interior noise the common exposure metrics are dB(A), SIL, AI, Leq, and Lex. For community noise the metrics are PNL, PNLT, and EPNL. For sound quality the metrics are sones, phons, loudness, and sharpness.

The transmission losses of aircraft partitions are predicted using models involving single walls (flat and curved panels and ribbed panels), double walls, fibrous insulation, and wall-to-wall vibration isolation. The basic transducers used are microphones in moving media and loudspeakers of special design. For the heating, ventilating, and air-conditioning systems plane waves in ducts with reactive mufflers are used as models. For high-frequency models resistive and labyrinth mufflers are used.

What does Boeing consider that a new hire who is "ready to train" should know? He or she should have a technical background, communication skills, and computer skills. In the technical background of the new hire should be a knowledge of basic architectural and engineering acoustics (transmission loss, HVAC, and vibration isolation), structural acoustics (wave number and modal viewpoints), fluid dynamics (Navier-Stokes equations and the Lighthill analogy), mechanical design (stress-strain, fatigue, 'standard parts'), and basic signal processing (DFT, FFT, filters, sampling).

The new hire should be able to write a good "to-the-point" technical paper, should be able to work with a team, and have presentation experience with both oral and written reporting skills. The new hire should have facility with Microsoft Office tools (Word, PowerPoint, Excel), and with MatLab, Labview, Tech plot. Familiarity with the computer languages C++ and Fortran is expected.

Boeing suggests the following texts for education in the fields of noise control engineering:

Aeroacoustics

- *Aeroacoustics of Flight Vehicles Theory and Practice*, Vol. 1 and 2, by Hubbard.

Engineering/Architectural Acoustics

- *Architectural Acoustics (Applications of Modern Acoustics)* by Long
- *Fundamentals of Noise and Vibration Analysis for Engineers* by Norton and Karcuzb
- *Engineering Noise Control: Theory and Practice* by Bies

Psycho-Acoustics

- *An Introduction to the Psychology of Hearing, fourth edition,* by Moore
- *Psycho-Acoustics Facts and Models, third edition,* by Fastl and Zwicker

Physical Acoustics

- *Fundamentals of Physical Acoustics* by Blackstock
- *The Foundations of Acoustics* by Skudrzyk

Structural Acoustics

- *Sound and Structural Vibration* by Fahy and Gardonio
- *Structure-Borne Sound* by Cremer, Heckl, and Petersson

Handbooks

- *Noise Control Engineering* by Ver and Beranek
- *Springer Handbook of Acoustics* by Rossing

Noise control engineering courses for the working stiff

Courtney B. Burroughs, Consultant (formerly Penn State)

Most of the noise control engineering education currently available is offered either in-residence at universities or through short courses. Many who have started a career in noise control engineering without a formal education in noise control engineering cannot stop work for an extended period of time to attend a university full time, and short courses usually lack the depth many seek and need. To fill this gap, Penn State offered a series of three, 3-graduate-credit courses in noise control engineering through their World Campus. Course material was sent to students on a Compact Disk and interaction with the instructor was via email. All of the students taking these courses were employed full time in noise control engineering. As such, they wanted to improve their work-related skills. Also, there was little doubt that they wanted a career in noise control engineering. There was no need for these courses to attract them into the field of noise control engineering.

Students completing these courses liked the course material, grading system, access to the instructor and flexible schedule which minimized disruption of their work. They did not like the "collaborative learning activities" (basically group projects), embedded animations and accessibility to other students.

With the retirement of the instructor from Penn State, these courses are no longer offered. However, the Institute of Noise Control Engineering (INCE) has expressed interest in offering these courses through INCE, as has the retired Penn State instructor. Changes in response to student feedback, as well as corrections to the course material, are planned before offering these courses through INCE.

Penn State World Campus noise control engineering courses

Introduction

From 1997 to 2004, The Pennsylvania State University offered three courses in noise control engineering through their World Campus. Each of these courses was offered for three graduate-level credits, for a total of nine credits. The courses began with fundamentals and progressed from there to more advanced topics. The overall objective of these courses was to provide a comprehensive series of courses on noise control engineering for those embedded in noise control engineering careers who could not take the time from work to take courses at this level in residence at a university. The students received a CD which contained the text of the course material, and a notebook with instructions on the computer software and assignments used in the courses. The students communicated with the instructor and with each other via email.

There were four key ingredients in the development and delivery of these courses; 1) content, 2) presentation, 3) student participation and 4) communications. Although all four ingredients were critical to the success of these courses, the last two ingredients were more significant, since all communication between students and the instructor was nonsynchronous and electronic.

Course Content

These courses contained material at a technical level similar to courses offered by Penn State in-residence by the Graduate Program in Acoustics. They were designed for practicing noise control engineers who needed answers to real problems that rarely have simple "cookbook" solutions. Thus, in developing course content, an attempt was made to strike a balance between the fundamental theory of acoustics and practical guidelines for solving complex noise control problems. The theory not only gave the students an appreciation for how and why design guidelines worked or did not work, it also provided some direction in situations where "cookbook" design practices did not fit. If the theory did not lead to something useful for the control of noise, it was not included in the course material.

Each of the three courses contained five units and each unit contained five lessons, for a total of 75 lessons. A listing of the topics included in the courses is given in Table 1. As indicated by this listing, the courses started with the fundamentals of acoustics and vibration which were then employed in later lessons to address topics of increasing complexity and relevance. The lessons started with simple oscillators and acoustic sources, which were then applied to acoustic radiation from ideal and realistic sources, and noise propagation in acoustic spaces and structures. There was a unit in each course on measurement and analysis of noise and vibration, starting in Course I with transducers and sound level meter measurements, and continuing in Courses II and III with narrowband single and two-channel measurements. Course II also included information on how noise is generated by real sources and the effects of room and enclosures on noise. Since the goals of noise control are based on human responses to noise, a unit in Course II was devoted to the mechanisms of hearing and metrics for quantifying human response to noise. Advanced topics in Course III included noise control treatments such as damping, vibration mounting systems, enclosures and mufflers, active control,

Table 1. Topics included in the courses

Course	Unit	Topics
I	One	Orientation – Installation and description of software, overview of noise control, background mathematics
	Two	Simple mechanical vibration control – single and coupled simple oscillators, four-pole parameters
	Three	Noise measures and mechanisms of sound propagation – waves, levels and spreading losses
	Four	Measurement & analysis I – transducers, measurements with a sound level meter
	Five	Reflection and absorption at boundaries – normal, oblique and random incidence, mechanisms of absorption, scattering and barriers
II	One	Mechanisms of noise generation – multipole localized sources, distributed simple sources, impact sources, nearfields, intensity
	Two	One- and two-dimensional systems – strings, ducts, beams and plates
	Three	Room acoustics – room modes, statistics of acoustic fields, large rooms, small spaces, coupled spaces, reverberation and absorption, loudspeaker systems
	Four	Measurement & analysis II – methods of measuring acoustic properties, vibration, narrowband analyses, Fast Fourier Transforms
	Five	Effects of noise – mechanisms of hearing, metrics of loudness, noisiness and speech interference, hearing damage and sound quality
III	One	Sources of noise – power transmission, electric equipment, non-turbomachinery, flow-induced and turbomachinery
	Two	Outdoor noise and structural acoustics – Outdoor noise propagation, transportation noise, response of, propagation in and radiation from structures, coupled structures
	Three	Measurement & analysis III – Single and two-channel frequency analyses, coherence, and transfer functions
	Four	Noise treatments – vibration mounting systems, damping treatments, mufflers and silencers, active noise and vibration control
	Five	Modeling – Finite and Boundary Element methods, Statistical Energy Analysis

the mechanisms and methods of control of flow-induced noise, and methods of both numerical and statistical modeling.

Presentation

The course material was contained in pdf files on the CD sent to the students. The student usually printed out the lesson material for reading, studied graphics, listened to sound files and replayed animations. Animations were used to illustrate phenomena that were difficulty to illustrate with words and figures. In addition, interactive animations were included as exercises for the students where they changed input parameters (e.g. frequency or stiffness of a mount) to observe the resulting changes in behavior. Also, a virtual sound level meter and narrowband analyzer were used in the simulation of measurements conducted on noise recordings made under realistic conditions, such as in a manufacturing plant and around individual sources of noise.

Student Participation

Student participation was essential to enhance the learning experience. Simply put, the students did not learn much without doing some work. In these courses, there were three methods for student participation; study questions, individual learning activities and collaborative learning activities.

Prior to reading a lesson, students emailed their best guess at answers to study questions. These questions were designed to focus the student on key concepts in the lesson and to give the instructor information on how much the student knew before reading the lesson. The student then posted answers to the study questions after reading the lesson. This provided an opportunity for the instructor to correct any misconceptions that the student may have still had after reading the lesson. Individual learning activities included written problems, development and/or use of MatLab computer code, and interactive animations. Written problems were similar to the homework problems employed in most courses taken in residence at a university. The students submitted solutions to the problems to the instructor who then provided help if needed. Students were required to complete the problems correctly to receive credit. In addition to conventional written problems, students were required to use MatLab to show dependence of system responses as a function of input parameters and in the design of noise treatments. Finally, interactive animations were used by students to explore phenomelogical behavior.

Teams of five students were formed, with an appointed team leader, for a

collaborative learning activity in each course. These activities were based on open-ended realistic problems. In the first collaborative learning activity in Course I, students selected from a list of noise control problems and developed an approach to that problem including a list of information needed to solve the problem. All team members then comment on the approaches before a final set of approaches to all of the problems was submitted by the team to the instructor. In Course II, the students were given recordings of noise and vibration made in a manufacturing facility, along with descriptions of the noise-producing equipment, and then asked to develop conceptual designs for noise treatments. In Course III, the students were given recordings of noise and vibration from a riding lawnmower and asked to develop noise treatments.

Grading was based on the number of individual learning activities successfully completed, the collaborative learning activities, and final exams. The final exams were similar to 'take-home' exams where, for these courses, a time limit for completing the exam was given.

Communication

Because these courses were offered at a distance and the instructor and students never met each other during the courses, it was critical that the communication links were effective and easy to use, and that the instructor was readily available to the students. An email server was used where an assignment folder was provided for each student for submission of assignments and responses by the instructor. To make these courses work for the students the instructor responded daily to all postings by the students. The students wanted to know immediately how they did on their assignments, get feedback from instructors and/or answers to their questions. This was particularly important to keep the students involved and interested since they all were working daily, had other responsibilities and only saw a computer screen which was not warm and friendly.

Students

There were several possible reasons that students may have wanted to take these courses; 1) credit toward an advanced degree in acoustics, 2) preparation for certification as a noise control engineer, and 3) improvement of skills in noise control engineering needed in their job. Although some of the credits earned could be applied toward an advanced degree in acoustics and the content of the course was designed to provide a solid background for passing the INCE Board Certification Examination, most of the students that took these course were taking them to become more proficient at work.

These courses were taken by students who were all highly-motivated, but had a wide range of technical backgrounds. They did well in these courses in spite of the large amount of work involved. One of the students was on the engineering faculty of a large state university. Another had a degree in interior design but completed these courses starting with a weak mathematics background. There was another student in these courses that had over 20 years experience testing and designing automobile mufflers. Although he knew more about mufflers than the instructor of these courses, he was seeking a wider knowledge in noise control engineering.

Student Evaluation

An informal survey of the evaluation of these courses by students who had completed the courses was conducted. The students liked the course content, method of grading and accessibility to the course material and instructor. They had less favorable evaluations of the collaborative learning activities, accessibility to other students, usefulness of animations and helpfulness of the study questions. The collaborative learning activities were hard to administer with the wide variety of student schedules. The instructor found the study questions useful as a measure of how much the students were learning and where to focus instruction for individual students. Measurements conducted by the virtual instruments were viewed by the students as inefficient learning tools. Additional information on student responses to these courses, see *Noise Control Engineering Journal*, **50**(4), 146-7 (July-August 2002).

Discussion – Session 3

Noise control engineering at Cummins

Question for Dan Kato: How many noise control engineers does Cummins have?

Answer: Two. I'm the acoustical strategist for power generation worldwide, and do things like manage university research projects in sound and vibration and decide the kind of facilities we need around the world for acoustic testing. I write the standard work procedures, but personally don't do day-to-day sound control on the products. Cummins wants to increase their count in that area next year, so there may be some opportunities for graduates in our company. Within the Cummins company there are several noise control engineers. At Cummins, Walesboro, where they do engine testing, noise control engineers work on the drive-by truck noise. Nelson Filtration and Universal Silencer are part of Cummins, and employ noise control engineers. At each facility around the world there is at least one person designated as the acoustics contact. I am responsible for training these people.

Question for Dan Kato: What is the dollar value of your funded university research?

Answer: About a million dollars a year, but that's not all for noise control. Last year it was about $300,000 in the budget for power generation. I don't have a

budget for university, but those who do come to me for ideas about research projects. I give them ideas, and they have to go to the top of the list to get funded.

Question for Dan Kato: You mention in one of your slides that the first requirement for noise control engineers was an advanced degree. Why did you say advanced as opposed to just a degree?

Answer: A specialist in that area that would need an advanced degree. By the time you take all your other core courses in an undergraduate program, how much time do you have for noise control courses? I had one in my senior year, and I didn't' really get into the more advanced courses until I was in graduate school.

INCE/USA chapters within universities

Question for panel: Should INCE/USA encourage the formation of chapters within schools? For example, ASA has local chapters in universities that provide and promote student activities and interaction with the local people who are members of that chapter.

Comment: A very interesting question. I just discussed this with a dean in charge of student activities. Probably at some schools that would be possible—the larger universities with the larger programs. An even better possibility might be to strengthen our ties on the student level with ASA so that we would have some cooperative chapters where we would draw on INCE members and ASA members. Such a relationship between the two organizations would require that we figure out how to have joint memberships rather than trying to start separate student chapters.

Comment: Another group could be the Audio Engineering Society. They also have chapters at many universities. A general pool of acousticians would probably make sense, and one chapter per university is probably enough.

INCE/USA and engineers in industry

Question for panel: The way the noise control field has grown; there are many professional societies that have an interest in the field such as AIAA, SAE, ASME. Do you feel that INCE/USA provides an adequate home for engineers practicing noise control in industry?

Comment: There are a number of engineers in industry practicing noise control who are not aware of this society (INCE/USA). There are also engineers who would like to do noise control engineering but don't have the educational or technical background. Industry needs an acoustical society for practicing noise control engineers. The only society that most effectively addresses this need is SAE. I think it's a good opportunity for INCE/USA to create a home for engineers practicing noise control. A majority of the NOISE-CON attendees are consultants and instructors from universities. Just look through the registration. Who comes to these meetings? It would be ideal to have one third consultants, one third university, and one third industry. It would be a worthwhile goal for INCE/USA to try to recruit engineers from industry to join this society. I think it would solve a number of problems for INCE/USA and make the society as a whole better. It would solve membership problems. It could increase the interest in papers. Increased industry involvement would provide feedback and help universities and consultants.

Comment: One of the things the Society of Automotive Engineers does is to help focus their group with their sound and vibration counterattack to what's better in Europe. The practicing engineers in the automobile industry have regular meetings with a goal and with enough time in between meetings so that they can actually produce quality papers, a cycle that one can plan on. If you consider societies in general—INCE/USA, ASA—their meetings occur once or twice a year. Joint meetings would help, but they're difficult to organize.

Comment: I don't know how to get organizations together. The automotive industry very much likes us. I think it would be wonderful if the societies could all come together with more joint meetings. I personally would like to be able to spend more of my time not only with INCE/USA, but with SAE, ASHRAE, and ASME; but I don't have the time. There are great things going on in engineering noise control in each of those organizations. We occasionally have joint meetings. That's a good idea, but it would be nice if we could consider joint memberships. I don't know how to make that happen.

Comment: I believe that INCE/USA has had three joint meetings with ASA. In 2004 we met with ADC40 which is a Transportation Research Board Group that was successful. For NOISE-CON 2008 next year we're meeting jointly with the Noise Control and Acoustics Division of the ASME. Partnering with other organizations to run a meeting is not easy because there's quite often a culture clash between the ways societies operate, but I do think it benefits both parties. It certainly benefits the attendees. Maybe we ought to plan more joint meetings in the future.

Comment: Regarding people from industry, a lot of them aren't members of any noise control associated societies. Consider the Society of Automotive Engineers. There are as many SAE members in the GM noise laboratories as belong to INCE/USA which is about two. A lot of engineers just aren't joiners of organizations. There is definitely an opportunity to interest those engineers in a society that has a noise focus.

Comment: INCE/USA provides a good home for noise control engineers if only in the sense that those working in industry sometimes are the only ones in noise control in their area. They have no one to

talk to. Being a member of a professional organization offers the opportunity to make face-to-face contacts—people you can be friends with, call up and discuss problems that you couldn't otherwise discuss with people within your own company.

Comment: One thing I would personally like to see is more publications on the application of noise control technology to specific products. If we had that not only at congresses as well as in our journal, I think we would begin to break loose these industry people and they would want to come to our congresses.

Comment: One of the discussion items that came up was whether or not we're getting good participation from members in the corporate world. Having worked in the corporate world for 20-25 years, there's not a lot of support for employees to go to such events or become members of such organizations. I have to credit George Maling for encouraging me to join INCE/USA back in 1984 because at that time I was working for a corporation that had absolutely no interest in providing support for employees. I was able to attend INCE/USA conferences when they were convenient enough to where I live because I went on my own nickel. Corporations should be made aware of the benefit membership in such organizations is to their employees.

Continuing noise control education

Comment: Continuing employee education benefits most corporations. A few years ago we ran a survey that asked how much money individuals spent on continuing education out of their own pockets. At the time someone had proposed that there be a book budget. Every engineer would be reimbursed for the purchase of a text book. Only two people bought books; nobody else participated. We find this also true of professional societies. Many students graduate high school thinking they've got their diploma and are done with education. Those who move forward in our organization are usually the ones who say that they need to buy the latest textbook or find a way to take a short course. Right now within the Boeing environment it's easy to attend conferences, yet we have few people who want to go to conferences. It goes back to continuing education for engineers and self motivation. I don't understand it because I'm always curious about the latest advances in engineering science. Every year I spend about $500 on books I actually read. Then I can walk over to my bookshelf and know that everything is here. There's no magic, engineers must be involved in their own education process.

Communication skills

Comment: Several participants from industry commented about the need for good writing skills and good oral communication skills. Speaking as an academic, and I suspect some others have had a similar experience, we do exit surveys on our graduating seniors. We have oral and written communications skills laced throughout our program starting in the sophomore year. It is common for the students to complain about how many times they do presentations and how much emphasis we put on writing. We also survey the students five years after graduation. It is then common to receive comments like "You need to emphasize writing and communication more."

Student attitudes

Comment: Students don't appreciate much of what you're trying to teach them when you're trying to teach them. They say "I don't need this; I don't want to see another equation." Five years later they say "That class I slept through, I probably should have paid attention." I did it too. It's human nature.

Comment: It's very hard to get students to appreciate their education while they are in school. They tend to choose programs where they don't have to do a thesis. This really hurts them because the main reason to get a Master's degree is to gain the experience of writing a thesis. To write a thesis involves a literature search and a research project.

Highlights of the discussion

1. Does INCE/USA provide an adequate home for noise control engineers?
2. The SAE holds regular meetings for practicing engineers in the automotive industry. They have a goal and enough time in between meetings to produce quality papers.
3. Great things are going on in engineering noise control in SAE, ASHRAE, and ASME. INCE/USA occasionally has joint meetings and should plan more in the future.
4. Although many corporations offer opportunities for continuing education and participation in professional activities, few employees take advantage of them. Engineers must be involved in their own education process.

NOISE-CON 08/SQS 08 Report

NOISE-CON 08, The 2008 National Conference and Exhibition on Noise Control Engineering was the first ever INCE/USA joint meeting with the Noise Control and Acoustics Division of the American Society of Mechanical Engineers. Between the two organizations 319 persons registered for the conference, and there were more than 100 exhibitor personnel in attendance. Teik C. Lim and Jay H. Kim, both of the University of Cincinnati, served as general chair and technical program chair, respectively. Steven A. Hambric served as both general chair and technical program chair for the NCAD portion of the conference which was the 30th NCAD meeting.

Left: *Teik C. Lim, General Chair of NOISE-CON 08.* ***Right:*** *Steven A. Hambric, General and Technical Chair of the NCAD 30th meeting.*

One feature of this year's NOISE-CON was that several papers addressed two emerging topics:

- Flow tones and instabilities as a NOISE-CON/ASME-NCAD joint session, for flow induced noise generation and transmission (6 papers),
- Hearing loss prevention in industry/bio-acoustics, particularly with possible application of auditory system simulation to noise control (7 papers)

Flow tones and hearing loss were emphasized at NOISE-CON 08

The conference was held on 2008 July 28-30 at the Hyatt Regency Dearborn hotel in Dearborn, Michigan, USA. It was immediately followed by the 2008 Sound Quality Symposium held in the same hotel on July 31.

The first plenary speaker was Sean F. Wu, Department of Mechanical Engineering, Wayne State University, Detroit, Michigan, USA. The title of his presentation was "Overview of nearfield acoustical holograpy and its comparison to other technologies." The abstract of his presentation follows: An overview of nearfield acoustical holography (NAH) and its implementations together with its comparison with other technologies such as transfer path analysis (TPA), intensity probe scanning, and beamforming were presented. Specifically, planar NAH, boundary element method (BEM) and Helmholtz equation least squares (HELS) method based NAH and their respective advantages and limitations are discussed. The presentation was structured with strong consideration towards applications in the auto industry. Specific examples of reconstruction of all the acoustic quantities, which include the acoustic pressures, particle velocities, and acoustic intensities in 3D space and on 3D surfaces inside full-size vehicles, identification of sound transmission paths into a passenger vehicle compartment, and disk brake squeals analyses were presented. Comparisons of NAH and TPA intensity probe, and beamforming techniques were presented, and their advantages and limitations as noise diagnostic tools were discussed. It is hoped that a good understanding of various technologies will ultimately enable users to


Left: *The first plenary speaker, Sean F. Wu.* ***Center:*** *Martin L. Pollack presented the second plenary lecture on July 29.* ***Right:*** *The third plenary lecture was given by G. Richard Price.*

come up with optimal solutions to tackle a variety of complex noise problems facing practicing engineers.

Following the plenary lecture were parallel technical sessions that continued for the rest of the day. The equipment exhibition opened with a reception in the exhibition hall from 5.00 to 7.00 p.m., and busses departed from the hotel immediately afterward for a tour of the Ford River Rouge factory.

The second plenary lecture held on Tuesday, July 29, was the ASME Rayleigh Lecture, and was given by Martin L. Pollack, Applied Physical Sciences Corporation, Groton, Connecticut, USA. The title of his presentation was "A history of the ASME Noise Control and Acoustics Division," and the abstract follows: In 1978, the idea emerged of establishing a Division within ASME to focus on noise control and acoustics. Since then the Noise Control and Acoustics Division (NCAD) has evolved into a strong organization with focused technical committees, extensive technical sessions at its annual meetings, tutorials and invited lectures, and a journal serving to disseminate key information through peer reviewed technical papers. An overview of the history and evolution of NCAD is presented in this lecture. The growth in scope and membership of the division is described, along with the diversity of organizations involved. Major technical thrusts of NCAD are discussed, as well as its organization structure. Key technical contributions by NCAD members are highlighted, and select past Rayleigh lectures and tutorials were revisited. NCAD participation in the *Journal of Vibration and Acoustics*, and interaction with other acoustics professional societies were summarized. An overview of the current NCAD Division was provided, including its organization structure and view to the future.

Parallel sessions followed for the rest of the day. The exposition was open in the afternoon, and a second reception was held in the exhibition area in the evening.

The third plenary lecture was presented by G. Richard Price, Auditory Hazard Analysis, Charlestown, Maryland, USA.

NOISE-CON 08

Steve Ingraham, director of the new INCE/USA Business Office.

Jenni Vincent, left, and Alison Long of the new INCE/USA Business Office.

The title of his presentation was "AHAAH: A mechanically-based damage assessment for auditory hazard from intense sound." The abstract of his presentation follows: Treating the ear as a "black box" may make for simpler hazard measures; but it does not produce insight into the loss processes or arguably, the most efficient remedies. The Auditory Hazard Assessment Algorithm for the Human (AHAAH) is an electro-acoustic analog of the ear developed at the Army Research Laboratory. In it, hazard at high levels, typical of gunfire, is calculated by following displacements of the basilar membrane in the inner ear, and summing their effects at roughly 1/3 octave intervals. The resultant value is in Auditory Risk Units, which have been shown to correlate very highly with shift in the ear's sensitivity and cellular loss. A "movie" of the loss in the inner ear permits a time-domain analysis of the effect of the noise, which can in turn suggest palliative measures that are practical and novel. The AHAAH model is presently used by the Society of Automotive Engineers (airbag noise hazard) and the US Army, and it is being considered as a possible ANSI standard for impulse noise exposure. The basis for and limitations of the model were be presented and discussion focussed on the range of its applicability and the possibilities associated with extending a physiologically oriented time-domain analysis to lower sound pressure levels typical of industrial noises.

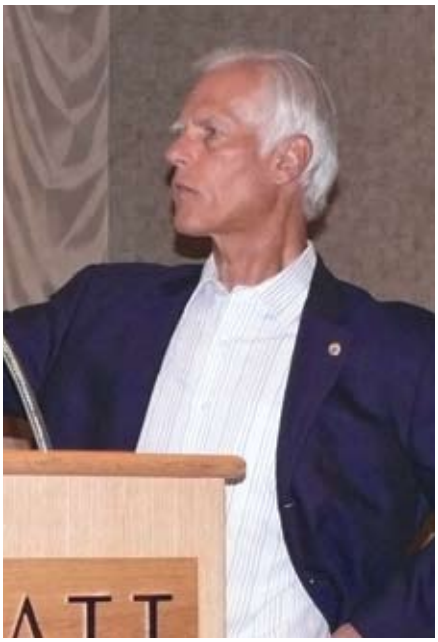
An alternative method for the evaluation of hearing loss due to exposure to impulsive noise.

NOISE-CON 08 was the first chance for most members of INCE/USA to meet the personnel in the new business office *(See NNI, June 2008, page 27—Ed.).* The business office started up on July 01, just 28 days before the opening of NOISE-CON. The director of the office, Steve Ingraham, gave a presentation on the capabilities of the business office, and introduced Alison Long who will be handling day-to-day activities, and Jenni Vincent who will coordinate conferences.

In all, more than 200 technical papers were presented in more than 40 technical

Patricia Davies, co-chair of SQS 08.

Gordon Ebbitt, co-chair of SQS 08.



Bill Hartmann gave the plenary lecture at SQS 08.

sessions. There was emphasis on the subjects below;

- Vehicle Interior Noise (14 papers, co-organized with ASME-NCAD)
- Modeling and Measurement of Acoustic Material Properties and Design for Noise Performance (13 papers, co-organized with ASME-NCAD),
- Numerical Methods in Acoustics (12 papers, co-organized with ASME-NCAD),
- Information Technology Noise (11 papers)
- Aircraft interior Noise (11 papers)
- Experimental Techniques and instrumentation in Noise and Vibration (10 papers)

There were 47 ASME papers published on a separate CD-ROM, and 80-100 conference attendees from ASME.

There was also a one-day forum organized by Janet Moss, Noise Control Foundation, and *NNI* managing editor George Maling. The title was "How do we Stimulate Collective Action to Motivate the Public to Demand Quiet?" Three sessions were held on Tuesday, July 29. The papers do not appear in the conference proceedings, but the slide presentations were collected and the discussion transcribed. The material will appear in a "Source Book" which will be issued in the near future.

The third Sound Quality Symposium was held on July 31. The first was in 1998 and the second was in 2002.

An excellent exhibition of noise control materials, measurement systems, and modeling software was organized by Richard Peppin, Scantek, Inc., who served as exhibition manager. In all, 42 companies participated. A listing of exhibitors and the products shown will appear in a future issue of this magazine.

Five organizations contributed to the success of NOISE-CON 08:

- **The National Council of Acoustical Consultants** (NCAC) co-sponsored this year's conference social at the Ford Rouge Factory, along with a student lunch meeting.
- **ACO Pacific** sponsored the manufacturing of the conference CD-ROM.
- **3M E-A-R and Saflex (Solutia Inc.)** sponsored the Expo receptions.
- **ESI North America** sponsored the badge holders.

There were 161 NOISE-CON 08 papers published on the CD-ROM. In addition, the CD contains all of the papers presented at NOISE-CON 07 and the 18 papers presented at SQS 08 on July 31. See the announcement on the back cover of this issue. In addition, there are 47 papers on a second CD-ROM published by the ASME. Order No. 1797CD. ISBN 0-7918-3830-7.

Thursday, July 31 was devoted to SQS 08, the 2008 Sound Quality Symposium. Patricia Davies and Gordon Ebbitt were co-chairs for the symposium.

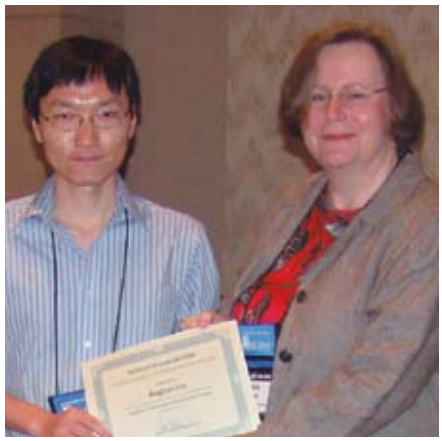
The symposium opened with a plenary lecture by Bill Hartman. Then followed 18 papers devoted to various aspects of sound quality. The 18 papers are in the SQS 08 Proceedings on the NOISE-CON 08 CD-ROM. The table of contents of the proceedings may be downloaded free of charge from the INCE/USA page at the Atlas Bookstore (http://www.atlasbooks.com/marktplc/00726.htm).

NOISE-CON 08

Five Students are Awarded Prizes at NOISE-CON 08

Four students from four universities were awarded $1000 prizes in the 2008 INCE/USA Student Paper Prize Competition. The prizes were funded by the INCE Foundation, and were awarded at the NOISE-CON 08 conference on July 30. The awards were presented by Patricia Davies, INCE/USA president. In addition, Krista Michalis was given an outstanding paper award by the Noise Control and Acoustics Division of the ASME. *Photo credits: Henry Scarton.—Ed.*

Above: *Krista Michalis, Duke University, receives the NCAD/ASME outstanding paper award from conference co-chair Steven Hambric. The title of her paper was Prediction and Modification of Broadband Interior Noise in Enclosures Using Energy-Intensity BEM and Absorption Scaling.*



At right (top to bottom): *Asim Iqbal, left, Ohio State University, for "Effect of flow on the acoustic attenuation characteristics of Helmholtz resonators"; Jinghao Liu, left, University of Kentucky, for "A simplified two-load method for measuring source impedance"; Brent Rudd, left, University of. of Cincinnati, for "Evaluation of MRI compatible headphones for active noise cancellation"; and Taewook Yoo, left, Purdue University, for "Absorption of finite-sized microperforated panels with finite flexural stiffness at normal incidence."*

Directory of Noise Control Services

Information on listings in the Directory of Noise Control Services is available from the INCE/USA Business Office, 210 Marston, Iowa State University, Ames, IA 50011-2153; +1 515 294 6142; Fax: +1 515 294 3528; IBO@inceusa.org. The price is USD 400 for 4 insertions.

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Mark your calendar and plan to participate!

Inter-Noise 2009

Ottawa, Canada
23–26 August, 2009

Ottawa, Canada, will be the setting for the 38th International Congress and Exhibition of Noise Control Engineering (Inter-Noise 2009). The annual Congress opens 23 August with a special ceremony, lecture and reception, and continues through 26 August. Several plenary sessions and hundreds of papers on various aspects of noise control will be presented during the four-day event. A large vendor exposition will be held during the congress and the ACTIVE 09 Symposium will be held immediately before the congress.

Noise as a Public Health Problem

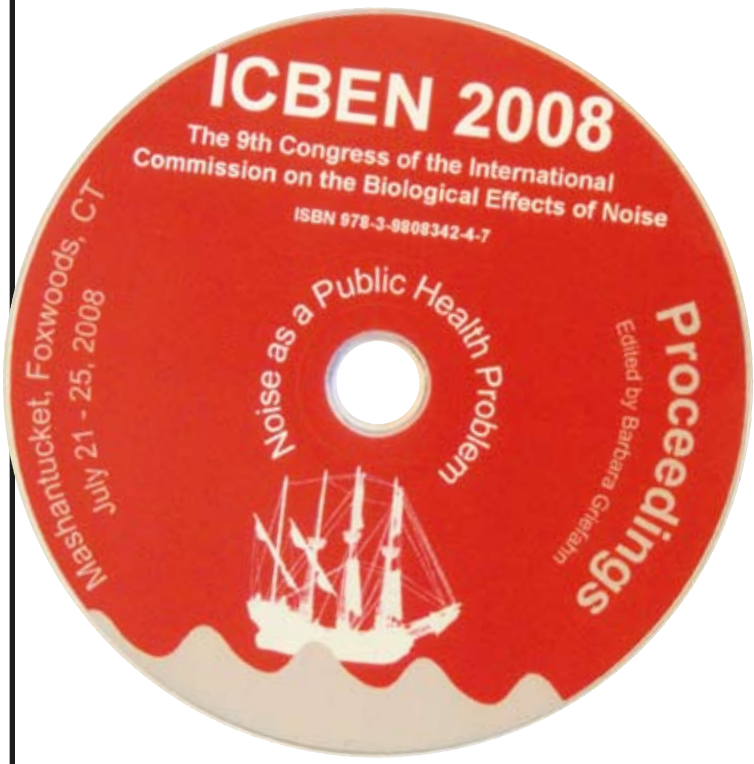
The Proceedings of ICBEN 08, the 9th Congress of the International Commission on the Biological Effects of Noise, are now available. The Congress was held on 2008 July 21-25 in Mashantucket, Connecticut, USA. In his keynote address, Adrian Davis, MRC Hearing and Communications Group, Manchester University, UK opened with:

Noise is a major public health challenge. It is major because noise is all pervasive in our societies at a level that it can seriously affect population health and quality of life throughout the lifecourse. It is a challenge because the noise sources are constantly changing as the pace of technology and change gathers globally. As some areas of the world legislate or change their strategies the issue is displaced or changed rather than lessons being learnt and applied globally. There is much that we know in terms of solutions in good practice that is reduced in effectiveness because it is not known widely or is not applied / seen as a priority. There are also huge gaps in our knowledge of current population exposure and effectiveness of new ways to combat noise e.g. in particularly challenged groups such as in military or in airline/airport industry.

Scientific papers were presented in ten areas:

- Noise-Induced Hearing Loss (38 papers)
- Noise and Communications (11 papers)
- Non-Auditory Effects of Noise (15 papers)
- Noise and Performance (18 papers)
- Effects of Noise on Sleep (16 papers)
- Community Response to Noise (27 papers)
- Noise and Animals (5 papers)
- Noise Policies: Regulations and Standards (14 papers)

The table of contents for the ICBEN 08 Proceedings may be downloaded free of charge from the Web address at the bottom of this page.



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NOISE-CON 08 CD-ROM

This searchable CD-ROM contains PDF files of the 161 papers presented at NOISE-CON 08, The 2008 National Conference and Exhibition on Noise Control Engineeering which was held in Dearborn, Michigan, USA on 2008 July 28-30. Also included are all of the papers presented at NOISE-CON 07 which was held in Reno, Nevada, USA in 2007 October. The CD-ROM also contains the proceedings of SQS 08, the 2008 Sound Quality Symposium.

This CD-ROM supplements the NOISE-CON 05 CD which contains all of the papers presented in NOISE-CON Proceedings beginning in 1996.

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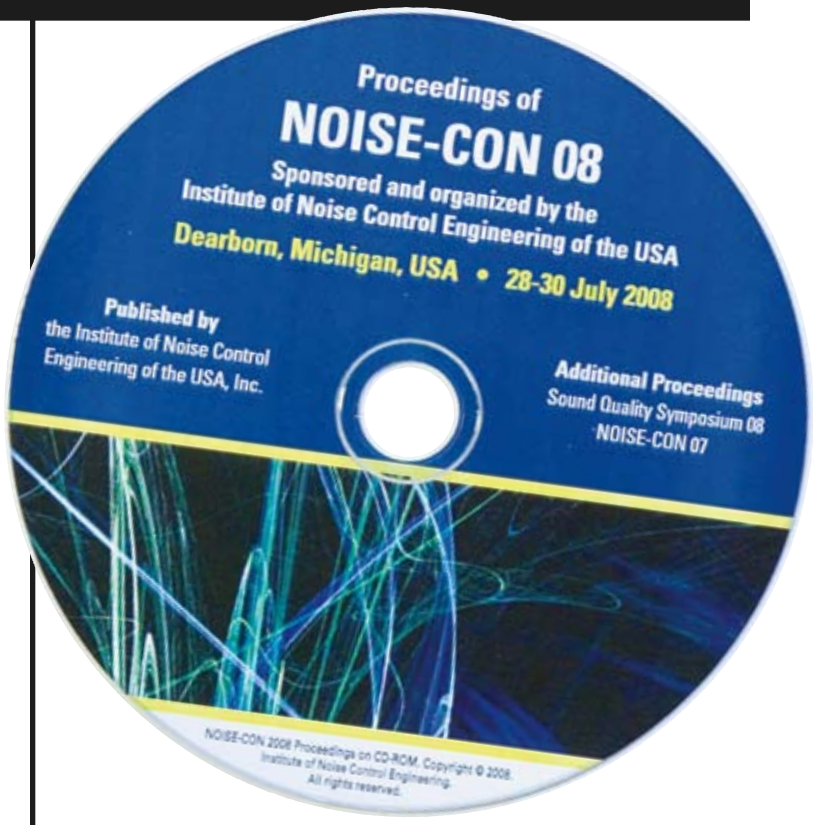
- Experimental Techniques and instrumentation in Noise and Vibration (10 papers)

The tables of content of the NC08, NC 07, and SQS Proceedings may be downloaded free of charge from the Web address below.



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