NOISE/NEWS INTERNATIONAL

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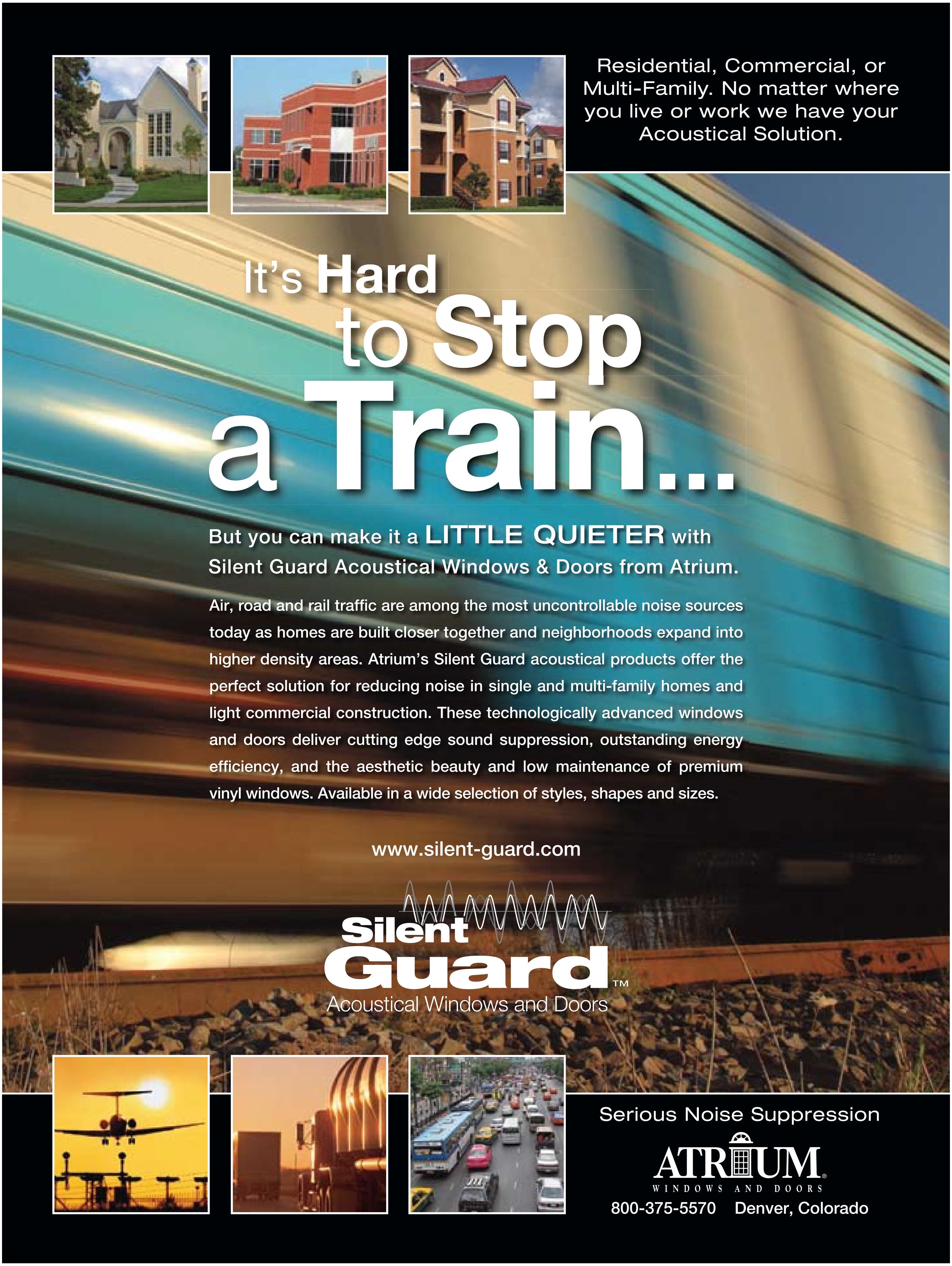
2011 June

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

- **Controlling air-borne and structure-borne sound in buildings**
- **MEMBER SOCIETY PROFILE**
  INCE/Japan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Advertising Sales Manager
Richard J. Peppin
Scantek, Inc.
6430 Dobbin Rd. #C
Columbia, MD USA 21045
410-290-7726, 410-290-9167 fax
e-mail: PeppinR@ScantekInc.com

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The Institute of Noise Control Engineering of the USA, Inc.
Business Office
9100 Purdue Road. Suite 200
Indianapolis, IN 46268-3165
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NOISE/NEWS INTERNATIONAL

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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 and its Internet Supplement

www.noisenewsinternational.net

The primary change in this PDF-only volume of *NNI* is the ability to have "hot links" to references, articles, abstracts, advertisers, and other sources of additional information. In some cases, the full URL will be given in the text. In other cases, a light blue highlight of the text will indicate the presence of a link. At the end of each feature or department, a light blue back to toc will take the reader back to the table of contents of the issue.

- The Internet supplement contains additional information that will be of interest to readers of *NNI*. This includes:
- The current issue of *NNI* available for free download
- *NNI* archives in PDF format beginning in 2003
- A searchable PDF of annual index pages
- A PDF of the current *NNI* conference calendar and a link to conference calendars for worldwide meetings
- Links to I-INCE technical activities and I-INCE Technical Reports

Progress in International INCE

The 40th International Congress and Exposition on Noise Control Engineering (INTER-NOISE 2011) will be held in Osaka, Japan from 2011 September 4- 7 in the Osaka International Convention Center (Grand Cube Osaka). The Congress is being co-organized by the Institute of Noise Control Engineering of Japan (INCE/J) and the Acoustical Society of Japan (ASJ). The main theme of the Congress is *Sound Environment as a Global Issue*. The technical program includes two plenary lectures and six keynote lectures. At the close of abstract submissions, the organizers had received over 900 abstracts. Please visit the web site at www.internoise2011.com for full details to plan your trip.

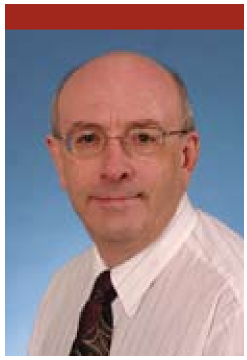
Plans to award between ten and twelve Young Scientist Conference Attendance Grants ware announced on the INTER-NOISE 2011 web site earlier this year. These grants will assist young noise control professionals in attending INTER-NOISE 2011. In addition to the main technical program, I-INCE will again hold a Workshop for Young Professionals. The Workshop follows the one held in Lisbon last year. The purpose of the Workshop is to mentor young noise control professionals, discuss research problems, and provide an informal forum for networking between senior and junior professionals. A detailed program will be posted on the web site about 3 months in advance.

In an effort to involve younger noise control professionals in the affairs of the Institute, changes to the Bylaws were proposed during the General Assembly in Lisbon. The changes allow the General Assembly to nominate candidates for positions of Director-at-large. Thus every third year the General Assembly will elect to the Board one member from each of three Member Societies from the different geographical regions (Europe-Africa, Pan-America, and Asia-Pacific). The term of office of the three Directors will be for three years beginning on January 1st of the year following the election. The first election is expected to be held during the General Assembly in Osaka.

In order to meet the expanding needs of the field of noise control engineering, I-INCE has now established a Symposium Series. The I-INCE Symposium Series replaces the past procedure in which the Institute was requested by other organizations to co-sponsor a series or an individual event. Thus, when approved by the Board as a co-sponsor, the Institute had little or no influence on the programs of the co-sponsored symposia. The I-INCE Symposium Series will be sponsored by the Institute, and requests for co-sponsorship of events outside the I-INCE Symposium Series will no longer be accepted.

The first I-INCE Symposium titled *Inducing 'Buy-Quiet' Purchasing Attitudes Through Simplified Product Noise Ratings* will be held in Paris on 2011 July 5-6. The Symposium is being organized by INCE/Europe in cooperation with the Federal Institute for Occupational Safety and Health (BAuA) in Germany and the Centre d'Information et Documentation sur le Bruit (CIDB) in France, and in partnership with the International Council of Academies of Engineering and Technological Sciences (CAETS). The objectives of the Symposium are to stimulate noise ratings and to provide manufactures with the information needed to design low noise products. Further details of the Symposium were published in the European News Department of the December NNI.

I am also pleased to announce that I-INCE has now signed a Memorandum of Understanding with CAETS. Recall that CAETS is a worldwide consortium of national academies. CAETS is without affiliation or bias and independent of the stakeholders on the noise issue. With broad engineering expertise, CAETS brings an independent voice and source of information to the discussion by policymakers of what is technically feasible. The cooperative activities under the agreement are undertaken by the CAETS Noise Control Technology Committee and the new I-INCE Noise Control Evaluation Panel. The CAETS Noise Control Technology Committee is currently chaired by past I-INCE President Tor Kihlman. As part of the interaction between I-INCE and CAETS, Tor made a presentation at a workshop held in Brussels, Belgium on 2010 October 29. The workshop was organized by the Belgian Presidency of the Council of the European Union and by the European Commission. It brought together various stakeholders, representatives from national governments and noise experts in order to launch a dialogue on complementary measures to develop a market for low-noise machinery and to enhance environmental awareness and commitment. A summary of Tor's presentation was published in the December issue of NNI. back to toc



Gilles Daigle
President, International INCE

INTER-NOISE: An Educational Event

Marion Burgess
Asia Pacific Editor

At this time it is common to consider what has happened in the first half of the year and plan for the remainder. 2011 has certainly been a dramatic year for extreme climatic events and particularly in the Asia/Pacific region. The more major of these have been the devastation from the earthquake and tsunami in Japan, the heavy rains and severe flooding in Australia and the earthquake in Christchurch New Zealand. And elsewhere in the world there have been the hurricanes in U.S. and volcano eruption in Chile. The damage caused by these major events to buildings and major infrastructure will take some considerable time to be repaired. For the new constructions, as well as taking into consideration the requirements to reduce future risks there is the opportunity to incorporate changes aimed at improving the overall functioning of the buildings. And it is hoped that acoustical considerations, in particular those that enhance noise control, will be taken into consideration and many of the improvements and advancements in recent decades will be implemented.

Also at this time the Japanese Acoustical Society is busy preparing for the INTER-NOISE 2011 conference, 4 to 7 September in Osaka. The Congress Chairman, Ichiro Yamada, has reassured the international community that the venue is over 600 km south west of the area devastated by the tsunami and that the conference will go ahead as scheduled.

Participation in an INTER-NOISE conference involves learning from the technical presentations but has far more benefits than may be initially apparent. These include the planned and the chance meetings and discussions outside the main program. It is therefore very good to see that as well as the comprehensive program covering the many technical areas of noise and its control there is to be a workshop on "Noise Issues in Developing and Emerging Countries" to be organized by a consortium with Larry Finegold as chair and Dieter Schwela as co-chair. Many of the developing and emerging countries are in South East Asia and so the location of this workshop in Japan is ideal to minimize the overall travel costs for the participants. Those in developing countries rarely get the opportunity to meet together to discuss common noise problems nor do they have the opportunity to attend relevant conferences and meet with a range of international people with similar concerns. This workshop is a commendable initiative which will extend the "outreach" of INTER-NOISE. It may well provide the only opportunity for those from developing countries dealing with noise issues to meet with acousticians from around the world.

I hope that all those interested in "Sound Environment as a Global Issue," the theme for INTER-NOISE 2011, will travel to Osaka to participate and enjoy the Congress. back to toc

Marion Burgess
Asia Pacific Editor

Continued on page 14

INCE/Japan

The Institute of Noise Control Engineering of Japan (INCE/J) was established in 1976 through the efforts of the Organizing Committee for INTER-NOISE 75, which was held in Sendai, Japan on 1975 August 27-29. The aims of INCE/J are to foster the development of science and technology in the field of noise and vibration control and to promote cooperation and mutual exchange of relevant knowledge among members.

The membership of the Institute is at present about 1,000 with about 140 companies and institutions as sustaining members. Members include researchers and engineers, administrative officials and others from universities, public agencies, instrument manufacturers, construction companies, consultants, and other institutions. They are specialists in a wide range of fields such as architecture, civil engineering, mechanical engineering, applied physics, physiology, psychology, electrical engineering, medicine, and so forth.

The Institute publishes the journal *Journal of INCE/J* bimonthly. Each issue focuses on some problems related to noise and vibration and includes some technical papers. The journal was archived on website that is managed by the Japan Science and Technology Agency from 2009 at the following URL. http://www.journalarchive.jst.go.jp/japanese/jnltop_ja.php?cdjournal=souonseigyo1977
It works effectively to indicate the state-of-the-art research on noise and vibration control worldwide.

At annual meetings of the Institute, about 110 papers and technical reports are presented. In addition to the regular autumn meeting, a spring meeting was added in 2001. The technical committee of INCE/J also has some ten active subcommittees. Each subcommittee concentrates on its own special topic to meet the requirements of the times. Some such topics are "low frequency sound," "administrative actions required for environmental noise and vibration abatement," "noise in the work environment," and "environmental noise prediction." Various technical reports edited by the subcommittees have also been published for distribution among members. These reports include "The methods of assessment of noise and vibration for land use planning," "Measurements and evaluations of noise in the work environment," "Foundations and applications of sound intensity measurements," "Measurements of low frequency sound and infrasound," "Case study on noise and vibration control—visualized causes and solutions," and others. Some technical reports on building acoustics have been recently published, and the issues in the condominiums such as floor impact sound and others are investigated.

The Institute of Noise Control Engineering of Japan has also contributed to international technical meetings such as INTER-NOISE, the Western Pacific Acoustics Conference (WESPAC), and the International Congress on Acoustics (ICA), and also to drawing up the Japanese Standards concerning noise and vibration.

In 1984 and 2006, INCE/J co-organized INTER-NOISE 84 and 2006 both held in Honolulu, Hawaii with Institute of Noise Control Engineering of the USA. Also in 1994, INCE/J co-organized INTER-NOISE 94 held in Yokohama, Japan, with I-INCE and the Acoustical Society of Japan (ASJ).

In 1995, INCE/J joined with the Acoustical Society of Japan, the Acoustical Society of America, and the Institute of Noise Control Engineering of the USA to sponsor ACTIVE 95, the 1995 International Symposium on Active Control of Sound and Vibration. The symposium was held in Newport Beach, California, USA on 1995 July 08-10.

In April 2004, INCE/J joined with the Acoustical Society of Japan and International Commission for Acoustics to sponsor the 18th International Congress on Acoustics (ICA 2004). The congress was held in Kyoto, Japan on 2004 April 4-9.

In September 2011, INCE/J will join with the Acoustical Society of Japan and I-INCE to organize the 40th International Congress and Exposition on Noise Control Engineering, INTER-NOISE 2011. The congress will be held in Osaka, Japan on 2011 September 4-7. Details are shown in the following webpage.
http://www.internoise2011.com/

INCE/J qualifies persons with sufficient experience in noise and vibration control for the title of "INCE/JAPAN/Consultant." It also gives the following Prizes; Morita Sakae Prize for outstanding paper appearing in the Journal published in the recent two years to commemorate Dr. Sakae Morita, the first president of INCE/J, Prize for distinguished achievements or books in noise control, Prize for outstanding design of sound environment, and Incentive Prize for outstanding presentations given at the annual meetings

This is the 76th in a series of articles on the Member Societies of International INCE. This is an update of the profile that appeared in the 2001 September issue of this magazine.—Ed.

Member Society Profile is a regular feature of *Noise News International*. If you would like to have your society featured, please contact George Maling at inceusa@aol.com.

Dear Colleagues:

We hope you will join us at INTERNOISE 2012 at the Marriott Marquis Hotel in New York City, USA, 19-22 August 2012. This year, ASME's Noise Control and Acoustics Division (NCAD) is joining with the Institute of Noise Control Engineering (INCE) in planning a large congress of over 1000 delegates, including:

- Three days of technical papers spanning many areas of noise and vibration, including our congress theme – "Quieting the World's Cities."
- A large vendor exposition (60+) of noise and vibration control materials, analysis software and measurement systems and instrumentation.
- Three plenary sessions on City Noise Codes, the Effects of Noise on Children and Airport Noise.
- A series of short courses on noise and vibration control.

We will be issuing our call for abstracts (due 15 February 2012) shortly. In the meantime, visit our website, www.INTERNOISE2012.com, to learn more about what promises to be the premier vibration and acoustics conference in 2012.

Sincerely,

Stephen Hambric, General Chair
Stephen Conlon, Technical Chair
Brent Paul, ASME NCAD Chair
Rich Peppin, Exhibitions Chair
Amy Herron, Conference Secretariat

Controlling air-borne and structure-borne sound in buildings

J. David Quirt, National Research Council Canada, Ottawa, K1A 0R6, Canada

ABSTRACT

In recent years, the science and engineering for controlling sound transmission in buildings have shifted from a focus on individual assemblies such as walls or floors, to a focus on performance of the complete system. Standardized frameworks for calculating the overall transmission including structure-borne flanking, combined with standardized measurements to characterize sub-assemblies, have advanced these issues from research concepts to engineering practice in many countries. From studies of relatively homogeneous and isotropic constructions of concrete and masonry in the 1990s, the technology is now expanding to include the more complicated behavior of lightweight framed constructions. These advances in measurement-based calculations offer the potential for better design based on comprehensive prediction of sound transmission between units in multifamily buildings.

Introduction

This paper attempts to provide an overview of some key advances in dealing with sound transmission within buildings. It is naturally limited by the author's personal biases, and hence focuses on issues from a North American perspective, and deals mainly with experimental results and experiment-based models used to translate the scientific concepts into engineering practice. To focus further, this paper deals with transmission of sound from airborne sources in multi-family residential buildings. In this context, the paper addresses some key questions:

A photograph of the author and a short vita appear on page 49 of this issue.

- Can we accurately predict transmission to the receiver?
- What are the sound transmission paths of concern?
- Do available criteria reflect how people react to the transmitted sound?
- How can we effectively package the technology for the intended users?

Shifting to a New Paradigm

Until about 2000 (with some notable exceptions[1]), research on sound transmission between rooms in buildings has focused mainly on sound transmission through individual assemblies. This perspective is still evident in North American building codes, which for many decades have considered only the ratings for the assembly separating adjacent dwellings: Sound Transmission Class (STC) or Field Sound Transmission Class (FSTC) for airborne sources[2] or Impact Insulation Class (IIC) for footstep noise.[3]

Implicit in this approach is the simplistic assumption, illustrated in Fig. 1, that sound is transmitted only through the obvious separating assembly—the separating wall assembly when the units are side-by-side, or the floor/ceiling assembly when units are one above the other. If there is a problem with the sound insulation, this is ascribed to errors in either design of the separating assembly or the workmanship of those who built it. Unfortunately, this paradigm is still predominant among designers and builders in North America.

In reality, the problem is more complex as illustrated in Figure 2—the airborne sound source excites all the surfaces in the source space. All these surfaces vibrate in response, and some of this vibratory energy is transmitted across the

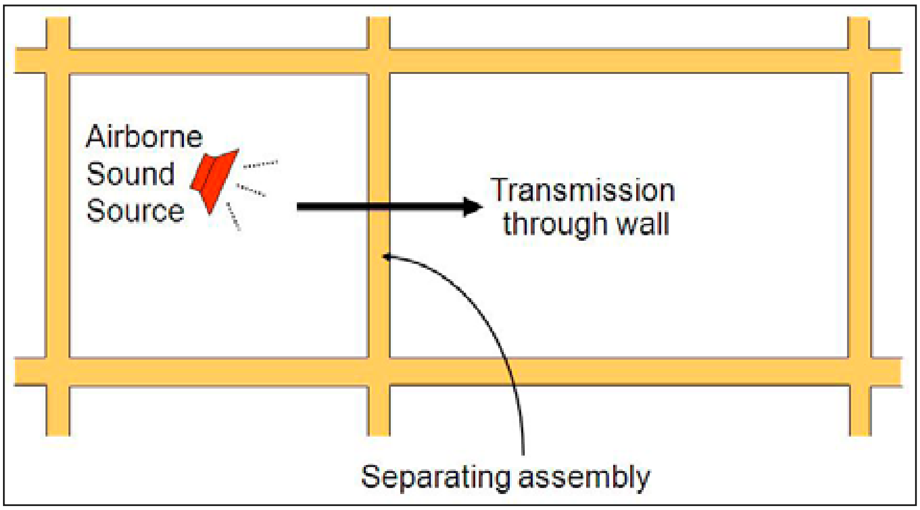


Figure 1. *The drawings in Figure 1 and 2 show a cross-section through a building with two adjacent dwellings. Some of the sound from an airborne source in one unit (represented by red loudspeaker in the drawings, which could be anything from a home theatre to people talking loudly) is transmitted to the adjacent unit. The traditional approach, illustrated in Figure 1 focuses on only the direct sound transmission through the separating assembly.*

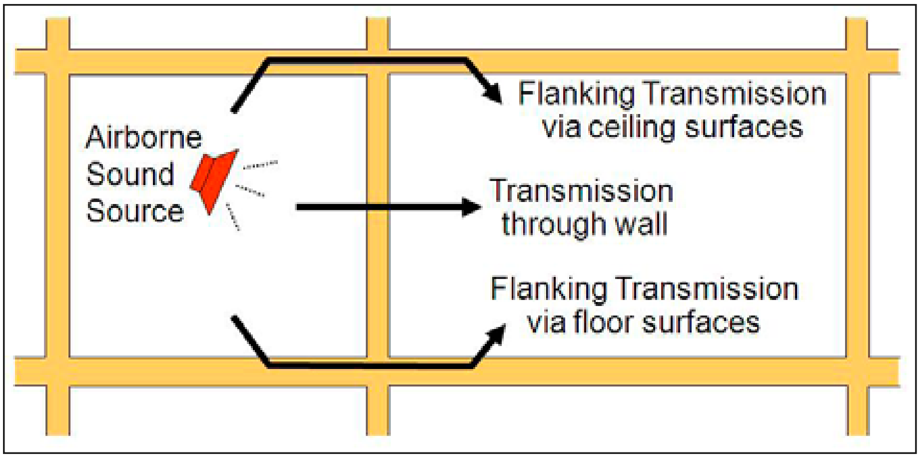


Figure 2. *In reality there are many paths for sound transmission including both direct transmission through the separating assembly and indirect structure-borne paths, of which a few are indicated here. The structure-borne paths often significantly affect the system performance.*

surfaces abutting the separating assembly, through the junctions where these surfaces join the separating assembly, and into surfaces of the adjoining space, where part is radiated as sound. It follows that the sound insulation between adjacent dwellings is always worse than the sound insulation provided by the obvious separating assembly. Of course, this has long been recognized in principle (and the fundamental science was largely explained by Cremer and Heckl[4] decades ago)—the problem was to reduce the complicated calculation process to manageable engineering that yields quantitative estimates.

Occupants of the adjacent space actually hear the combination of sound due to direct transmission through the separating assembly and any leaks, plus sound due to structure-borne flanking transmission involving all the other elements coupled to those assemblies. For design or regulation, the terminology to describe the overall sound transmission including all paths is well established. ISO ratings[5] such as the Weighted Apparent Sound Reduction Index (R'w) have been used in many countries for decades, and ASTM has defined the corresponding Apparent Sound Transmission Class (ASTC), which is used in many examples in this paper. There are other variants using different normalization or weighting schemes that have arguable advantages, but this paper uses ASTC as the basic measure of sound insulation for airborne sound.

While measuring the ASTC in a building is quite straightforward, predicting the ASTC due to the set of transmission paths in a building is more complex, and requires data on structure-borne transmission. For heavy "monolithic" construction, standardized statistical energy analysis (SEA) prediction methods have been used for more than a decade to support performance-based European code systems, and supporting commercial software packages have been developed. For lightweight framed constructions these SEA predictions are less accurate.

Most of the remainder of this paper is an overview of experimental results and experiment-based models that have been developed to predict the overall sound insulation between adjacent spaces in a building with lightweight framed construction. But first, to assess whether the predicted ASTC or R'w is adequate, criteria must connect the physical performance to the reaction expected from building occupants.

Ratings and Subjective Criteria

For efficient design, we need design criteria—objectives that quantify "acceptable levels" of noise from obvious sources. For the occupants of a building, that includes noise from outdoor sources such as highways and aircraft, noise from appliances and building services (plumbing, ventilation, etc.) and noise from neighbors. This paper focuses on noise from neighbors in multi-family residential buildings.

Even with that restricted focus (and decades of refining pertinent regulations and standards), the criteria seem to be based more on tradition than on substantial scientific studies of human response. ISO 717 offers 15 metrics for airborne sound insulation between rooms, 27 for insulation of facades, and 6 for impact sound insulation. As Rasmussen has periodically documented,[6] even within "unified Europe," this has led to a bewildering array of national criteria, and many non-European countries have added further variants. One could make a strong case for the benefit of continuing recent research efforts in this area,[7, 8] especially to assess the most suitable ratings to handle low frequency sound and special sources such as footsteps and building services (ventilation, plumbing, etc.) to establish a credible foundation for improved consensus standards. That is clearly one of the key challenges for the next decade.

To maintain a manageable focus, this paper simply presents some existing consensus criteria for insulation against airborne sound, expressed in terms of the ASTC metric chosen for this presentation. Because of the wide variation in national approaches to regulation, comparing specific regulatory limits is not very instructive, but recent schemes for labeling housing—to provide potential buyers or tenants with a market indication of quality of sound insulation (among other factors) offer a clearer perspective, shown in Fig. 3.

Most of these labeling systems have 2 or 3 classes for acoustic comfort better than the regulatory minimum; some also have lower classes directly connected with national requirements. The top categories have been grouped here as basic/better/best clusters in Fig. 3. Because the various schemes use different metrics from the set in ISO 717, only an approximate conversion to ASTC is possible, but that suffices to illustrate the rather small range of criteria - the "Basic" quality class requires ASTC in the range from about 50 to 55, and the "Best" class requires 60 to 65. The existence of a range in requirements is not surprising given the different national traditions both for regulations and social expectations. But despite strong individualism in national expression of the requirements, it appears that there is a fairly clear consensus on how much sound insulation is good enough to satisfy occupants.

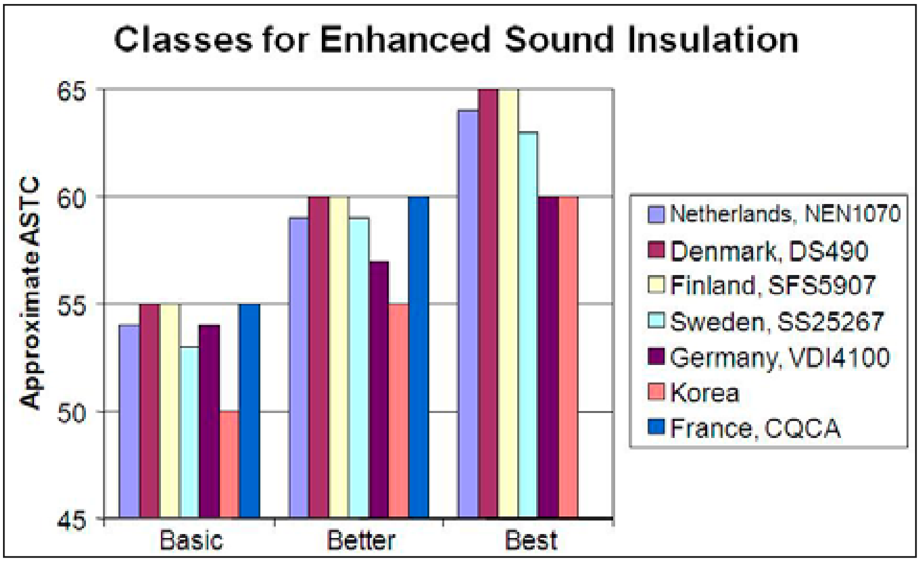


Figure 3. *Criteria for enhanced sound insulation between adjacent units in multi-family buildings in acoustic quality classification systems for several countries, translated to approximate ASTC scale.*

For practical design objectives, the requirements for typical occupants seem fairly clear:

- ASTC ~ 52 is good enough to satisfy many people, much of the time.
- ASTC ~ 65 (maximum of top class range) should almost always provide satisfaction.

From a Canadian perspective, these criteria are quite consistent with the social response data obtained by Bradley in a survey of 300 pairs of neighbors, living side-by-side in multi-family residential buildings.[9] After obtaining survey responses from each pair of neighbors, the survey team measured ASTC between the dwellings. As expected there was a range of responses, but there were clear trends in the mean responses, varying from significant annoyance when ASTC was under 50 to negligible annoyance (and reporting not hearing sound from the neighbors) when the ASTC approached 65. These results were broadly consistent with the criteria proposed above and with the market classification schemes shown in Fig. 3.

However, it must be recognized that these criteria are at best fuzzy targets, because many factors (noisiness of individual neighbors, ambient levels due to building services and intruding outdoor sound, sensitivity of individual listeners, etc.) ensure that any assessment of social response versus sound insulation will exhibit significant variance.

Improved measures for the sound insulation should reduce the scatter in these responses, and would presumably shift the relative acceptability of some types of construction, especially for those cases where low frequencies dominate—which are problematic according to anecdotal evidence. Pursuing the refinement of the ratings is worthwhile, especially if clear international consensus can be established. But for purposes of this paper, the criteria noted above give reasonable working indications of acceptability in terms of the current metrics.

Transmission in Heavy Monolithic Construction

Significant advances in predicting the sound transmission through the complete building system, including the direct and indirect paths, occurred first for heavy monolithic construction, with structural elements such as concrete floors and masonry walls. These systems are well-suited to modeling using statistical energy analysis (SEA) to calculate the transmission: The elements such as floors or walls can be treated as homogeneous and isotropic, they are lightly damped so they can reasonably be characterized by reverberant levels, and most energy losses are due to transfer to adjoining elements. Craik and others advanced this subject from research studies to textbooks.[3] By the mid 1990s SEA was part of widely accepted engineering practice.

This engineering concept was implemented in European standard EN 12354, which was published in 2000, with parts to address airborne and impact sound transmission between rooms within buildings and the transmission of outdoor sound into a building. In 2005, the Parts of EN 12354 were adopted as international standards, as ISO 15712, "Building acoustics— Estimation of acoustic performance of buildings from the performance of elements."[10]

For two adjacent rooms, either side-by-side or one above the other, sound is transmitted both directly through the separating assembly and via a set of indirect paths involving all the surfaces connected at each junction common to both rooms. In the simple case, where room dimensions at the separating element match, there would be four such junctions, one at each of the four edges of the separating wall or floor assembly. There is a set of indirect paths for each junction, each path involving transfer of energy from a surface in the source room to one in the receiving room. For heavy monolithic constructions, this transfer can be calculated, and depends only on junction geometry, and properties of the joined assemblies, which can be determined in the standard laboratory test according to ISO 140-3 (functionally equivalent to ASTM E90), if one includes the (formerly optional) measurement of structural damping. For more complex assemblies, measurement protocols were developed to characterize junction performance.[11]

The practicality of the calculation framework comes from the rather straightforward extension to deal with the incremental effect of "linings" added to the basic structural elements. It is common practice, especially in residential buildings, to add finish surfaces to the basic structural wall and floor assemblies, for example, various multi-layer floor surfaces, or gypsum board wall and ceiling surfaces that mask both the bare concrete and the building services such as wiring and pipes. These additional linings can significantly improve the sound attenuation, both by limiting the transfer of vibration between the lining and the supporting assembly, and by changing the efficiency with which the exposed surface converts structure-borne vibration to airborne sound. If the lining is treated as simply changing the sound power flow from the reverberant sound field in the room to the reverberant vibration in the structural assembly, or vice versa, then as shown conceptually in Fig. 4, the practical calculation combines the basic flow of structure-borne power via the coupled structural elements, with simple additive changes due to the linings. Fortunately this approach works very well for heavy monolithic supporting structures.

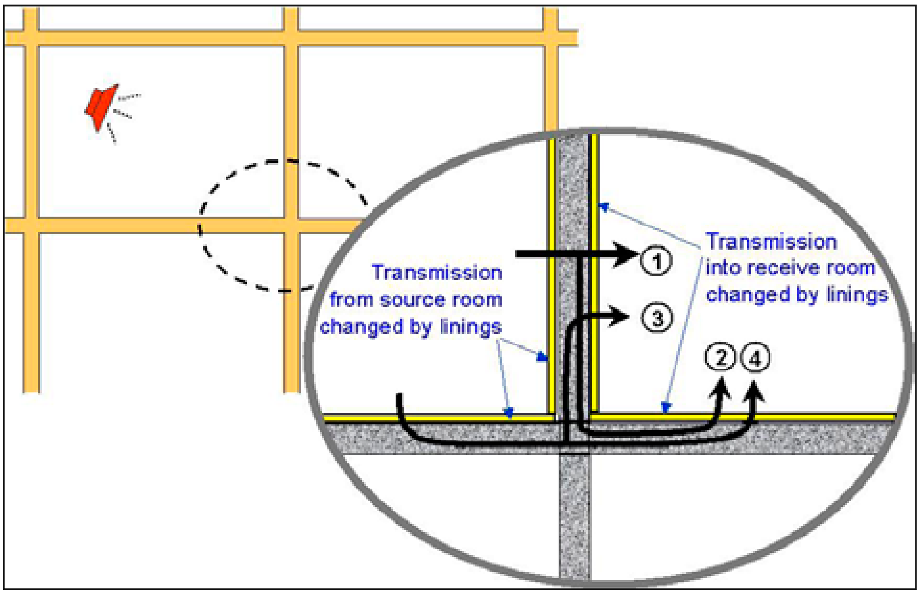


Figure 4: *Transmission combines direct path through separating wall (1) and structure-borne flanking via: wall-floor path (2), floor-wall path (3) and floor-floor path (4), plus corresponding set of paths at other junctions. Transmission via these paths is altered by addition of linings in the source room and/or receiving room.*

The effect of a lining added to a structural base assembly can be determined to first order by measuring the change in direct sound transmission loss when the same lining is added to a similar base assembly separating the two rooms of a standard laboratory sound transmission suite. This process for evaluation of linings was outlined in ISO 15712, and subsequently fleshed out more completely with a set of reference base assemblies in ISO 140-16.[12] ISO 140-16 uses the same procedures as ISO 140-3 or ASTM E90, to compare the laboratory transmission loss for a bare concrete or masonry assembly with that for the same base assembly with a lining added.

The ISO 15712 standard notes that a good (but slightly conservative) estimate can be obtained by simply plugging the standard laboratory transmission loss results for the wall and floor assemblies into the calculation. Enhanced accuracy can be obtained by making adjustments to laboratory results to correct for differences in structural damping expected in situ and to remove the non-resonant part of the transmission for flanking paths. Thus conventional laboratory tests of the basic assemblies and linings, together with estimates of junction losses (provided in Annex E in ISO 15712) provide the inputs for implementing Part 1 of ISO 15712 to create estimates of the ASTC in a building. According to ISO 15712, for concrete and masonry structures such estimates should be within a standard deviation of 1.5 dB.

Although extensions to include other types of floor and wall assemblies in the ISO 15712 framework have been proposed, there are significant additional complications that must be considered to get accurate estimates for lightweight framed construction.[13,14]

Transmission in Lightweight Framed Construction

Rather than attempt to fit sound transmission for lightweight framed construction into the framework developed for heavy monolithic systems, research in Canada has focused on developing an approach customized for performance of typical North American wood-framed buildings.

Concepts for Flanking in Lightweight Constructions

In this approach, developed by Nightingale et al.[15], the power flow via each flanking path is defined by five transmission factors whose combined effect is characterized by a path transfer function specific to the type of excitation (airborne or impact) and the construction detail. This is most simply explained in the context of impact sources. Figure 5 identifies the factors controlling the transmission of structure-borne sound to the room beside, and the resulting vibration levels across the floor surface are illustrated in Fig. 6, for one position of a standard tapping machine on a lightweight floor.

A general model for such a system must account for all five factors indicated in Fig. 5, for a realistic range of source positions. Clearly the system is anisotropic and highly damped – the vibration field exhibits a strong gradient that is different in the directions parallel and perpendicular to the joists. In general, this vibration field is a poor approximation of a diffuse field, which limits the applicability of simple SEA models. Not only do vibration levels vary strongly across the surface of the structural assembly, but also some added linings (such as floor toppings) change the attenuation across the structural assembly, with different changes in the three orthogonal directions pertinent to direct and flanking transmission. Hence, a simple correction for a given lining (derived from measurement of direct transmission and then used to correct structure-borne flanking transmission via the supporting structural assemblies) is not generally applicable for lightweight framed assemblies. The direction of transmission relative to the framing members becomes an additional parameter needed for accurate prediction.

Essentially the same five factors apply to characterizing the propagation with an airborne source, as indicated in Fig. 7. With an airborne source, the effect of source position is largely eliminated because there is fairly uniform incident sound power on the surfaces of the room, but all five factors still affect the sound power reaching the receiving room via the flanking paths as illustrated in Fig. 7 for a subset of the paths at a floor/wall junction.

Changing construction details will alter one or more of the five factors. For example, linings commonly affect both the attenuation across the underlying structural assemblies and the power flow to/from the underlying assembly. Experimental results demonstrating these behaviors, for both airborne and impact sources driving specific wood framed assemblies, were presented at preceding INTER-NOISE conferences.[16]

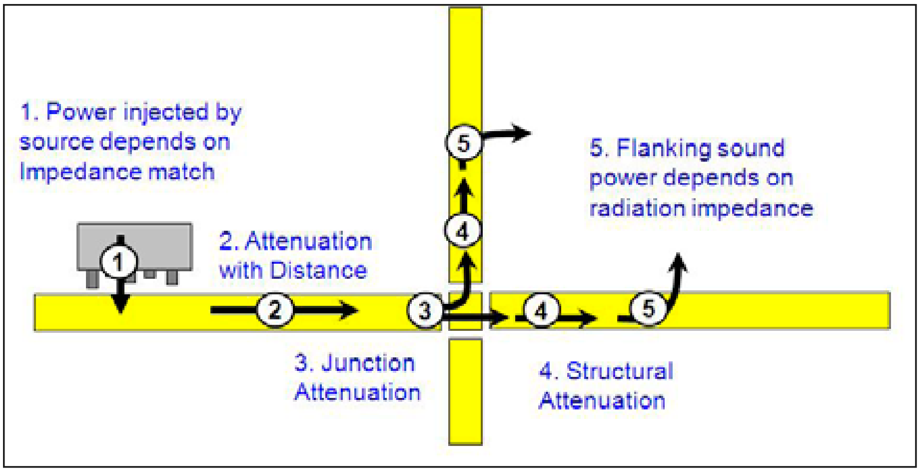


Figure 5: Five factors that affect flanking transmission via the floor/wall junction, with an impact source.

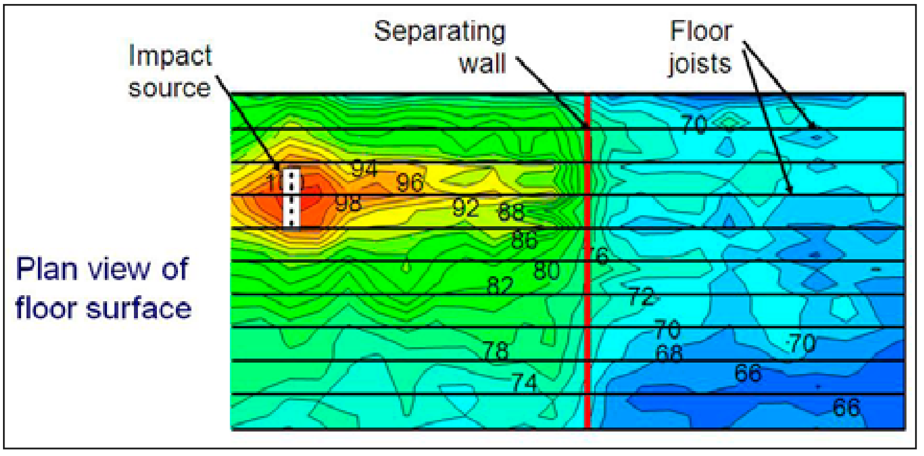


Figure 6: Variation across the floor surface of the vibration levels (2kHz band) due to an impact source. The floor construction has wood joists perpendicular to the separating wall between the two side-by-side rooms.

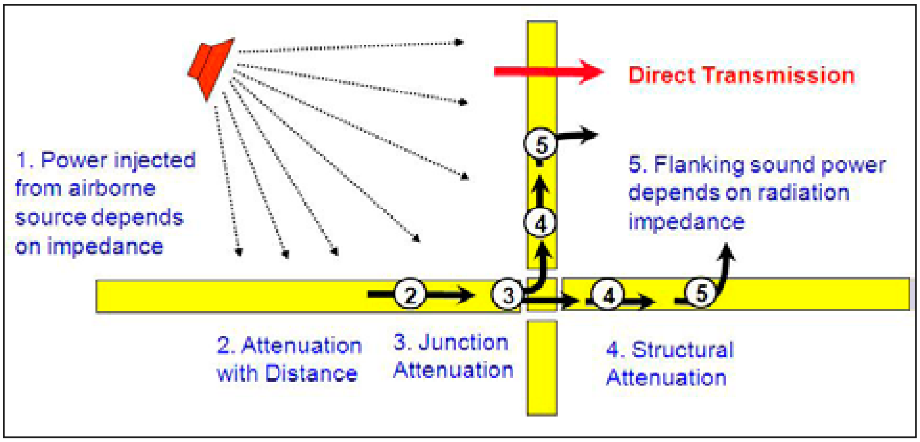


Figure 7: *Five factors that affect flanking transmission, with an airborne source for the paths involving the floor surface in the source room. Similar factors apply for all other paths.*

Examples of Flanking Transmission in Lightweight Constructions

A few examples to illustrate the effects due to common variations in construction are presented and discussed here, to provide context for the empirical prediction methods presented subsequently. The discussion concentrates mainly on one set of base assemblies, but other systems show comparable trends.

Figure 8 shows a specific set of constructions where a wall separates two side-by-side units; the wall has gypsum board screwed directly onto one side of the wood stud framing and mounted on resilient metal channels on the other, and achieves STC 52 in laboratory testing. The floor assembly has a bare oriented strand board (OSB) floor surface, with its gypsum board ceiling mounted on resilient channels (STC 55 in laboratory testing).

In repeated tests with minor variations of the materials and in the floor/wall junction details, the overall sound insulation observed between the side-by-side rooms was ASTC 43 to 45. Measurements of direct transmission through the wall itself showed that its sound transmission in the complete building system is very similar to laboratory results (STC 52). The difference in the system performance is due to flanking transmission via the floor assembly, which transmits far more sound than the separating wall assembly above 250 Hz.

For the case shown in Fig. 9, the measured ASTC was even lower than the ASTC observed when the joists were parallel to the separating wall (as illustrated in Fig. 8). The problem here is not that the separating wall is transmitting more sound than expected—it is performing as designed—but that most of the sound energy is able to circumvent the separating wall as structure-borne flanking transmission. Once again, the system ASTC is much lower than the STC of the separating assembly because flanking limits performance for this design.

The systems illustrated in Figs. 8 and 9 would result in noise that most neighboring occupants would find annoying and would complain about. To remedy this, a builder's first impulse would likely be to 'fix' the separating wall assembly by, for example, sealing any possible leaks and adding a second layer of gypsum board on the side with resilient channels. The added gypsum board should increase the wall assembly's STC by about 5. Detailed testing would show that the sound transmission directly through the wall was improved (i.e. Field

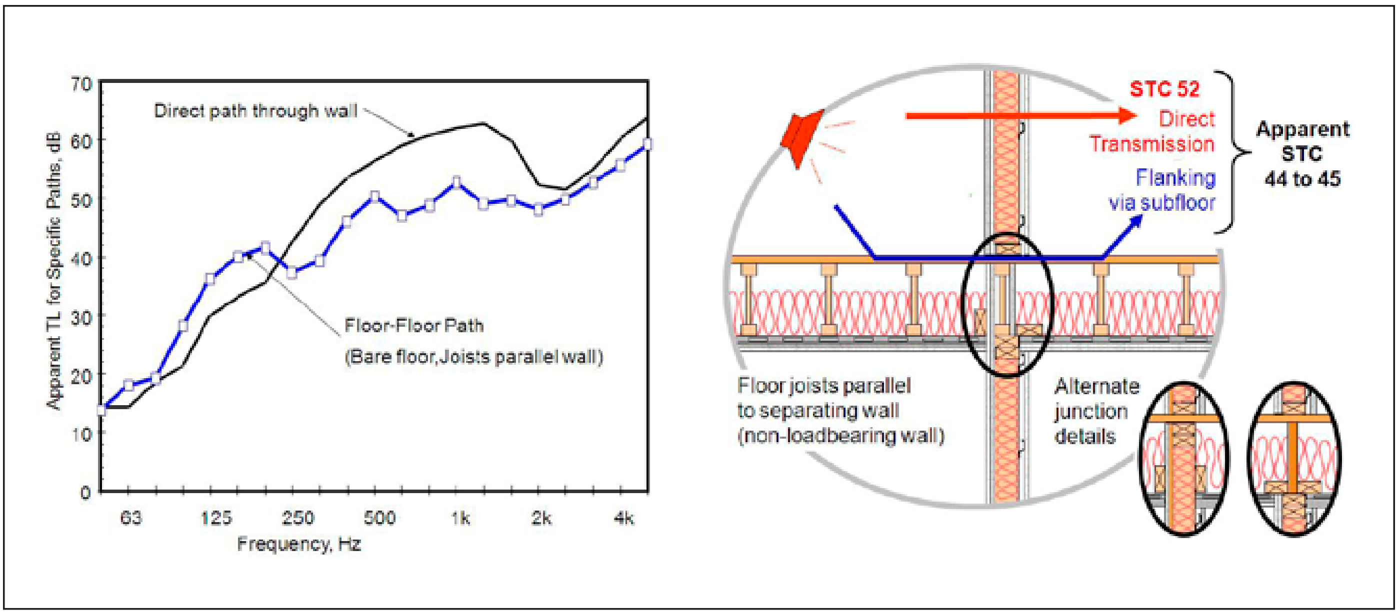


Figure 8: *Sound transmission between side-by-side units with simple wood-frame wall and floor assemblies, as illustrated.*

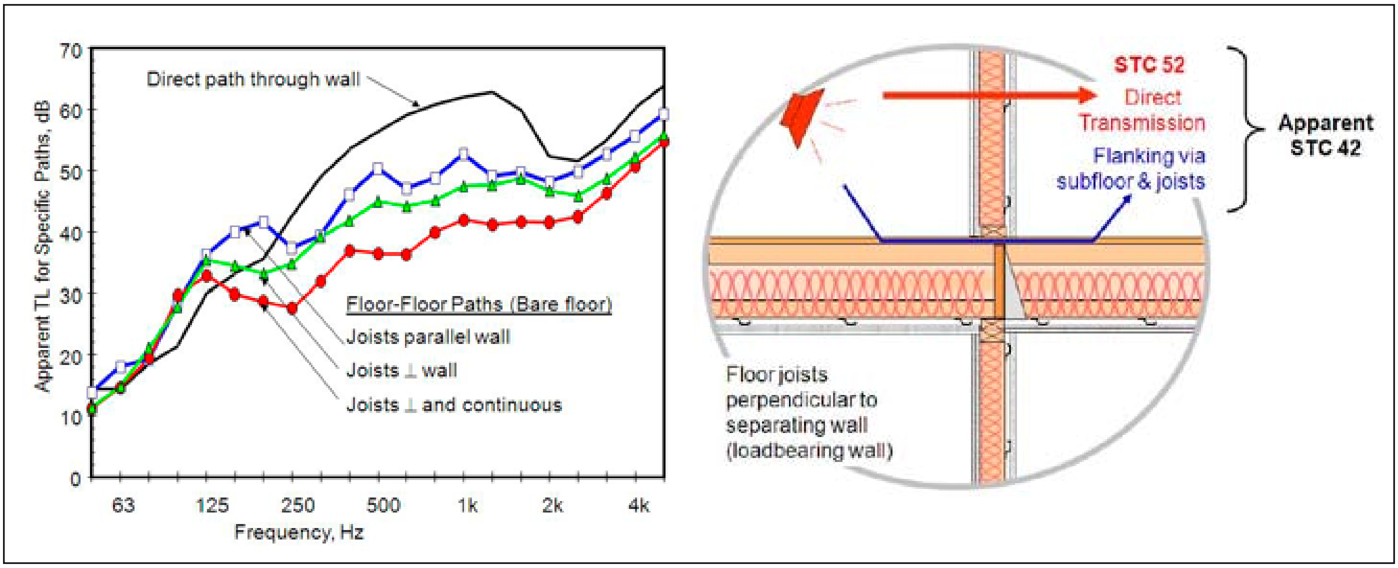


Figure 9: *Modifying the wall/floor system of Figure 8 by reorienting the floor joists to run perpendicular to the separating wall lowers the ASTC for the system, due to increased transmission via the floor surfaces.*

STC increased) as expected, but that the system performance was barely affected and only increased to ASTC 43 because the dominant sound transmission path (i.e., structure-borne flanking via the floor) was not dealt with.

In recent years, many enhanced products have been introduced, such as wallboard incorporating constrained-layer damping, or resilient mountings that improve on the traditional generic resilient metal channels of the walls in Figs. 8 and 9. Such products could increase this basic wall assembly's sound insulation to a rating of STC 60 or more, but the complete system would still provide only ASTC 43.

To address the problem, one must identify the key sound transmission paths and take appropriate measures to manage them. As illustrated in Fig. 10, since transmission via the floor is the dominant problem with the floor/wall systems illustrated in Figs. 8 and 9, treating the floor must be part of the solution. But a rational approach to the design must balance changes to the floor surface with changes to the separating wall, to achieve a cost-effective system with the desired ASTC performance. If the target were ASTC of at least 50, then a rather complex and expensive treatment of the floor would be required if using the basic wall illustrated in Fig. 9. A simpler floor treatment could provide the target ASTC if the wall were improved to STC 57 with an extra layer of gypsum board. With further enhancement of the wall surfaces, the ASTC could be increased to ~60 when combined with the best floor treatment illustrated in Fig. 10.

Unfortunately, making improvements to the floor and separating wall is not a complete solution, as other paths may also be significant, and once better floor and wall assemblies have been put in place, the sound transmission via other paths will become more obvious. Ceilings and sidewalls also need to be considered as possible paths of sound transmission.

Only at this stage, where all the first-order paths are considered, can acoustical benefits of specific changes be properly weighed and balanced against their cost to optimize the cost/benefit for the complete system. The examples above have focused on side-by-side spaces, but a similar set of tradeoffs is involved when one considers the case where one dwelling is above another.

This highlights the practical need for a more complicated design framework, as discussed in the next section.

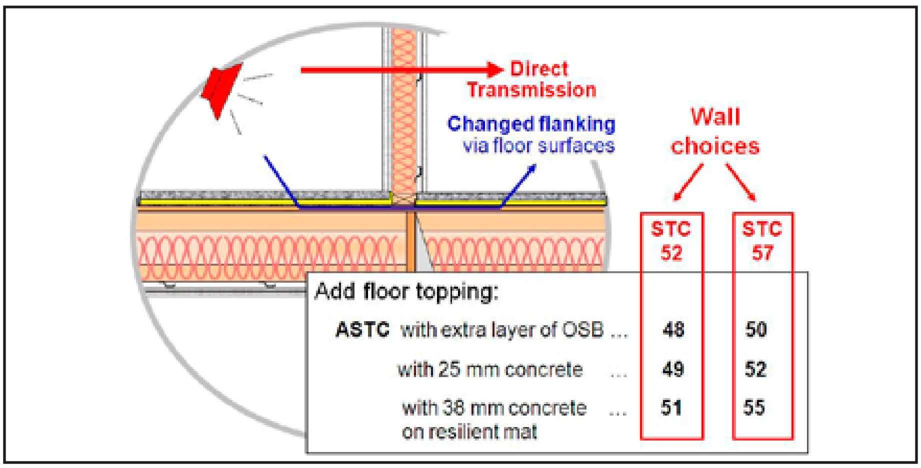


Figure 10. *With a range of choices for the wall and floor, the builder can look sensibly at cost/performance tradeoffs for improvements to the elements that affect the dominant paths, which are the separating wall and the floor surface in this illustration.*

Designing for System Performance in Lightweight Constructions

A simplified guide for design of wood-framed buildings was developed,[17] using a tabular approach to present alternative choices for all the surfaces likely to be significant to the overall sound transmission between adjacent spaces. The Guide presents single-number ratings for the transmission of sound from both air-borne and impact sources, for adjacent units that are side-by-side, or one above the other, for a limited set of the most common constructions.

A few examples for airborne sources are presented here to highlight the strengths and weaknesses of such an approach.

Figure 11 illustrates the situation typically found in apartment buildings. In single-story apartments, the gypsum board ceiling is normally mounted on resilient channels to enhance the sound insulation from the apartment above. This also reduces flanking transmission between the side-by-side units via the ceiling/ceiling path to an insignificant level.

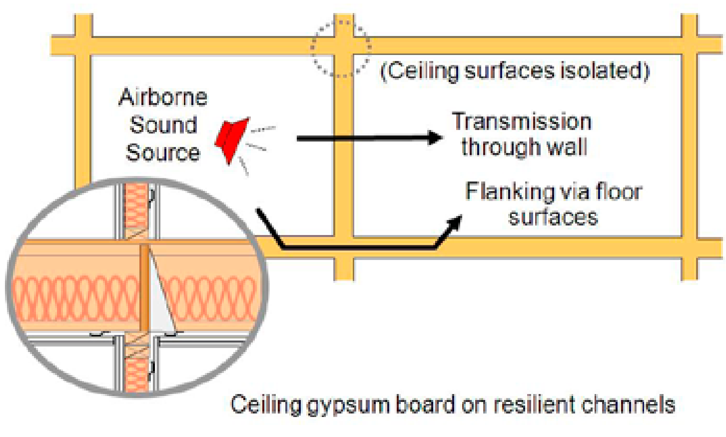
From Table 1, the effects of variations in the construction are readily seen. For example, with no topping added over the basic plywood or OSB floor surface, flanking via the floor surfaces is so strong that the ASTC between the adjacent units does not rise above 43 no matter what improvements are made in the separating wall or the sidewalls. Once the floor has been treated, then the effect of improving the separating wall becomes obvious. With the combination of a better floor and better separating wall, then the effect of improving the sidewalls also becomes significant. A paper by Nightingale[18] addresses this issue in more detail.

In applications where transmission between storys within a dwelling unit is not a concern (such as row housing), the ceiling is typically fastened directly to the bottom of the joists, as shown in Fig. 12. In such cases, the flanking paths via the ceiling also become significant, as evident in the lower ASTC values in Table 2 for this building design scenario.

Figure 12 and Table 2: Typical sound transmission paths between side-by side units in multi-level row housing where gypsum board ceilings are fastened directly to the joists. The sidewalls abutting the separating wall also transmit sound. The table presents the ASTC for the specific separating wall and floor constructions illustrated in Figure 12, with various treatments of the floor and wall surfaces.

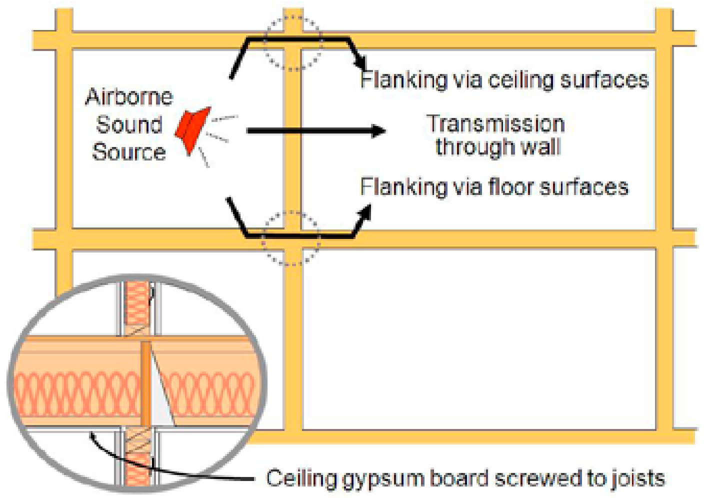
The corresponding effects when one unit is below another are less dramatic, but still warrant design consideration. The only significant flanking paths involve the floor surface and the walls in the room below. Transmission via the wall/wall paths shown in Fig. 13 is typically weak enough so that it can be ignored. The flanking transmission in this case is essentially the same for all the framing variants tested. The effect of joist orientation (stronger flanking via the walls supporting the floor joists) averages out if all wall surfaces in the room below are the same, because the joists are perpendicular to two walls and parallel to the others.

Table 3 shows the combined effect of changes to the floor surface, the ceiling and the walls, and allows one to perform a cost/benefit analysis for different design



Separating wall:	Basic wall (STC 52)	Better wall (STC 57)	
Attachment of gypsum board on sidewalls:	Direct or resilient	Direct	Resilient
Floor surface:	Apparent STC (ASTC)		
• No topping (basic)	43	43	43
• 19-mm OSB stapled to subfloor	48	50	50
• 25-mm gypsum concrete bonded to subfloor	49	51	52
• 38-mm gypsum concrete + resilient mat on subfloor	51	53	55

Figure 11 and Table 1: *Typical sound transmission paths between adjacent one-level apartment units. The sidewalls abutting the separating wall also transmit sound, but resilient channels supporting the gypsum board ceiling block structure-borne transmission via the ceiling surfaces. The table presents the apparent STC for the specific separating wall and floor constructions illustrated in Figure 11, with various treatments of the floor and wall surfaces.*



Separating wall:	Basic wall (STC 52)	Better wall (STC 57)	
Attachment of gypsum board on sidewalls:	Direct or resilient	Direct	Resilient
Floor surface:	Apparent STC (ASTC)		
• No topping (basic)	42	43	43
• 19-mm OSB stapled to subfloor	47	48	49
• 25-mm gypsum concrete bonded to subfloor	48	49	50
• 38-mm gypsum concrete + resilient mat on subfloor	49	51	52

Figure 12 and Table 2: *Typical sound transmission paths between side-by side units in multi-level row housing where gypsum board ceilings are fastened directly to the joists. The sidewalls abutting the separating wall also transmit sound. The table presents the ASTC for the specific separating wall and floor constructions illustrated in Figure 12, with various treatments of the floor and wall surfaces.*

options. This approach (which follows the same pattern as that used for side-by-side units) is especially helpful when used with lightweight floor surfaces.

Comparison of the ASTC values in Table 3 for a chosen floor topping show that because flanking transmission via the walls of the room below is comparable to direct transmission through typical ceilings with resilient channels, expensive solutions to improve the ceiling are not likely to provide much improvement in the ASTC, unless combined with wall improvements. Because both the direct transmission path and the significant flanking paths involve the floor surface, adding extra materials over the bare floor surface is often the most effective way to improve the sound insulation between units. When all three surfaces (floor, ceiling, and walls below) are improved, then very good overall performance can be achieved.

Similar tables in the Guide present impact (footstep noise) ratings for the same set of constructions. Thus the simple table-based design guide does provide information on sound transmission by the complete system, in a form that generalists can use, for a limited set of practical constructions.

Making the Design Process Usable in Practice

The tabular approach discussed above does show the effect of changes to all of the surfaces controlling sound transmission—both the separating assembly and the key flanking paths (hence indicating obvious choices)—and it also provides ASTC estimates for designers. Because tables are readily presented in conventional technical documents, distribution of the tabular Guide provided an effective means to convey concepts to builders and their generalist designers. But there are some obvious limitations:

- Each table (like Tables 1 and 2 above) applies to one specific combination of wall and floor constructions; therefore, many tables were required.

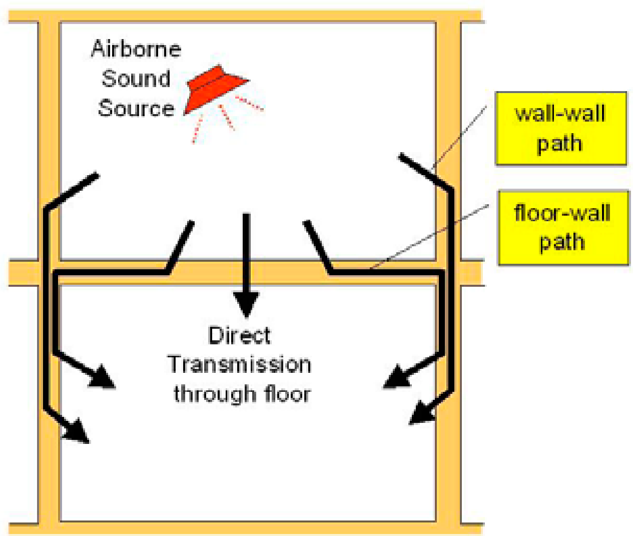


Figure 13: *Transmission paths between upper and lower units include both direct transmission through the separating floor and flanking transmission involving the floor and wall assemblies.*

Walls in room below	Floor surface	Worse ceiling 1 layer gypsum board on resilient metal channels spaced 400 mm o.c. (STC 51 if no topping)	Better ceiling 2 layers gypsum board on resilient metal channels spaced 600 mm o.c. (STC 59 if no topping)
		Apparent STC (ASTC)	
Basic walls: All walls with 1 layer of gypsum board fastened directly to the studs	• No topping (OSB subfloor)	49	52
	• 19-mm OSB stapled to subfloor	54	59
	• 25-mm gypsum concrete bonded to subfloor	59	61
	• 38-mm gypsum concrete + resilient mat on subfloor	63	64
Flanking suppressed: All walls with 1 layer of gypsum board supported on resilient channels	• No topping (OSB subfloor)	51	59
	• 19-mm OSB stapled to subfloor	55	64
	• 25-mm gypsum concrete bonded to subfloor	62	70
	• 38-mm gypsum concrete + resilient mat on subfloor	66	74

Table 3: *Apparent STC between units (one unit below another) for selected variations of the floor/ceiling assembly and the wall surfaces in the room below.*

- This multi-table format does not readily support comparison of different designs, or show the relative strength of direct and flanking transmission paths in each case (to highlight which surfaces limit performance, and hence should be priorities for treatment).
- A table can present only a few variants on possible elements such as floor toppings or coverings, or gypsum board type and attachment on flanking surfaces.

The obvious means to display more choices for each of the component materials—and to support a more detailed analytic approach—is to implement the calculation framework in software, linked to a database of sound transmission data for each path, for the matrix of construction options that have been characterized. For the SEA approach (which is applicable to heavy monolithic construction as described in this paper) commercial software packages are available.

A software system is also being developed to implement the approach outlined for lightweight framed constructions. Such software can easily present a much broader range of construction options than the tabular approach illustrated above.

A screen image of the user interface is shown in Fig. 14, to illustrate the potential of such tools to provide acoustical performance estimates in a form useful for generalists dealing with building design.

An interface like that shown in Fig. 14 can provide an interactive framework where the designer can explore changes in the building assemblies and materials to balance the sound transmission via the separating assembly versus the set of flanking paths for each of the four junctions (values at 3a), in addition to giving ratings of the overall sound insulation. Such software can readily switch to give the sound insulation estimates in the single-number ratings (ISO or ASTM) of interest to the designer.

These acoustical performance estimates provide the acoustical part of the information matrix needed by a design team for rational tradeoffs between the effect of specific changes in the building elements on the noise control, versus their impact on cost and other design objectives for building performance, such as fire resistance, structural capacity and energy use.

The balancing of many performance requirements is central to efficient design, and at the heart of the integrated design process central to modern "green building" schemes. Providing tools to support the acoustics part of satisfying the design requirements is essential to having acoustical performance effectively integrated into such schemes.

Summary

The engineering framework to deal with sound transmission between neighboring units in complete buildings—both experimental techniques to characterize subsystems and calculation methods to turn the experimental data into estimates of sound insulation—has largely been developed. Design tools to make the knowledge readily accessible to design generalists are rapidly becoming available. This is enabling a paradigm shift from the traditional simplistic focus on the separating assembly, to properly evaluating performance of the complete building system.

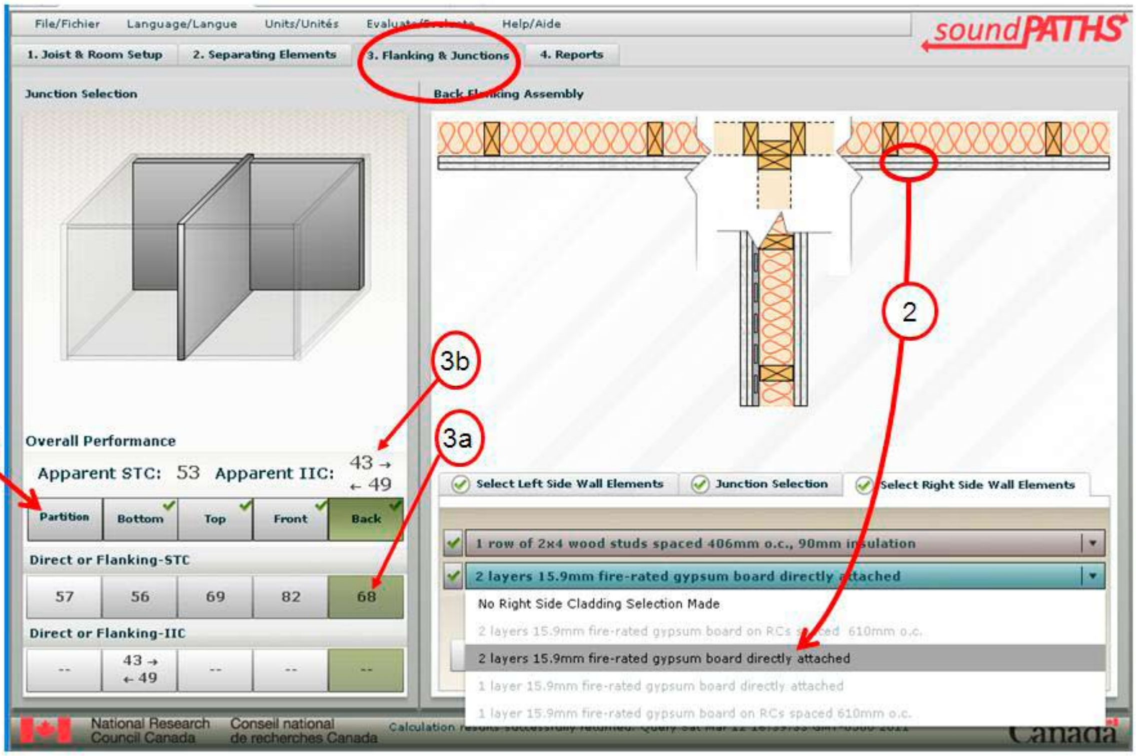


Figure 14: *Example of user interface to illustrate how software can facilitate the display of sound transmission estimates for the set of transmission paths between adjacent spaces, to guide design decisions and estimate system performance. Parts of the interface include: (1) buttons to select between the separating assembly or each of the four flanking junctions at its edges, (2) drop down menus to select details of framing and other components affecting transmission via the selected junction, (3a) calculated sound transmission ratings for each set of paths, (3b) calculated overall sound insulation estimate.*

Acknowledgements

The author gratefully acknowledges the contributions of colleagues in the Acoustics Group of the Institute for Research in Construction at NRC, especially Trevor Nightingale, Alf Warnock, and Robin Halliwell. Not only did they share in the development of key concepts reported here, but also, they contributed steadily to my education in building acoustics through decades of collaboration. I also acknowledge the repeated stretching of my perspectives provided by many colleagues in the working groups of ISO/TC43/SC2. Although I am the nominal author, this paper is truly a summary of the work of many others.

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INCE Update

INCE/USA

Leo Beranek Student Medal for Excellence in Noise Control Studies

A new student metal for excellence in the study of noise control is now being awarded by INCE/USA. The medal is named for the INCE/USA charter president, Leo L. Beranek. The award is being funded by the INCE Foundation to support education in noise control engineering. This special Medal was established by the Board of Directors of INCE/USA on 2010 October 24 to recognize excellence in the study of noise-control by undergraduate and graduate students at academic institutions in North America that have courses in, or related to, noise-control engineering including practical applications.

Candidates for the Beranek Student Medal are selected by their academic institution and nominated by a member of the faculty. An institution may submit up to two nominations per calendar year, one for a student who graduated (or will be graduating) with a baccalaureate degree and one for a student who graduated (or will be graduating) with a graduate degree. The INCE/USA Vice President for Student Activities and Education together with a Student Activities Committee established by the VP will review nominations and select awardees based on documented evidence of excellence in the study of noise-control as submitted by the nominating faculty member. Institution and Nomination Forms will be accepted for the 2011-2012 academic year after the NOISE-CON 2011 conference in Portland, Oregon. One form is the Institution Form that is to be submitted to establish the courses in, or related to, noise control that are offered by the Academic Institution wishing to nominate a candidate. The Institution Form is required only once and may be updated when necessary. The other form is the Nomination Form that is required for each candidate. For further information and nomination forms, contact the INCE/USA Business Office at ibo@inceusa.org.

Awardees will be invited, but not required, to attend a NOISE-CON Conference or an INTER-NOISE Congress in North America to receive the Award. Alternatively, Awards may be presented at an Awardees' institution (such as at the graduation ceremony, or other school function), if requested by the nominating faculty member. In the latter case, an appropriate announcement will be made at the NOISE-CON or INTER-NOISE meeting.

Upon learning of the new award, Leo Beranek said "Student contributions to the betterment of techniques for the control of noise in buildings, vehicles and outdoors, and of means for reducing noise produced by any loud source is readily sought and will now be recognized by this Student Medal. I am proud to be named for this important student award."

A list of the first undergraduate and graduate awards will be published in the September issue of this magazine.

INCE/USA Elects New Officers and Directors

The Annual Meeting of the INCE/USA Board of Directors and the Annual Meeting of the Institute were held over the weekend of February 26-27, 2011 in Tempe, Arizona.

James K. Thompson, National Institute for Occupational Safety and Health is serving his second year as president. Patricia Davies, Director of the R.W. Herrick Laboratories at Purdue University, is the immediate past president. Eric Wood of Acentech, Inc. was elected president-elect of the Institute, and will become president in 2012. Richard Kolano of Kolano and Saha Engineers, Inc. was elected to a new position, vice president of board affairs. Stuart Bolton of Purdue University was elected as vice president-communications.

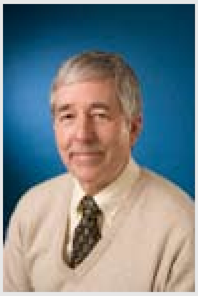
The election of three directors by the voting members was certified at the Annual Meeting of the Institute. They are Marko Beltman of Intel, Inc., Dean Capone of The Pennsylvania State University, and Mandy Kachur of Soundscape Engineering LLC. In addition three directors, Eric Wood of Acentech, Inc., Todd Rook of Goodrich Aircraft Wheels and Brakes, Teik Lim of the University of Cincinnati, were elected by vote at the Annual Meeting of the Institute.

Patricia Davies and Paul Donavan are continuing as directors. Deane B. Jaeger, Charles T. Moritz, Thomas E Reinhard, J. Stuart Bolton, Paul Burgé, and Mardi Hastings also continue as directors.

Teik Lim of the University of Cincinnati continues as vice president-technical activities, Christopher W. Menge, Harris Miller Miller and Hanson, Inc. continues as vice-president-public relations, and Kenneth Kaliski, Resource Systems Group, continues as vice president-board certification, and Todd Rook of Goodrich Aircraft continues as vice president-membership. Paul Burgé continues as vice president-honors and awards, Ralph Muelheisen, of Argonne National Laboratory continues as vice president-student affairs and education. Stephen Hambric of The Pennsylvania State University continues as vice president-conferences.

Courtney Burroughs continues as editor of *NCEJ*, Joseph M. Cuschieri continues as executive director, and George C. Maling continues as managing editor of *NNI*. Richard J. Peppin of Scantek, Inc., continues as *NNI* advertising manager and INCE/USA exposition manager. Ralph Muehleisen of Argonne National Laboratory continues as chair for student activities.

About the author of the feature article in this issue (see page 37).



Dr. J.D. (David) Quirt retired in 2009 from the Institute for Research in Construction at the National Research Council of Canada, where he was a Principal Research Officer, and led building acoustics group from 1987 to 2008. He is continuing his work with the NRC-IRC staff as a Guest Researcher, to develop the web-based application for predicting sound transmission in buildings, as described in this article. His projects have typically combined noise control with other factors such as fire and thermal performance, to address industry needs for complete building systems. *This article is based on a distinguished lecture presented by the author at the INTER-NOISE 2009 Congress held in Ottawa, Canada in August, 2009.—Ed.*

Asia-Pacific News

Marion Burgess, Asia-Pacific Editor

Australia

Hear Us: Inquiry into Hearing Health in Australia

In May 2011 the Australian Government released a report from a Senate Enquiry into Hearing Health in Australia.

This enquiry included call for public submissions plus a series of public hearings around the country. The full report is available from www.aph.gov.au/Senate/committee/clac_ctte/hearing_health/index.htm. While a substantial part of the report deals with services for the hearing impaired it contains some recommendations regarding noise control. For example recommendation 1 states that the governments "work with the appropriate agencies and authorities to devise recreational noise safety regulations for entertainment venues," recommendation 15 for "longitudinal research into the long-term impacts of recreational noise, particularly exposure to personal music players" and recommendation 16 that "Australian Governments continue to prioritise and fund research into occupational noise exposure."

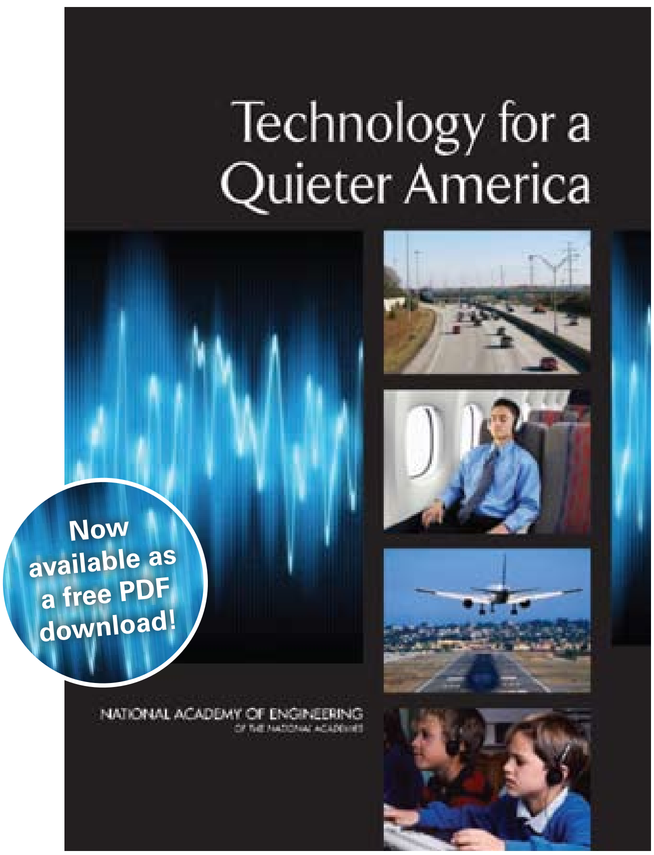
Social and Economic Impact of Rural Wind Farms

In mid-June, the report from the Australian Senate inquiry into the Social and Economic Impact of Rural Wind Farms is due to be released. The terms of reference for this inquiry include effects of noise and vibration and adverse effects on health. Much of the concern over health affects relate to high levels of low frequency or infrasound. There has been intense interest in this topic with over 900 submissions received and four public hearings. This has meant the panel has needed an extension to allow time to consider all submissions. In the meantime the submissions can be viewed from the website: www.aph.gov.au/senate/committee/clac_ctte/impact_rural_wind_farms/index.htm

New Zealand

Name Change for the New Zealand Acoustical Society

John Styles, secretary, has announced that effective Friday 1 July 2011, the New Zealand Acoustical Society (NZAS) changed its name to the Acoustical Society of New Zealand (ASNZ). Also effective from 1 July 2011 is the new membership regime. Existing members are welcome to apply for Member grade; please see the ASNZ website for more details, FAQs, transitional procedures and application forms.



In 2006, NAE initiated *Technology for a Quieter America*, a multi-year study to review state-of-the-art noise-control engineering, describe the technological, economic and political climate for noise control, and identify gaps in research. During the past three years, a 14-member umbrella committee, chaired by NAE member George Maling (managing director emeritus of the Institute for Noise Control Engineering of the USA), five subcommittees, and focused working groups have explored three categories of issues related to noise-control engineering and public concerns: applications of current technologies; research and development initiatives; and intra-governmental and public relations programs. The report is now available from the National Academies Press.

Technology for a Quieter America assesses major sources of noise (transportation, machinery and equipment, consumer products, etc.), how they are characterized, efforts to reduce noise emissions, and efforts to reduce noise in work places, schools, recreational environments, and residences. The report reviews regulations that govern noise levels and the roles of federal, state, and local agencies in noise regulation. It also examines cost-benefit trade-offs between different approaches to noise abatement, the availability of public information on noise mitigation, and noise-control education in U.S. schools of engineering.

Findings of the report focused on several critical areas: Hazardous noise-Occupational noise exposure limits should be reduced and engineering controls should be the primary focus of controlling workplace noise. "Buy-quiet" programs that promote the procurement of low-noise equipment and allow market forces to operate can play an important role.

Cost Benefit analysis: The Federal Aviation Administration has been proactive in cost-benefit analysis of noise reduction at airports; these studies, along with similar research from Europe, could lead to highway noise reduction. The report examines the relative merits of "low noise" highways and the use of noise barriers.

Metrics: Advances in the ability to collect, store, and analyze noise data challenge us to reexamine metrics that were developed in the 1970s. Purchase information: http://www.nap.edu/catalog.php?record_id=12928

Bernard Berry, European Editor

Europe

(The following two articles are lightly-edited press releases from the publication Transport and Environment (T&E). T&E is Brussels-based independent pan-European association with scientific and educational aims, with no party political affiliation and devoid of any profit making motive. See www.transportenvironment.org.—Ed.)

Traffic Noise Health Impacts Second Only to Air Pollution, New WHO Report Says

In the EU and Norway, traffic noise is the second biggest environmental problem affecting health after air pollution, says a report published on April 12 by the World Health Organization (WHO) [1]. This new health evidence highlights the urgency of adopting more stringent EU vehicle noise standards, according to health, environment and sustainable transport campaigners. The European Commission is expected to release a proposal to update the Vehicle Noise Directive 70/157/EEC in June [2].

"The Commission has an opportunity in the coming weeks to cut road traffic noise by half, and protect millions of Europeans from this health risk", said Nina Renshaw, Deputy Director at Transport & Environment (T&E). "The proposal for an update of the Vehicle Noise directive should set strict new noise standards for cars, vans, lorries and buses. Policy-makers must act on this WHO report and cut road noise to benefit us all by protecting health, improving quality of life, and easing the strain on government healthcare budgets."

The WHO report says that each year Europeans lose at least one million healthy life-years due to disability or disease caused by traffic noise. And that estimate is said to be conservative. The new calculation includes data that measure exposure to traffic noise and its impact on health related to cardiovascular disease, cognitive impairment in children, sleep disturbance, tinnitus, and annoyance.

According to the study, 1.8% of heart attacks in high income European countries are attributed to traffic noise levels higher than 60dB. Cardiovascular disease is the largest cause of death in the EU and accounts for approximately 40% of healthcare budgets [3]. A 2008 report by consultants CE for T&E [4] found that noise from rail and road transport is linked to 50,000 fatal heart attacks every year in Europe and 200,000 cases of cardio-vascular disease.

"The new figures are worrying but the true impact of noise pollution on health is likely to be much higher," says Anne Stauffer, Deputy Director at Health and Environment Alliance (HEAL). "Noise pollution is a critical public health problem. We hope that now the EU has the evidence, policy makers will make changes in transport and other legislation that will better protect citizens' health." Ms. Stauffer added.

HEAL is particularly concerned about the effect of traffic noise on children's learning abilities. In a recent children's health summit in Parma, Italy, environment and health ministers committed to reducing the exposure of children to noise [5].

The European Environmental Bureau hopes the WHO study will also help strengthen the existing EU directive on environmental noise, which includes noise mapping. This legislation is currently under review by the European Commission. "The review is long overdue", says Louise Duprez, Policy Officer at EEB, "and with this report reinforcing already-known health implications of noise there is no excuse not to come up with a more ambitious Environmental Noise Directive [6]."

European citizens are well aware of the health impacts of traffic noise. According to a recent Eurobarometer [7], almost half of all Europeans believe that noise affects their health "to a large extent" and another one-third said that it affected their health "to some extent".

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EU Announces Plan to Make Cars and Lorries Quieter

The European Commission has announced plans to tighten noise limits for cars, lorries and buses with a proposal expected within weeks and by September at the latest. Environmental and health organisations have welcomed the Commission's announcement but called for standards that go much further towards World Health Organisation (WHO) recommendations for avoiding dangerous impacts on health from traffic noise pollution.

Philippe Jean, acting director of the European Commission's Enterprise Department, told a conference organized by Transport & Environment (T&E), the European Environmental Bureau (EEB) and the Health and Environment Alliance (Heal)[1] that the Commission plans to cut noise emissions from cars by 4 decibels and from lorries by 3 decibels. The new limits would come into force within four years of a new Vehicle Noise Directive being agreed, he said.

The Commission's announcement follows publication of an EU-funded study by consultant TNO which says implementing vehicle noise limits that halve traffic noise would bring about benefits to society outweighing the costs of introducing quieter vehicles by a factor of twenty to one.[2]

According to Jean, the new noise limits would be introduced in two stages: car limits, which are currently set at 74 decibels, would be reduced to 72 decibels within two years and to 70 within four years. Lorry limits would have to be lowered by 1 decibel within two years and by a further 2 within four years, he said. The Commission is also expected to announce a new test method, to better reflect the real world noise emissions of vehicles.

Environmental and health groups have urged the European Commission to set more stringent noise reduction standards at least 6 decibels lower than today. The decibel scale is logarithmic; a reduction in car noise emissions of 6 decibels would reduce the noise level of an individual vehicle by three-quarters but it would take many years of fleet renewal for overall traffic noise to be reduced. Many cars sold today already meet the standard recommended by environmental and health groups, including conventional internal combustion engine vehicles, not just hybrids and electric cars.

Nina Renshaw, deputy director of Transport & Environment said: "The Commission has finally admitted that current vehicle noise legislation has blatantly failed to tackle the problem; tightening these limits was long overdue. If car manufacturers can already meet the standards with existing technology, there is no excuse for further delay. Furthermore, The Commission must improve the testing process to ensure noise tests for heavy vehicles on the test bench reflect what happens in the real world. Cutting noise emissions on paper only is not an option."

Anne Stauffer, director of Heal, said: "Traffic noise in cities is an important public health issue. As well as the evidence of increased heart attacks as a result of exposure to environmental noise, evidence shows noise pushes up rates of stroke, especially in older people, and affects children's ability to learn. New data on the harm to health from noise are emerging all the time. We would like to see much greater awareness raising with medical professionals and decision makers and ambitious legislative proposals to reduce exposure."

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USA

Ungar Receives ASA Gold Medal

Dr. Eric E. Ungar received the Gold Medal from the Acoustical Society of America on 2011 May 25 for his contributions over half a century in the fields of vibrations and noise control, and for service to the Society and the acoustics community. He is a past president of INCE/USA.

Eric served as Chief Consulting Engineer while employed at Bolt Beranek and Newman (BBN) and during 37 years performed research and consulting for a wide range of clients and projects. He is now continuing his technical activities and contribution at the consulting firm Acentech in Cambridge, Massachusetts. His facile use of mathematics along with his clear insights into the relevant physical principles have allowed him to make widely-recognized practical contributions in the areas of structural damping (particularly regarding the use of viscoelastic materials), high-frequency vibration isolation, vibrations of complex structures, and structure-borne sound. Many extremely vibration-sensitive facilities and those requiring resistance to intense sound and vibration have benefited from his decades of consulting efforts.

He continues demonstrating his skills as a superb teacher of students and professionals as well as a prolific author. He has lectured at and chaired numerous short courses on vibration control and has authored or co-authored hundreds of technical reports, chapters, and published papers – some recognized as the "bible" in his field. Eric is a willing and enthusiastic mentor for many of us with the good fortune to work with him. His advice and support are provided with both a smile and unparalleled wisdom.

Eric is a Fellow of INCE/USA and ASA, a Life Fellow of ASME, and an Associated Fellow of the American Institute of Aeronautics and Astronautics. Eric served as president of INCE/USA in 1984 and as president of ASA during 1991 – 1992. He has received previous major awards from INCE/USA, the Shock and Vibration Information Center, ASME, and ASA.

Eric's wife Goldie has contributed greatly to his most successful career with important support, encouragement, and understanding. They have raised three daughters and have ten loving grandchildren. They celebrate their 60th wedding anniversary this year.

— *Eric W. Wood*

Bradley Receives NSF Grant

A multifaceted 5-year project developed by Assistant Professor of Physics David T. Bradley has been funded for 410,000 USD by the National Science Foundation's prestigious Faculty Early Career Development Program (CAREER), which "supports junior faculty who exemplify the role of teacher-scholars." Bradley's research focus is architectural acoustics, and the National Science Foundation (NSF) funds will enable him to both further his investigations and deeply integrate them into the Vassar College curriculum, providing hands-on laboratory experiences and research mentoring for undergraduate students. The grant also supports the expansion of Bradley's efforts to introduce acoustics topics to secondary school students and cultivate their interest in the sciences, with particular attention to students of color and others underrepresented in the sciences.

Highlights of what Bradley's NSF award will make possible include:

- The creation of 10 undergraduate summer research positions at Vassar.
- The addition of 150,000 USD in acoustics research equipment for the Vassar physics department.
- A collaboration with the IBM Acoustics Laboratory in Poughkeepsie.

- The extension of a physics workshop series for ethnic minority high school students from the Bronx, NY.

In advance of Bradley joining the physics and astronomy department in 2007, Vassar built a new acoustics laboratory to support his teaching and research, with state-of-the-art computational and experimental equipment and facilities. Bradley's current research objective is to characterize the behavior of reflected sound energy from surfaces used in acoustically sensitive spaces, such as concert halls and classrooms.

Bradley earned a B.A. in Physics from Grinnell College, and he completed his Ph.D. from the Architectural Engineering program at the University of Nebraska-Lincoln with the aid of several fellowships, including the Ford Foundation Diversity Fellowship. In addition to his special interest in performance space acoustics and the behavior of sound energy in enclosed spaces, Bradley's areas of expertise also include room acoustics, sound isolation, mechanical noise control, and environmental noise control. He worked for BRC Acoustics and Technology Consulting in Seattle, WA immediately before joining the Vassar faculty, and his earlier industry experience included consultant positions and internships with acoustical firms in Los Angeles, Dallas, Omaha, and Chicago.

Hanson Retires from HMMH

Dr. Carl Hanson, P.E., retired from HMMH June 30, 2011. Dr. Hanson was Senior Vice President and a co-founder of the firm.

He has specialized in noise and vibration control engineering projects for rail transportation since 1972. He was lead author of FTA's Transit Noise and Vibration Impact Assessment and FRA's High Speed Ground Transportation Noise and Vibration Impact Assessment, the guidance manuals for methods used in rail projects in the U.S. He has been principal instructor for HMMH's Transit Noise and Vibration Course and has been involved in a wide range of transit and railroad projects across the U.S. and abroad.

As a result of his many years of experience, he was called upon by the National Academy of Engineering to serve as a member of the Committee on Technology for a Quieter America to study and recommend engineering controls for noise reduction in the U.S. He has been a licensed professional engineer in four states, a Fellow of the Institute of Noise Control Engineering, and has served as an active participant on committees of Transportation Research Board (TRB), the American Railway and Maintenance-of-Way Association (AREMA), and the international committee organizing the International Workshop on Railway Noise (IWRN). He can be reached at chansonjag@aol.com.

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info@elnadycompany.com

Finland: APL Systems Ltd.
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Ville.ilves@apl.fi

France: ViaXys
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Germany: ROGA Instruments
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roga@roga-messtechnik.de

India: Welan Technologies
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info@welantechnologies.com

Ireland: Sonitus Systems
+353 01 2542560/+44 020 81236009
enquiries@sonitussystens.com

Israel: Emproco Ltd.
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sales@emproco.com

Italy: Spectra Sri
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shamatec@signet.com.sg

South Africa: Vibranalysis Instruments S.A./
+27 118867993 qqq +27 115075823
laurence@vibranalysis.co.za

South America: SMART Tech
+55 11 3168 3388
marcelo@smarttech.com.br

Spain: Anotec Consulting S.L.
+34 916 897 540
nico@anotec.com

Spain: PROTOS Euroconsultores de Ingeneria S.L.
+34 91 747 5891
Kimono.alexiou@protos-eci.es

Spain: Uros Ingenieria
+34 91 3329621
Jalon_id@uros.es

Sweden: Acoutronic AB
+46 87 650 280
toby@acoutronic..se

Sweden: Arotate-Consulting AB
+46 708 955150
janos@arotate.com

Sweden: Sound View Instruments
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Anders.norborg@soundviewinstr.com

Taiwan: OE SCIENTECH CO., LTD.
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terry@oe.com.tw

Taiwan: Tops Technologies, Inc.
+886 932 068 059
kenlee@topstech.com.tw

Thailand: Geonoise Instruments Thailand Co. Ltd.
+66 042 342091
info@geonoise-instruments.com

The Netherlands: ABC International Trading B.V.
+31 162520447
nl@abctradings.com

Turkey: DTA Ltd Sti.
+90 224 280 84 44
Akif.goksa@dta.com.tr

Turkey: VibraTek
+90 0312 479 0302
Ibrahim.Caglayan@vibratek.com.tr

United Kingdom: Sonitus Systems
+353 01 2542560/+44 020 81236009
enquiries@sonitussystens.com

USA: Scantek, Inc.
+1 410 290 7726
PeppinR@scantekinc.com

NGC Testing

USA: NGC Testing
+1 716 873 9750 • +1 716 873 9753
email@ngctestingservices.com

NTI

Australia: Amber Technology Pty Ltd
+61 2 9452 8600
lhart@ambertech.com.au

Austria: Wien-Schall GmbH
+43 1 811 55 100
proaudio@wienschall.com

Bahrain: ATEIS Middle East FZCO.
+971 4 6091325
info@ateis.ae

Belgium: Belram sa/nv
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info@belram.com

Brazil: NTI Americas Inc.
+1 503 684 7050
ntisales@ntiam.com

Bulgaria: ATC Ltd.
+35 988 9528 649
hlebarovg@dir.bg

Canada: NTI Americas Inc.
+1 503 684 7050
ntisales@ntiam.com

Chile: NTI Americas Inc.
+1 503 684 7050
ntisales@ntiam.com

China: NTI CHINA CO.,LTD.
+86 10 5791 0038
china@nti-audio.com

Czech Republic: NTi Audio Praha
+420 2209 99992
info@ntipraha.cz

Denmark: Kinovox Pro ApS
+45 44 53 3011
ck@kinovox.dk

Estonia: EW Sound & Light Vaarmann OÜ
+372 6612 768
ewsound@ewsound.ee

Finland: Noretron Components Ltd.
+358 (10) 525 8000
ari.nissinen@noretron.fi

France: SCV AUDIO
+33 1 486 322 11
f.voiffray@scv.fr

Germany: Hermann Adam GmbH & Co. KG
+49 8131 2808 0
info@adam-gmbh.de

Germany: Schalltechnik Süd & Nord GmbH
+49 201 5456 980
besselmann@akustiktest.de

Germany: Schalltechnik SÜD & NORD GmbH
+49 941 94 555 85
kotterer@akustiktest.de

Greece: Bon Studio S.A.
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bon@bonstudio.gr

Hungary: Elimex Kft
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India: AVF Distributors (I) Pvt. Ltd.
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India: AVF Distributors (New Dehli)
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Indonesia: Santika Multi Jaya
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andre@cbn.net.id

Iraq: ATEIS Middle East FZCO.
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info@ateis.ae

Israel: Sontronics Electr. Equipm. Ltd
+972 3 570 5223
sales@sontronics.co.il

Italy: Spectra SRL
+39 039613321
info@spectra.it

Japan: NTI Japan Limited
+81 3 3634 6110
okayasu@nti-japan.com

South Korea: SOVICO Corporation
+82 2 2106 2877
ijchoe@sovico.co.kr

Latvia: Audio AE Ltd.
+371 67807310
audioae@audioae.lv

Lithuania: Midiaudio Ltd.
+370-37-223288
sales@midiaudio.com

Malaysia: TekMark Broadcast Sdn Bhd
+603 9057 8999
gs.wong@tekmarkgroup.com

Mexico: NTI Americas Inc.
+1 503 684 7050
ntisales@ntiam.com

Netherlands: TM Audio Holland B.V.
+31 30 2414070
reinier.bruijns@tmaudio.nl

New Zealand: Amber Technology (NZ) Ltd.
+64 9 443 0753
ross@amber.co.nz

Norway: Benum siv. ing. AS
+47 2213 9900
post@benum.com

Poland: Konsbud Audio Sp. Z O.O.
+48 226 44 3038
info@konsbud-audio.com.pl

Portugal: Arestel S.A.
+351 213 030 850
audiovideo@arestel.pt

Romania: db Technolight
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info@ntipraha.cz

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Spain: Neotécnica, S.A.
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neotecnica@neotecnica.es

Sweden: Sennberg AB
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contrik@contrik.ch

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china@nti-audio.com

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victorco@truemail.co.th

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samimm@sf.com.tr

Ukraine: Real Music Ltd.
+380-482 347382
realmusic@realmusic.ua

United Kingdom: Neutrik (UK) Ltd.
+44-1983-811 441
sales@neutrik.co.uk

USA: NTI Americas Inc.
+1 503 684 7050
ntisales@ntiam.com

Scantek, Inc.

Mexico and South America: CIAAMSA División Acústica
(55) 1054 3209 • (55) 1054 3210
nbenitez@ciaamsa-acustica.com

SoundPLAN LLC

Argentina: Dakar ingenieria acustica Argentina
+54 (11) 4865 79 84; +54 (11) 4 865 79 84;
soundplan@dakar-acustica.com.ar

Australia: Marshall Day Acoustics
+612 9282 9422; +612 9281 3611;
MCottle@marshallday.com.au

Brazil: GROM Acustica & Automacao
+55 212516 0077; +55 21 2516 0308;
comercial@grom.com.br

Canada: Navcon Engineering Network
+1 714 441 3488; +1 714 441 3487;
Forschner@navcon.com

China: BSWA Technology Co., Ltd.
+86 10 62526360; +86 10 82251626;
conghaidong@bswa.com.cn

Chile: Sinruido
+562 2398736
Ing.mora@gmail.com

Czech Republic: SYMOS s.r.o.
+42 220 999 977; +42 257 225 679;
symos@symos.cz

Denmark: SoundPLAN Nord
+45 (39) 46 12 00; +45 (39) 46 12 02;
jkl@soundplan.dk
Egypt: Elnady Engineering and Agencies
+20 2 23420896; +20 2 23421791;
info@elnadycompany.com

Finland: Oy Teknocalor Ab
+358 9 825 46024; +358 9 826 151;
johanna.hokkanen@teknocalor.fi

France: Euphonia
+33 02 40 18 05 18; +33 02 40 19 05 20;
bsuner@euphonia.fr
Germany: Braunstein + Berndt GmbH
+49 7191 91 44 0; +49 7191 91 44 24;
bbgmbh@soundplan.de

Greece: I Acoustics Hellas
+30210 6630 333; +30210 6630 334;
dpramas@acoustics.gr

Hungary: VIBROCOMP GmbH
+36 1 3107292; +36 1 3196303;
bitep@vibrocomp.hu

India: Foretek Marketing Pvt. Ltd.
+91 80 2525 4706; +91 80 2525 6813;
info@foretek.in

Italy: Spectra s.r.l.
+39 039 613321; +39 039 6133235;
spectra@spectra.it

Israel: RTA Engineering Ltd.
+972 (0) 77 5503994; +972 (0) 77 6499964;
Ronen@rtaeng.com

Indoneisa: SHAMA Technologies (S) Pte Ltd.
+65 6776 4006; +65 6776 0592;
shamatec@singnet.com.sg

Japan: Ono Sokki Co., Ltd.
+81 45 935 3833; +81 45 935 3805;
Watanan@onosokki.co.jp

Kenya: Mackenzie Hoy Consulting Engineers
+27 214245719;
machoy@iafrica.com

Korea (South): ABC TRADING
+82 2 2226 3161, +82 2 2226 7383;
yklee@abctrd.com

Kuwait: Elnady Engineering and Agencies
+20 2 23420896; +20 2 23421791;
info@elnadycompany.com

Malaysia: SHAMA Technologies (S) Pte Ltd.
+65 6776 4006; +65 6776 0592;
shamatec@singnet.com.sg

Mexico: Ingenieria Acustica Spectrum Sa Cv
+52 55 55 67 08 78; +52 55 53 68 61 80;
acusticaspectrum@prodigy.net.mx

New Zealand: Marshall Day Associates
+64 3 365 8455; +64 3 365 8477;
siiri.wilkening@marshallday.co.nz

Norway: SoundPLAN Nord
+45 (39) 46 12 00; +45 (39) 46 12 02;
jkl@soundplan.dk

Peru: Global Group S.A.
+51 1 4464627;
globalgroupsa@gamil.com

Poland: PC++ Software Studio S.C.
+48 606 110 270;
support@pcplusplus.com.pl

Portugal: AAC Centro de Acustica Aplicada SL
+34 45 29 82 33; +34 45 29 82 61;
aac@aacacustica.com

Romania: Vibrocomp Kft
+40 723 614 524; +36 1 3196303;
bitep@vibrocomp.hu

Russia: Baltic State Technical University
+7 812 5338907; +7 812 5338907;
marina_butorina@inbox.ru

Serbia: Dirigent Acoustics D.O.O.
+381 11 763 887; +381 11 763 887;
dgtdejan@yahoo.com

Singapore: SHAMA Technologies (S) Pte Ltd.
+65 6776 4006; +65 6776 0592;
shamatec@singnet.com.sg

South Africa: Mackenzie Hoy Consulting Engineers
+27 214245719;
machoy@iafrica.com

Spain: AAC Centro de Acustica Aplicada SL
+34 45 29 82 33; +34 45 29 82 61;
aac@aacacustica.com

Sweden: SoundPLAN Nord
+45 (39) 46 12 00; +45 (39) 46 12 02;
jkl@soundplan.dk

Thailand: Geonoise Instruments Thailand
+662776857833; +6628603600;
sales@geonoise-instruments.com

Taiwan: Purtek Engerprise Co Ltd.
+886 2 2769 3863; +886 2 2756 7582;
purtek@ms13.hinet.net

Turkey: Hidrotek Mimarlik Muhendislik Ltd.Sti,
+90 216 384 7251; +90 216 384 72 51;
aakdag@hidro-tek.com

United Arab Emirates: Elnady Engineering and Agencies
+20 2 23420896; +20 2 23421791;
info@elnadycompany.com

United Kingdom: SoundPLAN UK&I
+44 1787 478498;
david@soundplanuk.co.uk

USA: Navcon Engineering Network
+1 714 441 3488; +1 714 441 3487;
Forschner@navcon.com

Vietnam: Viet Phuong
+84 8 22148911;
nqluan@vietenvico.com

Trane

USA: Trane
www.trane.com/Corporate/Contact/index.asp

New Spectral Limits Option for XL2 Analyzer

NTi Audio introduces the Spectral Limits Option for the XL2. It is a firmware module that extends the function range for the XL2 by trace capturing, relative curve display and comprehensive tolerance handling for the FFT Analysis and the new high resolution RTA function with spectral resolutions up to 1/12th octave.

The new Spectral Limits Option adds an additional RTA Analyzer with selectable spectral resolutions of 1/1, 1/3rd, 1/6th and 1/12th octave. It also allows capturing of multiple traces in the internal memory. Measurements can be either displayed as absolute traces or shown relative to previously stored traces. This powerful functionality simplifies comparison of frequency responses and adjustments to an ideal response curve.

Spectral measurement can be compared against a tolerance curve and exceptions are visualized in every frequency band. Out-of-tolerance conditions are further visualized by the bicolor "limit" button and forwarded to the I/O interface of the instrument in order to drive an external alarm device such the accessory SPL Stack Light.

Tolerance curves can either be imported from txt-files or directly derived from captured measurements. The XL2 calculates tolerances based on single reference data, the mean average or Min/Max of multiple captures.

For higher frequency resolutions beyond 1/12th octave the Spectral Limits Option activates the tolerance handling and capturing in the real time FFT function. With the zoom functionality of FFT, any frequency band with spectral resolutions of up to 0.4 Hz can be defined and monitored with tolerances.

The Spectral Limits Option is available for all XL2 Audio and Acoustic Analyzers now. Read more at www.nti-audio.com/XL2.

LMS-InterAC Partnership Completes the LMS Acoustic Simulation Solutions to Cover the Full Frequency Range.

LMS International and InterAC have signed a strategic partnership to distribute InterAC's SEA+, SEAVirt and related SEA modules to complement the market-leading LMS Virtual.Lab Acoustics package. In the world of vibro-acoustic simulation, SEA is a technology that provides a reliable solution for high frequency problems as well as full system vibro-acoustic evaluation.

LMS Virtual.Lab Acoustics users will significantly benefit from several unique technologies, like Virtual SEA, implemented in SEAVirt, which automatically and uniquely converts a structural FE (finite element) model from LMS Virtual.Lab into a SEA model. This model can then be further processed in SEA+, making mid-frequency vibro-acoustic analysis a reality.

SEA+ provides low calculation times, high modeling efficiency coupled with high fidelity and is said to be perfectly suited to address vibro-acoustic problems throughout the product development process, especially on large-scale or on high-frequency projects such as vehicle interior noise, sound package design, aircraft cabin noise, satellite vibro-acoustics and many more.

As acoustics takes more of a defining role in product development, vibro-acoustic engineers need better tools to assess concepts and early stage designs. Unlike other methods, SEA does not require geometrical details, but merely global system properties. This is why SEA is ideal early in the concept phase when design details, such as CAD or a FEM mesh, are not available.

InterAC's SEA+ is a top class product integrating the highest fidelity SEA technology. The many years of industrial experience of Dr Borello, founder and CEO of InterAC, in the field of SEA made the SEA+ product to what it is said to be: the most easy-to-use, highly refined and powerful SEA product on the market.

pinta acoustic SQUARELINE® Metal Ceiling Tiles grace the new National Museum of American Jewish History in Philadelphia

Contributing to the sophisticated, urban look of the new facilities of the National Museum of American Jewish History in Philadelphia are custom SQUARELINE® Metal Ceiling Tiles from pinta acoustic. The tiles were installed in a five-story open atrium and exhibit space and atop elevator vestibule areas.

SQUARELINE Metal Ceiling Tiles are constructed of expanded metal — galvanized powder-coated steel — from 35 percent to 55 percent recycled material. The 199 custom SQUARELINE Medium black metal ceiling tiles installed in the National Museum of American Jewish History were stretched to obtain an open rate of 70 percent. This open rate allowed for sprinkler heads to be installed above the ceiling tiles. Each tile appears to be floating but is held in place by concealed rows of Z-channel.

Some metal ceiling solutions make it difficult to access the systems above the ceiling. To meet this project requirement, pinta provided custom SQUARELINE Metal Ceiling Tiles.

SQUARELINE Metal Ceiling Tiles are available in sleek chrome, white and black metal with tile sizes of 24 inches by 24 inches, 24 inches by 48 inches and 48 inches by 48 inches. They are offered in three mesh patterns: Ultra, Medium and Standard. Tiles include an optional white, light grey or black acoustical backer. Matching trim tiles also are available. Tiles fit easily in 15/16" ceiling grid systems. Tiles are Class 1 fire-rated for smoke density and flame spread.

For information about pinta acoustic products, visit www.pinta-acoustic.com/museum or call 1-800-662-0032 or +1 612-355-4250.

PCB Piezotronics Releases New High Temperature Microphone and Preamplifier

PCB Piezotronics, Inc. announces the release of a new high-temperature microphone and preamplifier. Model HT378B02 is designed to overcome high temperature testing challenges associated with acoustic measurements in environmental chambers or other high temperature applications.

Previously, test engineers had access to microphones with 120°C capability but were limited by the preamplifier, which houses the electronics and powers the sensor, but operates only to 70°C. PCB's technology allows operating temperatures up to 120°C for both the microphone and preamplifier. This allows the microphone to be used to its maximum frequency specifications.

The HT378B02 is a condenser microphone and preamplifier combination that is used by test engineers to measure sound pressure amplitude (in pascals or decibels) and perform frequency analysis, in order to reduce noise, identify resonance frequencies, make products more pleasing to the ear, or preserve the human hearing. Typical applications include: under-hood automotive engine testing, aerospace engine tests, pump analysis, HVAC and general purpose acoustic testing in elevated operating temperatures.

The HT378B02 is offered with PCB's "Lifetime Warranty Plus" policy. For more information contact Mark Valentino at (716) 684-0002 or via email at mvalentino@pcb.com

Meggitt Sensing Systems Introduces Endevco® ISOTRON® Piezoelectric Accelerometer

Meggitt Sensing Systems, a Meggitt group division, has introduced the Endevco® model 25A, the world's smallest ISOTRON® (IEPE-type) piezoelectric accelerometer, designed to support high-reliability vibration measurement requirements on very small structures and objects. With a total weight of just 0.2 gram, its lightweight design effectively reduces unwanted mass loading effects.

Featuring a durable shear mode construction, the Endevco® model 25A incorporates integral electronics which convert high-impedance input into a low-impedance voltage output through the same cable that supplies the required 4 mA constant current power. Signal ground is isolated from the unit's mounting surface by a hard anodized surface. The unit comes with two pre-installed, easily field-reparable fine gage (34 AWG) wire output leads, allowing for immediate field use. If required, a new assembly lead may also be reinstalled at the factory. A heavier gage (28 AWG) cable is also provided for extension purposes. In addition, an optional triaxial mounting block (model 2950M16) is available to facilitate three-axis vibration measurement requirements. Units are adhesive mounted with a special field removal tool (model 31275) supplied for convenience.

With its small size and exceptional performance attributes, the Endevco® model 25A is well-suited for measuring overall vibration levels of scaled models and smaller electronic components within aerospace, automotive, electronic products, and in-laboratory testing applications, as well as biomedical research. Recommended optional accessories, sold separately, include the model 133 three-channel piezoelectric signal conditioner; the model 4416B low-noise, compact signal conditioner; the model 2775B PE, Isotron® and RCC signal conditioner; the model 6634C vibration amplifier; the model 4999 multi-channel signal conditioner; or the Oasis 2000 (4990A-X with cards 428 and/or 433) computer controlled system. All Endevco® accelerometers are accompanied by a comprehensive five-year product warranty, with designated quantities of the model 25A available for immediate customer shipment, as part of Meggitt's Endevco® Guaranteed InStock™ program.

For more information, visit www.meggittsensingsystems.com.

Meggitt Sensing Systems Introduces Endevco® General Purpose Accelerometers

Meggitt Sensing Systems, a Meggitt group division, has announced the global market introduction of the Endevco® model 7251A series, a family of small, lightweight, hermetically sealed piezoelectric accelerometers with integral electronics. The centrally located thru-bolt mounting hole of this series provides both 360° cable and connector orientation, allowing the sensor to offer a flat mounting surface, even when not fully perpendicular, for ease of use in a variety of applications.

Available in standard model sensitivity ranges from 500 mV/g to 10 mV/g with optional high-temperature (to +150°C) and TEDS versions, design of the Endevco® model 7251A series incorporates an annular shear piezoelectric sensing element, along with an internal hybrid signal conditioner, within a two-wire system. The system transmits its low-impedance voltage output through the same cable that supplies constant current power, with high-output sensitivity and wide bandwidth, while exhibiting low base strain sensitivity and excellent output stability over time.

For detailed technical specifications, drawings or additional information, visit www.meggittsensingsystems.com.

Acknowledgements

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Conference Calendar

Below is a list of congresses and conferences sponsored by International INCE and INCE/USA. A list of all known conferences related to noise can be found by going to the International INCE page on the Internet, www.i-ince.org.

2011 July 25-27
NOISE-CON 11
Portland, Oregon
Contact:
Institute of Noise Control Engineering-USA
Amy Herron, Conference Coordinator
INCE/USA Business Office
9100 Purdue Road. Suite 200
Indianapolis, IN 46268-3165
Telephone: +1 317 735 4063
E-mail: ibo@inceusa.org
http://www.inceusa.org/nc11

2011 September 4-7
INTER-NOISE 11
Osaka, Japan
Contact: INCE/Japan
c/o Kobayasi Institute of Physical Research
3-20-41 Higashimotomachi, Kokubunji
Tokyo 185-0022
Facsimile: +81 42 327 3847
e-mail: office@ince-j.or.jp
home page: http://www.internoise2011.com

2012 August 19–22
INTER-NOISE 12
New York City, USA
Contact:
Institute of Noise Control Engineering-USA
Amy Herron, Conference Coordinator
INCE/USA Business Office
9100 Purdue Road. Suite 200
Indianapolis, IN 46268-3165
Telephone: +1 317 735 4063
E-mail: ibo@inceusa.org

Directory of Noise Control Services

Information on listings in the Directory of Noise Control Services is available from the INCE/USA Business Office, 9100 Purdue Road, Suite 200, Indianapolis, IN 46268-3165. Telephone: +1 317 735 4063: e-mail: ibo@inceusa.org. The price is USD 400 for 4 insertions.

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Mark your calendar and plan to participate!

NOISE-CON 2011

Portland, Oregon
July 25 – 27, 2011

The 27th annual conference of the Institute of Noise Control Engineering, NOISE-CON 2011, will run concurrently with the summer meeting of the Transportation Research Board, Committee on Transportation-Related Noise and Vibration (ADC40) on Monday through Wednesday (25-27 July, 2011). This conference is joining the overlapping transportation noise and vibration interest of the two organizations in Portland, Oregon to take advantage of the strong public interest and readily accessible public transportation project sites currently found in the Pacific Northwest. The technical program for the joint conference will provide an opportunity for public and private organizations to share technical information on noise and vibration topics associated with high speed rail, light rail systems, highway surface and tire noise and aircraft noise to name a few.

The INCE/USA Page at the Atlas Bookstore

www.atlasbooks.com/marktplc/00726.htm

INTER-NOISE 06 Proceedings

This searchable CD-ROM contains the 662 papers presented at INTER-NOISE 06, the 2006 Congress and Exposition on Noise Control Engineering. This, the 35th in a series of international congresses on noise control engineering was held held in Honolulu,Hawaii, USA on December 3-6, 2006. The theme of the congress was "Engineering a Quieter World."

The technical topics covered at INTER-NOISE 06 included:

- Aircraft and Airport Noise Control
- Community Noise
- Fan noise and aeroacoustics
- Highway, automobile and heavy vehicle noise
- Machinery noise
- Noise policy
- Product noise emissions
- Sound quality.

The NOISE-CON 05 Proceedings Archive (1996-2005)

This searchable CD-ROM contains 198 papers presented at the joint NOISE-CON 05/ASA 150th meeting as well as 749 papers from the NOISE-CON conferences held in 1996, 1997, 1998, 2000, 2001, 2003, and 2004 as well as the papers from the Sound Quality Symposia held in 1998 and 2002. All papers are PDF files.

Several papers are taken from sessions organized by the Noise, Architectural Acoustics and Structural Acoustics Technical committees for this 150th ASA meeting. The three plenary lectures related to noise and its impact on the environment are included. Also included are papers in one or more organized sessions in the areas of aircraft noise, tire/pavement noise, and hospital noise.

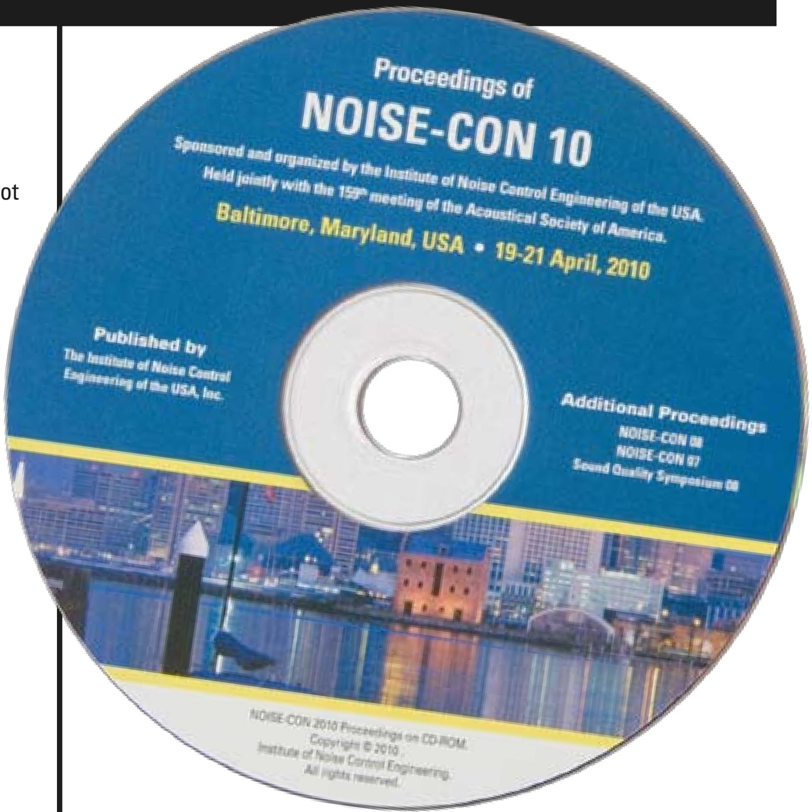
NOISE-CON 10 CD-ROM

This searchable CD-ROM contains PDF files of the 198 papers presented at NOISE-CON 10, the 2010 National Conference on Noise Control Engineering. NOISE-CON 10 was held jointly with the Acoustical Society of America on 19-21 April 2010 in the Marriot Waterfront Hotel in Baltimore, Maryland. This CD does not contain the papers presented as ASA contributions.

In NOISE-CON 10, there were 24 technical sessions:

- Rocket Noise Environments
- 15 papers Noise Control in Complex and Urban Environments
- 11 papers Ventilation, Fan and Duct Noise Control
- 21 papers Military Noise Environments
- 16 papers Case History, Application and Integration of Architectural Acoustics in Building Modeling
- 14 papers Materials for Noise Control
- Manufacturer Presentations
- 10 papers Building Design and Construction for Effective Acoustic Performance
- 10 papers Experimental Techniques
- 10 papers Construction Noise
- 14 papers Information Technology Noise
- 10 papers Aircraft Interior Noise

This CD also contains Proceedings from NOISE-CON 08, NOISE-CON 07 and papers on sound quality presented as SQS08, the 2008 Sound Quality Symposium. This CD-ROM supplements the NOISE-CON 05 CD-ROM which contains all of the papers published in NOISE-CON Proceedings from 1996 through 2005. These papers are a valuable resource of information on noise control engineering that will be of interest to engineers in industry, acoustical consultants, researchers, government workers, and the academic community.



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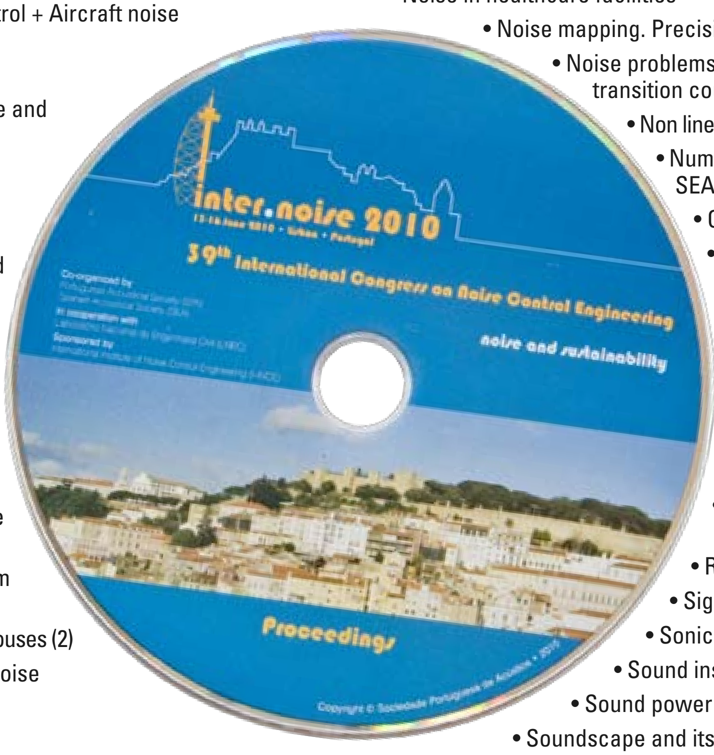
The INTER-NOISE 2010 Proceedings

Five Distinguished Lectures • 844 Technical Papers • Poster Sessions • Parallel Sessions

Parallel Sessions *(the number in parentheses is the number of sessions)*

- Acoustic and thermal interactions for energy efficient buildings
- Acoustic comfort in buildings
- Acoustical holography, imaging and beam forming (2)
- Acoustical metrology (instruments, measurements, standards, uncertainty) (cont.) + Instrumentation and standards (2)
- Action plans of urban areas: strategies and experiences (2)
- Active noise and vibration control (3)
- Aeroacoustics and fan noise
- Aircraft interior noise and related technology + Aeroacoustics and fan noise
- Aircraft noise modelling and control + Aircraft noise characterization
- Airport noise (2)
- Asphalt rubber pavements - noise and sustainability (2)
- Assessment and strategies for managing noise (2)
- Bioacoustics
- Building acoustics properties and comfort classes
- Characterization of structure-borne sound sources (2)
- Classroom acoustics
- Community noise around airports
- Community noise maps and action plans (2)
- Community response and exposure criteria in environmental situations
- Computational techniques in room and building acoustics
- Concert halls, theaters and opera houses (2)
- Diffraction reducing devices on noise barrier top
- Ducts and mufflers
- Economics of noise for sustainability
- Environmental noise (policy, standards, problems and approaches)
- Environmental vibration and its impacts on buildings and people
- Floor impact noise evaluation and control (2)
- General acoustics and vibration (2)
- Hearing protectors
- Industrial noise and noise at work
- Legislation and noise control policies
- Lightweight partitions and systems (2)
- longevity of pavements
- Low frequency and airport ground noise
- Measurements in room and building acoustics (3)
- Measurements of surface properties
- Metrics for environmental noise
- Musical acoustics
- New directions in noise and health research (2)
- Noise annoyance
- Noise barriers (2)
- Noise control engineering education
- Noise control materials
- Noise from information technology equipment
- Noise from renewable energy technologies
- Noise in healthcare facilities
- Noise mapping. Precision and uncertainty (2)
- Noise problems and solutions in developing and in transition countries (2)
- Non linear dynamics of acoustic resonators (2)
- Numerical techniques (FEM, BEM, IFEM, SEA) (3)
- Occupational noise (2)
- Outdoor sound propagation in living environment (2)
- Physiological health effects from environmental noise exposure
- Product sound auralization
- Psychoacoustics and sound quality (3)
- Psychological effects of noise (3)
- Public space acoustics for safety + Sustainable quiet buildings
- Recreational noise
- Signal processing and analysis (2)
- Sonic crystal noise barriers
- Sound insulation at low frequency
- Sound power measurements and analysis
- Soundscape and its applications (2)
- Soundscape-metrics (2)
- Speech communication in road vehicles
- Speech privacy
- Tire/road noise (2)
- Transportation noise (air, road, rail, marine vehicles) (3)
- Ultrasound
- Underground noise control
- Underwater acoustics
- Urban noise and its control
- Urban sound propagation and evaluation
- Vibration isolation and damping
- Vibro-acoustic performance of structures and vehicles (2)



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