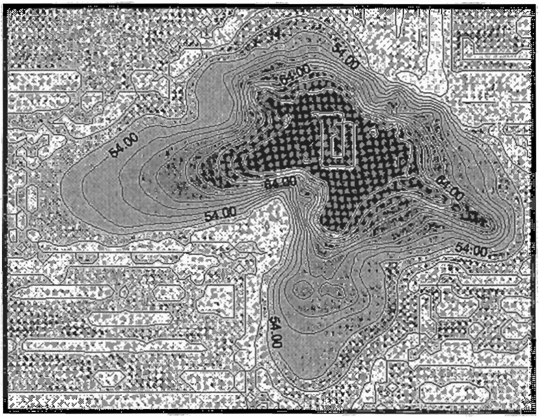
Acoustics Australia



- Acoustics in Australia
- Environmental Noise
- Active Isolation
- Animal Sounds

Australian Acoustical Society

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Acoustics Australia

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Editorial

In this issue, we present, as well as some regular articles, an extended review of acoustical activities across Australia. We do not pretend that this is a complete account, for reasons that I go into in a moment, but it is at least a snapshot of the more prominent activities in a large selection of fields of current interest. Our aim in this is largely to inform our readers about what is going on, but it may also provide an opportunity for a form of review to see whether there are things that we should be doing but that have somehow slipped our collective attention.

The word "review" leads me to my next point, for reviews of all sorts are a major growth industry in Australia – even more so, it seems, than in other parts of the world, though the custom is widespread. This fashion is linked, it seems, to the rise of management consultants at all levels, and to the passion of the government for "accountability".

No one would argue that we should not be careful about the expenditure of money, and particularly of public funds, and the professed purpose of manifold reviews is to ensure that such funds are spent wisely and for the greatest benefit to Australia. The one thing that has not been reviewed is the efficacy of reviews! Indeed, one might reasonably maintain, on the basis of many examples, that the very process of reviewing an activity or an organisation has a marked negative effect upon its productivity, simply through time and resources wasted on the process, and the unavoidable disruptions caused by implementing its findings. And findings and recommendations for change there must inevitably be – a review that concluded everything was in good order would be regarded by those who commissioned it as a failure!

While we are talking about reviews, let us hope that some of those that are currently nearing completion in the wider community will bear useful fruit. We know that our Universities are in a sad state, and it is little comfort to realise that we are following international trends – do all politicians read the same books? The Stocker Review had some good things to say about research, but what we read of the Mortimer Review is alarming to say the least. The brightest light in the sky at present is the hope of a fresh approach from the West Review of universities, due out in draft form in October.

But here, in our journal, is a review without pain and without recommendations, put together with the help of a few knowledgeable people and without very much cost to the acoustics community in either time or money, compared with an official review. My impression is that we have a wealth of good work in progress across the country in most areas, but I am sure there are other people working in the field whom we have missed. I urge you all to read it, think about it, and, if you have a good idea, do something about it. If your work has been omitted (or, indeed, if it has been included!), perhaps you would like to write an article about it for Acoustics Australia.

Neville Fletcher

Acoustical Research In Australia

Abstract: A brief review is given of Australian research and development work in a wide range of areas of acoustics. Areas covered include measurement and calibration, human hearing, biological acoustics, musical acoustics, ultrasonics, underwater acoustics, active noise and vibration control, mechanical vibration, building and industrial acoustics, and environmental acoustics.

From time to time it is appropriate to stand back and look at the range of acoustic activity that is going on around Australia. One reason for this is that each of us tends to interact mostly with others in our own particular specialised field, so that we are comparatively ignorant of work in other areas. This is a pity, since techniques are often usefully transferred between apparently quite different areas of research, development and application. Another reason for such a survey is simply one of the interests of the profession. At a time when both science and technology are finding decreasing levels of government support, we all gain by publicising our successes and by showing others the breadth and scope of our activities.

In putting together this survey, the Editors have not attempted an exhaustive compilation of all acoustics-related activity in the country. Rather, we have invited specialists in a wide range of different areas to each write a brief commentary on the things that seem to them to be most interesting among current activities. In this way we hope to have provided a readable and interesting document that conveys the general flavour of acoustical activity in Australia.

There may be areas that have been omitted by falling through the cracks in this approach, and to those people we apologise in advance. Particular topics that have not been treated include Australian noise standards, architectural design, human auditory physiology, and psychoacoustics. We have also not attempted to give a comprehensive account of the widely varied activities undertaken by acoustical consultants. Perhaps we will return to these at another time.

1. MEASUREMENT AND CALIBRATION

Suszanne Thwaites
CSIRO Telecommunications and Industrial Physics
Lindfield, NSW

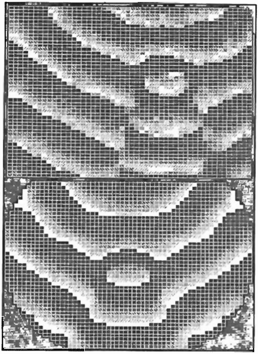
Australia's national standards of measurement are held at the National Measurement Laboratory (NML) in Sydney. NML is actually part of the CSIRO (Commonwealth Scientific and Industrial Research Organisation), a statutory body involved in all areas of scientific R & D and employing some 6000 people Australia wide. The roles of the NML and CSIRO in standards are defined in the National Measurement Act (1960) and essentially encompass the development and maintenance of world class primary standards of measurement and the dissemination of these into the measurement chain via a first level calibration service. At NML the Acoustics Project performs these roles in addition to an involvement with international standards committees and activities in the Asia Pacific region. However, as part of the CSIRO, the project also conducts research and development programs associated with the measurement of acoustic and vibration quantities in industry. In the following we look at these various functions, in the acoustics context, in turn.

Primary Standards

At the foundation of a national measurement system must be a primary, absolutely derived, standard. In acoustics this is achieved, world wide, by the maintenance of sets of three 1-inch capacitor microphones of an agreed design which are calibrated using the principle of coupler reciprocity as laid out in an International Standard (IEC 1094-1,2). At NML such a set is maintained although the implementation of coupler reciprocity is slightly different to the standard one (a 3-port coupler is used instead of a 2-port one) allowing equivalent volume corrections to be made automatically and also making the whole process amenable to automation. Our primary set was established in 1980 and has been calibrated over 700 times since then showing negligible drift over this time. The uncertainty at 95% confidence limits is 10.07 dB and the repeatability in the laboratory is within 0.02 dB.

Dissemination

Dissemination is the second responsibility devolved to NML under the National Measurement Act (see above). This is achieved in two ways; 1) operating a first level calibration service and 2) supporting the activities of the National Association of Testing Authorities (NATA) which accredits testing laboratories and services. As part of the accreditation process a laboratory's technical competence, organisational structure and the traceability of its instrument calibrations to NML are assessed. Frequently the technical assessor is an officer from NML. In addition NATA runs proficiency round robins for various tests, e.g. calibration of a sound level meter, by circulating an artefact amongst accredited laboratories. The NML acoustics group is usually the technical hub for these events and is coordinating a sound level meter round robin at the moment.



Phase map of sonic waves propagating across an aircraft composite panel with a delamination defect. The upper part of the figure shows experimental results. The vibration source is off the top of the figure (the origin of the circular wavefronts) and the defect is located near the centre of the panel. The lower part of the figure shows the results of a theoretical calculation. The size of the imaged section is about 20 cm.

Calibration Service

Any microphones can be calibrated by the acoustics project. If they are standard pattern microphones their absolute sensitivity is established in the 3-port coupler. Otherwise a closed coupler or free field comparison method is used. In a closed coupler a known sound field can be set up using a standard microphone and an insert volts technique. In a free field comparison a substitution method with a free field standard is used eliminating the need for a known sound field.

Frequency response may also be measured with these techniques although, for standard pattern microphones, electrostatic actuation is often a better approach. At low frequencies microphones are calibrated in a pressure and vibration isolation vessel which allows the back vent to be included in the sound field giving a true low frequency response. These techniques give an operating calibration frequency range extending from 10 mHz up to 100 kHz, depending on the microphone, but the usual range is 20 Hz to 20 kHz.

The range of other instruments commonly submitted for calibration includes pistonphones, calibrators, sound level meters, noise loggers and filter sets.

Setting Standards

Australian standards exist for most of the tests mentioned above. It is the general rule that Australian standards follow the international ones so that new or revised IEC standards are used as the basis for new or revised Australian ones. The development of these standards is followed with great interest since the compliance tests contained there-in have to be implemented at NML. In several cases the group has membership on the relevant IEC working group, as the Standards Australia (SA) representative; specifically TC29/WG 4 (calibrators) and 17 (sound level meters) and, beginning this year, 5 (microphones).

Asia-Pacific Metrology Program

The 22 member Asia-pacific Metrology Program (APMP) is a collaboration between national/territorial measurement laboratories in the region. Some of its main objectives are to

- Provide training, advice and consultancy to new laboratories.
- Develop objective technical evidence of measurement traceability and competence as a basis for multi-lateral recognition.
- Support the objectives of the Asia-Pacific Economic Cooperation (APEC).

The APMP is run by an elected regional coordinator and the secretariat is located at the coordinator's institute. For the term 1994-98 the secretariat is at NML. Funding comes from a number of sources including APEC, member governments, the United Nations and the World Bank.

Two activities in which the NML acoustics group is heavily involved are assessment of the needs of developing standards laboratories in the region and training at NML of officers from these laboratories. The group has hosted training visits from and visited groups in many south East Asian countries including Indonesia, Thailand, Philippines and Vietnam. Calibration intercomparisons between APMP members are on going, coordinated by various member institutions. Concomitant with these activities is the stepping up of the membership and development of APLAC, the Asia Pacific Laboratories Accreditation Cooperation, the regional equivalent of NATA. The NML acoustics group is coordinating a calibrator round robin for the APMP and a sound level meter intercomparison for APLAC.

Research and Development

R & D programs in the group vary from year to year. Recent and current activities include NDT of composite materials used in aerospace and marine applications. This, sizeable, project jointly run with Boeing Commercial Airplane Group, has investigated the use of low frequency lamb waves (< 35 kHz) to detect defects in honeycomb-cored composites.

Ultrasonic Transducers

This project worked towards a description of a novel, efficient, air coupled transducer developed at NML for use in gas flow metering. The transducer is air-coupled and operates in the 100 kHz range.

Microphone design

This work, undertaken for a successful small Australian company which manufactures and markets microphones of its own design, involved the development of a good model for the microphone with a view to making design changes in the interests of more efficient manufacture in Australia.

2. HUMAN HEARING

Denis Byrne
National Acoustic Laboratories
Chatswood NSW

Robert Cowan
CRC for Cochlear Implant, Speech & Hearing Research
Melbourne

In addition to physiological research, Australia has a strong record and extensive current programs of research into hearing prostheses. Primarily, this consists of hearing aid research, at the National Acoustic Laboratories (NAL), and research into cochlear implants, electrotactile and other aids at the Bionic Ear Institute, the University of Melbourne, and Cochlear Limited. Much of this work is now being conducted through the Cooperative Research Centre for Cochlear Implant, Speech and Hearing Research, in which the four above institutions are the major partners.

NAL's achievements include the development of prescriptive procedures for fitting hearing aids to suit individual hearing losses. The first procedure was published over 20 years ago and has been succeeded by numerous studies providing refinements, additions and validation data. A 1996 American publication states that the NAL procedure is "Probably the most well-known, widely used, and experimentally verified". The range of procedures includes prescriptions of gain, frequency response and maximum output as well as modifications for severe and profound hearing losses. Current research is extending procedures to the fitting of non-linear amplification and is optimising the design of non-linear hearing aids. It is also examining how amplification needs to be varied, either automatically or by the hearing aid wearer, to suit different acoustic conditions and listening preferences. Other forms of signal processing, for implementation in future digital hearing aids, are also being developed and evaluated. Another research program concerns the design and fitting of hearing aids to optimise auditory localization and possibly other abilities requiring binaural functioning. One aspect of this research has shown that the choice of earmould type, for coupling the hearing aid to the ear, can substantially affect the acoustic information available as cues for sound localization.

Current psychoacoustic research includes investigation of frequency and temporal resolution in hearing-impaired people and, especially, how speech recognition is related to signal audibility and hearing loss characteristics. This has suggested modifications to the Speech Intelligibility Index when using it to predict speech recognition by hearing-impaired listeners. This work has major implications for understanding the amplification requirements of people with severe hearing losses.

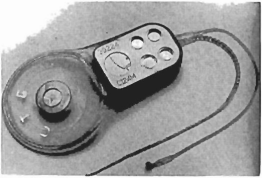
Other research has been concerned with the effects of noise on people and with hearing loss prevention. Currently, otoacoustic emissions are being studied extensively for various purposes which include the early detection of cochlear damage and, hence, a warning of the need for preventative measures. Otoacoustic data are being used to predict future trends in the prevalence of hearing loss in the community. The risk of damage from overamplification by hearing aids, through using "Walkman" devices, and from music, are other strands of hearing loss prevention research. Other research includes the development of hearing impairment tables, for compensation purposes, and the use of otoacoustic emission testing for the screening of hearing loss and identifying aural dysfunctions.

The National Acoustic Laboratories, now 50 years old, recently compiled a complete set of its research publications. These number about 200 on noise and its effects on people and over 400 on hearing and hearing aids.

Since 1978, the University of Melbourne and Cochlear Limited have collaborated in long-term research to develop the Nucleus 22-channel cochlear implant, and to consistently improve its performance capabilities over time, enabling cochlear implant recipients to obtain improved understanding of speech and sound, to engage in telephone conversation, and in the case of children, to develop near-normal speech and language when implanted at an early age.

This research program has been strengthened through the Cooperative Research Centre, which has concentrated efforts on both development of new hardware and speech processing to help the hundreds of thousands of persons in Australia and world-wide who suffer from severe hearing disability. Research is directed at further improvements to the Bionic Ear, so that users obtain improved speech perception and Australia remains foremost in the world market, and so that infants and those with some residual hearing can also gain benefits. The CRC is also directly involved in developing advanced speech processing hearing aids, noise reduction microphones, electrotactile devices, and auditory brainstem implants to extend speech perception benefits to all hearing-impaired persons. The CRC is also involved in research to develop improved tools for use by clinicians, an example being CASALA, or computer-aided speech and language analysis software, which greatly reduced the amount of time required to analyse speech samples.

A recent result of this research was the release of the Nucleus 24 Cochlear Implant System, incorporating an advanced cochlear implant, the CI-24M and two new speech processors, the ESPrit™ ear-level speech processor and the SPRINT™ body-worn speech processor. The new cochlear implant can operate at higher rates of stimulation, enabling implementation of both the current SPEAK coding strategy, and advanced speech processing strategies developed by the CRC. The CI-24M incorporates sophisticated diagnostic neural telemetry functions, simplifying use of the device with infants and young children. CRC biomedical research has also enabled the CI-24M to be specially shaped to enable infants to receive their implant during the critical period of speech and



The C124M™ implanted receiver-stimulator and flexible electrode array which is the heart of the System 24™ cochlear implant hearing system produced by Cochlear. This system is able to provide higher rates of stimulation, monopole stimulation, and a telemetry function.

The Sprint™ advanced speech processor, which is the external part of Cochlear's new System 24™ cochlear implant hearing system.

language learning. The ESPrit ear-level speech processor incorporates all of the features of the present Spectra 22 processor, but in a package similar in size and weight to current behind-the-ear hearing aids. The SPRINT body-worn speech processor is a significant advance, allowing the clinician to choose from a range of advanced speech processing strategies to best meet the needs of each individual user. The Nucleus 24 Cochlear Implant System has been awarded the 1996 Bradfield Award from the Institute of Engineers, and also won the NSW Government Award for Engineering Innovation and an Excellence Award for Engineering Products and Manufacturing.

CRC research is investigating mechanisms to increase the information available from cochlear implants through use of improved electrode arrays, and advanced speech processing strategies designed to take advantage of neural encoding patterns in the auditory system. Speech processing research has resulted in the release of the SPEAK speech processing strategy, and has demonstrated that hearing-impaired adults and children significantly improve speech perception using this strategy, particularly in noisy conditions. Long-term research will also identify cost effectiveness benefits for children receiving cochlear implants. The Speech Processing Hearing Aid program has developed a substantially improved form of directional microphone array to improve speech intelligibility in noise. This may be implemented both as a conference microphone and, after further development, in a hearing aid. A new frequency transposition hearing aid offers the potential for real benefit to people with steeply-sloping hearing losses, who cannot obtain much help from conventional hearing aids. The CRC research program has also produced an enhanced algorithm for selecting the maximum output of hearing aids. The CRC's Tickle Talker™ electrotactile speech processor has been demonstrated to provide significant assistance to lipreading for hearing-impaired adults and children unable to benefit from cochlear implants. The Tickle Talker uses similar speech processing hardware to that employed in the cochlear implant, but delivers this signal through an array of eight electrodes worn in a glove on the fingers of one hand.

The CRC and NAL both publish annual reports which provide summaries of the above mentioned projects and other aspects of hearing research.

3. BIOLOGICAL ACOUSTICS

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University of Melbourne

Sounds made by animals are a familiar and pervasive part of the outdoor acoustic environment. Some common examples are the calls of insects, frogs, and birds, which often consist of songs produced by a male in an attempt to attract potential mates. Another example is the biosonar of echolocating bats, which enables bats to hunt at night, and to avoid collisions. As the differential survival and reproduction of individuals underpins evolutionary theory, upon which modern biology is based, it is hardly surprising that the sounds made by animals are of great interest to many biologists.

There are several approaches to the study of bioacoustics, each of which provides valuable information about the use of sound by animals. One strategy takes advantage of the fact that males advertising for a female usually produce songs that are species specific. Hence, these songs can be used to determine the species-identity of an individual, or the species composition of a population. For example, populations of frogs around Australia have been assessed and monitored using the vocalisations of males. This method of population assessment has been used by Margaret Davies and her colleagues, based at the University of Adelaide, Dale Roberts' group at the University of Western Australia, and William Osborne and his colleagues at the University of Canberra. Similarly, researchers at the University of Queensland, led by Mike Ryan, have found that an Australian landbug can be distinguished from its Slovenian conspecifics by differences in vibratory signals. Surveys of the bat fauna of Belair National Park, near Flinders University in South Australia, have been carried out by Ken Sanderson and his research group using the ANABAT system, which detects and records their ultrasonic biosonar. The same research group at Flinders University has also characterised the songs and alarm vocalisations of many bird species.

Another approach is to study the behaviour of animals to determine the biological function of their acoustic signals. This approach has been used by Stella Crossley and her colleagues at Monash University to study the effects of the courtship song in fruitflies. Leigh Simmons and Win Bailey, at the University of Western Australia, have used a similar approach to study the function of the calling song in bushcrickets, and the way in which the whistling moth defends its territory with sound. A study carried out by Andrew Cooney, at the Australian National University, has investigated the role of female song in superb fairy-wrens. Michelle Hall, also at the Australian National University, is studying the duetting songs of magpie larks. Similarly, the function of song in zebra finches has been studied extensively by Richard Zann at LaTrobe University.

As acoustic communication plays such an important role in the reproduction of many species, it can provide insight into evolutionary processes such as sexual selection and the formation of new species. Murray Littlejohn and Graham Watson, at the University of Melbourne, have looked at the effect of variability in the call of male frogs on the choices made by females, and tested for changes in the song structure of an Australian frog species after its introduction into New Zealand. In a similar vein, Dale Roberts from the University of Western Australia has investigated the effect of hybridisation within a group of closely related frog species on the structure of the male call. Leigh Simmons, at the University of Western Australia, has also tackled evolutionary questions studying insect communication, such as how call structure in crickets is affected by age and parasite load. More recently, he has investigated the effect of asymmetry in the sound production apparatus of male crickets on the calling song, and how this in turn affects female choice.

Biologists are also interested in how animals produce the sounds used in their acoustic communication. Insects have provided valuable models for in-depth study of sound production in biological systems. Studies carried out at the University of Western Australia, by Win Bailey, Leigh Simmons, and others, have investigated the energetics of calling in bushcrickets, illustrating how costly it is for small animals to produce sound. A series of collaborations at the University of Melbourne, involving David Young, Alisdair Daws, and several colleagues, have also investigated sound production in insects. These studies have resulted in acoustic models of sound production in male cicadas, which possess large, hollow abdomens that act as resonant chambers, and male mole crickets, which sing from within a specially constructed singing burrow that is tuned to the song frequency.

Another aspect of biological acoustics is the study of the detection and processing of sounds by animals. The group at the University of Melbourne has studied the way female cicadas receive and process information in the songs of males, and how they use this information when choosing a potential mate. Likewise, the transmission and reception of the song of a desert clicker has been studied by Win Bailey at the University of Western Australia. An intriguing variation on the study of acoustic communication in insects, also carried out by Win Bailey and his colleagues, investigated the way bats localise insect calls when hunting. Hearing in other vertebrates has also come under investigation. Dexter Irvine, Ramesh Rajan, and Lisa Wise, at Monash University, have conducted extensive studies into the neural processing of auditory information in animals such as cats, rats, and guinea pigs. Research on the neural processing of auditory information in cats has also been carried out by Mike Calford and Jack Pettigrew at the University of Queensland. Similarly, Ken Hill at the Australian National University has studied the processing of auditory information in cats and wallabies.

Given the range of acoustic animals native to Australia, and the biological importance of the questions they pose, the study of bioacoustics promises to remain an exciting field with many avenues of research open for investigation.

4. MUSICAL ACOUSTICS

Neville Fletcher
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Musical acoustics is a field whose boundaries are hard to define. Properly it means the application of science to the study of musical instruments, but this definition shades off into the making and improvement of traditional instruments and the empirical development of new instruments in one direction, and into the study of performance techniques and the psychophysics of musical perception in the other. Some aspects of the development and programming of electronic and computer-based instruments might also be included.

Musical Instrument Making

The art and craft of musical instrument making is well developed in Australia, and instruments made in this country are praised by visiting performers. Only a few makers can be mentioned here, but a much wider survey is given in the recent excellent book by Michael Atherton *(Australian Made... Australian Played...* New South Wales University Press, Sydney 1990). The most visible instrument is probably the wonderful five-manual mechanical-action pipe organ in the Sydney Opera House, built by Ron Sharp, but there are many smaller instruments throughout the country by other builders, and Australian craftsmen maintain and restore notable instruments imported last century, a notable example being the great nineteenth century Hill organ in Sydney Town Hall, with its full-length 64-foot pedal reed rank. On a smaller scale, Fred Morgan's baroque recorders are in demand throughout the world, and we have fine makers of harpsichords, dulcimers, guitars, violins, flutes and oboes, while Hervey Bagot has a scientifically based bell foundry in Adelaide.

Innovative and experimental instruments also have a long and continuing history here, ranging back to Percy Grainger's experiments, at least twenty years before their time, with electronic sound synthesis. His Heath-Robinson-like invention is still on display in the Grainger Museum at Melbourne University. More recently, the Fairlight CMI (Computer Music Instrument) introduced many new concepts in sampled waveform manipulation, and for many years dominated the top-end market for film background music and popular music groups.

Turning to the more strictly scientific aspects of music-instrument acoustics, mention should be made of Graham Caldersmith's development of a family of four guitars, one higher in pitch than the standard guitar and two lower. This development, which pays careful attention to soundboard and body-cavity resonances, closely parallels Carleen Hutchins' development in the US of a family of eight bowed-string instruments based upon the design of a violin by Antonio Stradivari. Graham's guitar family can be heard on the best-selling CD by the Canberra School of Music Group "Guitar Trek", released by the ABC.

Acoustic Investigations

Studies of musical acoustics from a scientific viewpoint are generally undertaken by physicists with a major interest in some other area, so that the field is somewhat fragmented. Nevertheless, a significant number of students have completed higher degrees in the area, though their employment after graduation has been in other acoustics-related fields.

Among those who have worked in this area, and continue to do so, are Joe Wolfe and John Smith (University of NSW) who have developed a new method of measuring acoustic impedance and are applying it to wind instruments, Gordon Troup (Monash University) who has been particularly interested in vocal-tract effects in wind-instrument performance, Hans Gottlieb (Griffith University) who investigated an interesting series of annular drums with quasi-harmonic overtones, Hervey Bagot (Adelaide) and Neil McLachlan (RMIT) who are concerned with bells and gongs, Graham Caldersmith who examined resonances in string instruments, Howard Pollard (University of NSW) who worked on tone quality in organ pipes, and Neville Fletcher (ANU and ADFA) who studies nonlinear effects, particularly in wind instruments, gongs and cymbals.

Musicology

Australia has some significant collections of musical instruments, for example at the Power House Museum in Sydney, and in some University music departments, and the curators of these collections encourage study of their acoustics and performance techniques.

Much of the academic work on musical instruments is devoted to ethnomusicology, with particular emphasis on the didjeridu and other traditional instruments of the Australian aboriginal people, on the gamelan instruments of nearby Indonesia, and on instruments from other Pacific Rim cultures.

Vocal Performance

Over the past year, a new National Voice Centre has been established in the Faculty of Health Sciences at the University of Sydney, thanks to the efforts of Pam Davis. The objectives of this Centre are to apply scientific methods to studying and training the human voice, with particular practical applications to singers, actors, and others to whom the voice is vitally important. The Centre brings together respiratory physiologists, ear nose and throat surgeons, vocal coaches and professional musicians, and offers clinics as well as undertaking research. Many of the approaches vital in singing are also important in the playing of wind instruments, and the Centre initially has research projects related to breath control in flute playing and related areas.

Some of the work mentioned in the previous section is also relevant here, particularly Gordon Troup's interest in vocal-tract effects in reed instrument performance, and Joe Wolfe's equipment that allows real-time measurements of vocal-tract resonances.

5. ULTRASONICS

George Kossoff
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CSIRO Telecommunications and Industrial Physics
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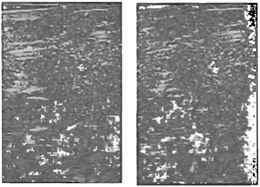
Research into ultrasonics in Australia is undertaken primarily by statutory authorities and government organisations. Often this research is performed on behalf of or in collaboration with a commercial partner. The applications include medical ultrasound, high resolution underwater imaging, measurement of flow in fluids and non destructive evaluation.

Medical Ultrasound

Research into medical ultrasound is undertaken by the Ultrasonics Laboratory of the CSIRO Division of Telecommunications and Industrial Physics.

Decision support analysis methods are being developed to allow accurate identification of high risk pregnancies. This will allow a more targeted utilisation of diagnostic ultrasound and a more cost effective provision of health services.



original corrected

Original and corrected ultrasonic image of a phantom containing a cyst. An aberrator simulating overlying subcutaneous tissues has been placed on the surface of the phantom. The corrected image has been processed using the near field redundancy algorithm. The portrayal of the cyst has been significantly improved.

Comparison of images obtained with transducers applied externally on the patient with those obtained with internal probes dramatically demonstrates the degradation in image quality incurred by propagation through the overlying subcutaneous tissues. Forward and inverse propagation compensation methods are being investigated and impressive improvements have been obtained on clinical images acquired on the Laboratory's array research synthetic aperture equipment.

Research into bioeffects has shown that, in some modes of operation, current equipment can cause significant temperature elevation in the foetal brain. Studies are being conducted to elucidate the various factors responsible for the effect with view to develop safe operational criteria.

High Resolution Underwater Imaging

Many of the coastal waters of Australia are muddy and this precludes conventional visual imaging of submerged objects.

The Ultrasonics Laboratory, in collaboration with Thomson Marconi Sonar, is developing a high resolution 3-D underwater imaging equipment suitable for mounting on a remote control operational vehicle. The aim is to provide resolution of the order of a few mm over a depth of several metres. The project is funded by the Department of Defence and is being undertaken in collaboration with DSTO.

Measurement of Flow in Fluids

Research into measurement of flow in gases and liquids is carried out in the CSIRO Division of Telecommunications and Industrial Physics (formerly Applied Physics).

A piezoelectric polymer foil transducer is used to generate ultrasound into gas and flow is measured by noting the difference in the speed of ultrasound between two opposing transducers. A domestic gas meter is being developed in association with the Australian Gas Light Company to measure flow rates to an accuracy of ~ 1%, over a range of flow rates from 40 l/hour to 6000 l/hour which corresponds to flow velocities from ~ 10 mm/s to 1500 mm/s. It is designed to operate satisfactorily in temperatures from -20° C to +60° C, and have a battery life of at least 10 years. The advantages of an ultrasonic meter are small size, lack of moving parts and adaptability to electronic remote meter reading.

Another group is working on the development of liquid meters, using similar techniques. The research problems involve the fluid dynamics of flow along a tube, within which the transducers are mounted. The flow patterns are complicated, changing from laminar at low flow to fully turbulent at higher velocities. The flow profile is also a function of the mean velocity and the position along the tube, and depends on pipe geometries upstream from the meter. Other research issues concern the propagation of ultrasound in a non-uniform flow profile and the measurement of time differences of a few tens of picoseconds.

Non-Destructive Evaluation

ANSTO

The Australian Nuclear Science and Technology Organisation conducts research into acoustic imaging in support of safe reactor operation.

The work on remote ultrasonic inspection of the HIFAR reactor has led to research into 2D arrays for high resolution imaging in heavy steel and aluminium sections. Studies are currently directed at developing a 3D bi-static imaging system based on a passive 2D PVDF receiving array and separate conventional piezo-ceramic transmitter. The emphasis is on achieving focussing entirely in reception, by using a combination of general purpose and DSP hardware.

The 2D array incorporates a single edge-connected PVDF film element with four sets orthogonal strip electrodes on each face. The orthogonal electrode pattern samples the 2D pressure field incident on the array, yielding Fourier coefficients for spatial frequencies in the X and Y directions. The result is that the array is sparse in the spatial frequency domain, unlike arrays which are sparse in the spatial domain. A single set of orthogonal Fourier coefficients is not sufficient for 3D image reconstruction. However simultaneous reconstruction with coefficients sampled from four quadrants of the array has been shown to yield a unique solution, provided imaging is conducted in the near field. A regularising operator is used to yield results comparable to a conventional filled array, while allowing a degree of super-resolution relative to linear reconstruction algorithms. The use of a non-linear reconstruction algorithm requires considerable computation , and imaging times are presently 15-30 mins for 3D images of 32×32×32 pixels.

CSIRO

Materials characterisation and non-destructive testing is a significant area of ultrasonics activity in the CSIRO.

Research, in collaboration with Boeing Airplane Group, is concentrated on the study of ultrasonic modes that propagate along multilayered plate structures. These are sensitive to material properties and to boundary conditions provided by adhesive bonding, to detect defects within a composite laminate and to disbonds. Current work is directed towards measurement of the strength of adhesive bonds which may be reduced by improper curing, inadequate surface preparation, water absorption, microcracking, etc.

Optical techniques, whereby a high power pulsed laser is used to generate ultrasound and a sensitive optical interferometer is used to measure surface vibrations, is being applied to the inspection of hot steel products, in collaboration with AEA Technology, Harwell, UK. Ultrasound is used to detect defects in the materials, to monitor microstructural changes and phase transformation kinetics, and to measure internal temperatures in large steel billets.

DSTO

DSTO ultrasonics program involves the development of improved methods to quantify corrosion in ageing aircraft, the detection of weld cracking, the disbonding of tiles on submarines, and the assessment thick-section glass-epoxy composite ship structure.

While much of the research involves conventional transducers, laser ultrasonics is also being evaluated. Modelling of laser generation has been carried out and laser ultrasonics is used to detect surface crack sizing in aluminium alloys, in one-sided measurement of elastic constant in composites, and for the development of Lamb waves for large-area scanning for early detection of corrosion in aircraft skins.

Considerable effort is presently being directed towards the reliable examination of boron-epoxy composite repair technology where it is used to validate reinforcement bond durability and to monitor cracks in non-standard configurations. Carbon-epoxy composite are also being examined to assess the minimum detectability of service-incurred damage to carbon reinforcement, both in the form of delaminations within the reinforcement and the reinforcement disbonding.

6. UNDERWATER ACOUSTICS

Douglas H. Cato
Defence Science and Technology Organisation
Pyrmont, NSW

Much of the underwater acoustics research in Australia is related to sonar, since sound is the most effective means of transmitting information through the ocean, though there is also significant interest in the extensive use of sound by marine animals. Most work is concentrated at the Salisbury and Sydney branches of the Maritime Operations Division of the Defence Science and Technology Organisation (DSTO), at the University of Sydney and at Curtin University of Technology in Perth. Australian underwater acoustics research covers the frequency range 0.1 Hz to 3 MHz.

The acoustic environment of the ocean is complex and variable and causes wide variation in sonar performance. Understanding the environment is an important input to sonar design and optimisation of performance. The same factors impact on the use of sound by marine animals. The Australian ocean environment differs significantly from the colder waters around North America and Europe which have provided most of our knowledge of underwater acoustics, so is a fertile field for research.

Transmission of sound in the ocean is complicated by sound speed variation, particularly vertically as a result of horizontal layering of water masses. This results in significant refraction, so that transmission in shallow waters (depths < 200 m) involves many boundary reflections. Transmission loss varies in both space and time, since it depends on the water temperature profile (through the sound speed), the sea surface roughness and the acoustics of the bottom. Prediction of transmission loss requires computational models and adequate knowledge of the environmental parameters for input to the models.

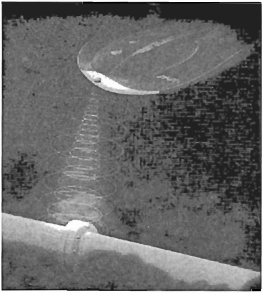
A number of computational models are available, including STOKES developed at DSTO (M.V. Hall). All are limited in their domains of validity, but between them cover most conditions of interest. DSTO research has assessed these domains for various models against benchmarks (S. Tavener, A.I. Larsson and M.V. Hall). Generally, the main limitation in accuracy is inadequate knowledge of the environment, particularly the acoustics of the bottom.

Shallow water transmission loss measurements around Australia have shown wide variation, prompting effort to determine the acoustic properties of the bottom (available geological data have not proved to be useful in this respect). Current research is aimed at developing and implementing techniques of inverting received signals from impulsive sources to determine the characteristics of the bottom acoustics (M.V. Hall, D.N. Mathews, G. Furnell and A.I. Larsson), in conjunction with laboratory measurements of bottom samples (J.I. Dunlop, University of NSW).

Interference patterns from multipath transmission provide complicated sound fields, reducing the coherence and detectability of signals. DSTO is studying the spatial, temporal and spectral statistics of the signal sound field, including measurements of amplitude and phase, and modelling of the times series, to allow signal processing to be optimised (A. Jones, A. Larsson).

Ambient sea noise provides a basic limitation on the detection of signals. It results from a variety of sources and temporal and spatial variation in Australian waters in excess of 20 dB is common. A major component results from motion of the sea surface, particularly breaking waves. DSTO has a long term project to understand the mechanisms of noise generation and the development of the noise field and its directionality (D.H. Cato, I.S.F. Jones, and S. Tavener). This has included theoretical modelling of mechanisms and experimental verification, including an extensive series of measurements of noise and its dependence on wind speed, wave height and white cap coverage.

There is continuing research on biological noise, which is widespread around Australia and is often the main component in tropical waters (D.H. Cato and R.D. McCauley). Biological choruses from large numbers of animals are show considerable



"Acoustics Vision" is an important aspect of marine acoustics that is being investigated at DSTO laboratories.

diurnal and seasonal patterns, commonly increasing noise levels by more than 20 dB in the audio frequency range, though shrimp noise extends more than 300 kHz. Whale sounds are becoming more evident as numbers increase. The intense and variable sounds of humpback whales are transient signals that must be discriminated by sonars.

In active sonar, scattering of the sonar signal from objects (e.g. fish) in the ocean or from the boundaries provides "reverberation" that limits the detection of the signal reflected from the target. Research on scattering includes measurement, particularly of bottom scattering and reflectivity at low grazing angles (G. Furnell and S. Taylor, DSTO) and general theoretical research on scattering from rough surfaces (C. Macaskill and P. Cao, Sydney University).

There is considerable effort in DSTO in assessing and improving the performance of sonar systems, including work on environment effects, sonar technology, and signal processing. The emphasis of current work is towards multistatic and combined active-passive operation for detecting vessels, including evaluation in Australian conditions of a low frequency active-passive sonar to be acquired by the Navy (S. Taylor, L. Kelly, I. Cox, J. Marwood and H. Lew). There is a continuing research on the tracking and classification of targets by multi-element systems, and on mine hunting sonars (B. Ferguson G. Speechley, D. McMahon and J. Riley). Some techniques are being applied to detection in air for Army operations. There is significant involvement by industry in sonar technology research (Tompson Marconi Sonar, Nautronix, R.J. Wyber).

DSTO projects are also concerned with the protecting vessels against sonar detection. This includes studies of their target strengths and their radiated noise (M.J. Bell, and G. Furnell). Reduction and control of vessel acoustic signatures, has addressed sources and acoustic paths to the water, and includes work on passive isolators, active noise control and modelling (C. Norwood).

Scattering of sound can be useful if it shows the environment in a way that aids detection of a target. Detection of mines on the sea floor is enhanced by the contrasting image of the sediment and the presence of the acoustic shadow. DSTO's current research includes measurement of scattering from a patch of sediment at precisely determined angles of incidence, using specially designed instrumentation, and imaging using side scan sonars (S. Anstee, A. Parkinson, R. Neill).

Scattering is also being applied to measure the thickness of Antarctic ice, the abundance of krill biomass, and fish stocks (A. J. Duncan, J.D. Penrose, G. Bush and P. Siwebessy of Curtin and T.J. Pauly, Antarctic Division).

When acoustic mines are investigated by divers or remotely operated vehicles as part of the clearance process, the noise they generate must be carefully controlled to avoid triggering the mines. DSTO is investigating the noise of divers and vehicles under operational conditions to minimise their vulnerability (B. Jessup, S. Bocquet, J. Barnes, D. Mathews, J. Mentjox, N. Capps and). DSTO is working with Australian Defence Industries to develop a new underwater noise source which would emulate ship signatures for mine sweeping (B. Castles and S. Page).

Fine scale imaging of mines is important in identification, but optical methods are ineffective in the turbid waters that are common around Australia. A research project on "acoustic vision" by DSTO and the former Ultrasonics Institute has shown the potential for innovation in underwater imaging by sound (I.S.F. Jones, D.G. Blair and D.E. Robertson). This has demonstrated that the ocean medium can support imaging of millimetre resolution at ranges of several metres, using frequencies of a few megahertz with sparse, random array technology. The project is now in the development phase with Thomson Marconi Sonar (A. Madry). Research continues on the effectiveness of the medium to support transmission at megahertz frequencies, including the scattering of sound by fine scale fluctuations in temperature and water flow, and by fine particles, and transmission through bubbly water (R.A. Thuraisingham).

"Acoustic Daylight" is a new sonar concept developed by Scripps Institution of Oceanography, California (M.J. Buckingham) that uses ambient noise to image objects in the ocean. DSTO is collaborating in further development and application to Australian conditions, particularly exploiting snapping shrimp noise (M. Readhead).

The University of Sydney has an active an active postgraduate research program in marine bioacoustics in conjunction with Taronga Zoo and DSTO (T. Rogers, K. Schultz, M. Noad, D.H. Cato and M.M. Bryden). Studies of the sounds of leopard seals in captivity and in the Antarctic have distinguished between local sounds of close range interaction between individuals and sounds broadcast by isolated individuals (both male and female) over long distances associated with breeding activity. Studies of communication sounds of three species of dolphin have related the characteristics to differing behavioural requirements of the species. Current research with humpback whales involves both acoustic and visual tracking of the whales to improve our understanding of the function of their long and complex song.

The impact on marine animals of noise from human activities is also an area of investigation (R.D. McCauley, D.H. Cato, J.D. Penrose and A.F. Jeffery). A study of the impact of whale watching on the humpback whales in Hervy Bay, Queensland has lead to guidelines on design and operation of whale watch vessels. A project at Curtin University is investigating the impact of air guns used in seismic surveys for the oil industry on a wide range of animals and includes modelling and measurement of sound propagation and ambient noise.

7. ACTIVE NOISE AND VIBRATION CONTROL

Colin Hansen
Department of Mechanical Engineering
University of Adelaide

There are a number of groups in Australia currently undertaking research in the active control of sound and vibration. Although much of the work is being funded by the Australian Research Council (ARC), a number of groups are receiving funding from industry and one group is supported entirely by the Defence Science Technology Organisation (DSTO).

University of Adelaide

At The University of Adelaide in The Department of Mechanical Engineering, the Active Noise and Vibration Control Group, led by Colin Hansen and Scott Snyder with a team of 12 postgraduate students, a Post Doctoral Research Fellow and a Research Officer, is undertaking research in a number of areas as follows.

Sound transmission into irregularly shaped enclosures

This project, funded by the Sir Ross and Sir Keith Smith Fund and The Australian Research Council, is concerned with the active control of sound transmission into enclosures of irregular shape such as aircraft cabins and motor vehicles. The project is concerned with a number of physical acoustics issues such as optimum location and type (vibration or acoustic) of sensors and actuators using genetic algorithms and the description of the vibration response of the enclosure bounding surface in terms of orthogonal acoustic radiation modes rather than normal vibration modes. Signal processing and controller issues being addressed include short-cut ways of performing on-line cancellation path identification for systems with many control channels, the development of a high-speed multi-channel floating point controller with a windows menu system for optimising the controller parameters.

Electric power transformer noise

This project is concerned with the active control of electric power transformer noise and is funded jointly by The Australian Research Council and the Electricity Supply Industry. The need for the work has arisen from the presence of substations in residential areas, usually as a result of houses being built around existing substations rather than vice versa. Problems which are being addressed by the research include control system instability resulting from many channels of control coupled with large distances between the control sources and error sensors. This problem is being tackled by using near field error sensing and fewer large control sources (cavity backed curved panels driven with piezoelectric actuators). Piezoelectric patches on the transformer tank are being considered for control of the 400Hz and partly the 200Hz tones. Near field acoustic error sensing poses some interesting problems in that only the propagating part of the field must be present in the error signal used by the controller. Other problems being addressed in the project are associated with the large number of controller channels required and associated techniques for optimising controller set-up procedures, practical installation of a system which must function for an extended time outdoors in a hostile electromagnetic environment.

Active vibration isolation

A third large project currently being undertaken at The University of Adelaide is concerned with a thorough fundamental study of the physics of active vibration isolation. The work is currently being funded by The Australian Research Council and includes the development of a 6-axis active vibration isolation system, consisting of 6-axis sensors and actuators. Error signal cost functions for minimisation which are being considered include force, acceleration and power transmission at the base of each mount. It is considered impractical to use distributed accelerometers to minimise the kinetic energy of the support structure.

Controller optimisation

Two projects are on-going in this area. One is concerned with the effect of parametric uncertainty on the performance of feedback control systems and how this may be compensated for. The other is concerned with the optimisation of algorithm parameters for feedforward control.

Other work at The University of Adelaide is concerned with a fundamental analysis of the use of shaped sensors for providing a signal proportional to sound radiated by arbitrarily shaped structures, optimisation of sensing systems and the development of a novel active vibration absorber.

The work at the University of Adelaide has led to the development and commercialisation of a low-cost multi-channel active noise and vibration control system (for both tonal and random noise) which is currently being marketed by Causal Systems.

University of Western Australia

At the University of Western Australia, there is a very active group led by Jie Pan undertaking research on a number of important theoretical and experimental projects. In addition to Dr Pan, the group consists of 4 postgraduate students and 1.5 post Doctoral Research Fellows. Projects currently being undertaken by this group include the following.

Active ear defenders

Systems being investigated include digital feedforward and feedback as well as analogue feedback. The project has received funding from the Western Australian mining industry and also involves the construction of prototype units.

Sound through walls

This project involves an investigation of the coupling and control mechanisms associated with the transmission of sound through double walls with application to the reduction of low frequency transmission of sound into an enclosure.

Pipeline noise transmission

This project is concerned with the investigation of an integrated active/passive system for the control of the transmission of structure-borne and fluid-borne acoustical energy in piping systems. Of special interest is the interaction between the pipe wall vibration and the internal and external sound fields, the interaction between passive and active control elements and the excitation mechanisms responsible for the acoustical energy.

Barriers

This project is concerned with the use of active noise cancellation to improve the low frequency performance of acoustical barriers. Issues being investigated include the effect of the ground on the performance, characterisation of the extent of influence of active control and the optimum design of the controller.

Other projects being undertaken by the group in the University of Western Australia include: active control of non-linear vibration in flexible structures, and active control of vibration in ribbed structures with fluid loading.

Australian Defence Force Academy

At the Defence Force Academy, School of Electrical and Electronic Engineering, University of New South Wales, a research group consisting of two Academic staff (Hemanshu Pota and Ian Petersen) and a Post Doctoral Research Fellow are working on an ARC funded project involving the application of H-infinity and LQG feedback control techniques to the distributed control of vibrations in a flexible structure. Control actuators and sensors being considered are piezo-electric patches and films.

University of Sydney

At Sydney University, Fergus Fricke and one of his graduate students is investigating a novel active noise control approach to reducing the transmission of intermittent noise (such as aircraft noise) into buildings. The work involves the development of a control system which shuts windows when an undesirable noise (such as a truck or plane) approaches. A large part of the work is associated with the classification of unwanted noise types and training the control system to only react to these.

University of Technology, Sydney

In the Faculty of Engineering at The University of Technology, Sydney, Guang Hong and David Eager are investigating the active control of vehicle exhaust noise; at the DSTO Aeronautical and Materials Research Laboratories, Ross Juniper and Chris Norwood are investigating the active control of fluid-borne pulsations in liquid filled pipes and with John Dickens are beginning investigations on the development of practical active/passive vibration isolation systems suitable for isolating propulsion and service equipment from the hulls of ships and submarines.

8. MECHANICAL VIBRATIONS

Len Koss
Department of Mechanical Engineering
Monash University

This section outlines vibrative and acoustic investigations which fall in to the general category of Mechanical Vibrations with or without acoustic radiation. The spectrum of research varies from heart sounds to acoustic fatigue of pipelines, however, the principles of measurement and analysis which underlie the investigations fall into the area of vibrations.

I am grateful to Bob Hooker and Samuel Asokanthan (University of Queensland), Michael Norton (University of Western Australia), Bob Randall (University of New South Wales) and Joseph Lai (Australian Defence Force Academy) for help in the preparation of this report.

University of Queensland

Transmission Line Dampers

Overhead electrical transmission lines experience Aeolian (wind-induced) vibrations which can lead to fatigue failure of conductor strands. Similar problems can arise in suspension and cable-stayed bridges.

Loudspeakers

Two loudspeaker applications are being investigated. One of the use of loudspeakers as passive absorbing devices—they can be used as narrow frequency band absorbing devices. The other concerns a more common situation, the measurement of insertion loss. A measured insertion loss can be dependent on the properties of the source loudspeaker used and the studies concern the extent of that dependence and the conditions necessary to minimise it.

Impact Noise through Floors

The project deals with sports noises—'soft' impacts such as from basketball bouncing and athletes running and jumping. These activities often operate on lightweight floors and noise is transmitted to occupied spaces beneath the sports area. The nature of the impacts, the transmission behaviour and the radiation are being modelled with a view to ensuring floor designs of adequate performance.

Dynamic Stability and Control

Several projects are in progress related to spatially distributed actuators and the optimal dynamic control of flexible systems. Some of the research is at the fundamental level, and some has been developed in the specific context of control of aerospace vehicles, and particularly of flexible components of these, such as deployable solar panels. At a more down-to-earth level, similar techniques, particularly in relation to torsional motion, are being applied to railway rolling stock in collaboration with Queensland Rail.

University of Western Australia

Research interests include noise and vibration control, flow-induced vibration and sound, the effects of dynamic stress on fatigue, unsteady boundary layer, acoustics and stability, statistical energy analysis, and noise and vibration, a diagnostic tool.

Current major research projects include vibration and strain analysis on wellhead flowlines and associated small bore piping, flare piping, vessel bore piping, major structural members, dynamic stress prediction and fatigue flowlines and small bore piping, development of dynamic stress and vibration acceptability criteria, and flow induced vibration and dynamic stress effects on industrial gas turbines. Current research projects include:

- the effects of dynamic stress on fatigue life of piping systems;
- the prediction of stress distribution in structures subjected to random excitation;
- flow-induced noise and vibration in gas pipeline systems;
- industrial and environmental noise pollution and noise control studies;
- development of adaptive-based active noise control ear defenders;
- high voltage transformer noise control;
- high temperature strain gauging and analysis;
- quantification of acoustic and hydrodynamic fields in flow duct systems;
- development of environmental noise prediction models;
- maximum entropy approach to fatigue life distribution; and
- fatigue under cyclic stressing with non-zero means.

University of New South Wales

Most of the research is in machine diagnostics, and in four main areas:

- Rolling element bearing diagnostics, including cases where the bearing (eg. helicopter gearboxes) and rail vehicle bearing diagnostics using an array accelerometers along the rail. The helicopter gearbox bearing diagnostic is the main focus so far of the work supported by AMRL under the 'Centre of Expertise' scheme. In particular, we have developed techniques to enhance envelope analysis by improving the signal/noise ratio of bearing to background noise. In particular, where the latter is dominated by gear vibrations, we developed self-adaptive noise cancellation techniques to remove it. We have developed techniques to deal with the short signals limited by the passage of the bearing past the transducer(s).
- Gear transmission error simulation and measurement with applications to gear noise studies and diagnostics. One developed method was measuring TE down to fractions of an arc second using shaft encoders mount each shaft, and also developed a simulation method which gave very good correspondence with measurement on automotive quality gears. A further development includes techniques to eliminate encoder error (thus allowing the use of much cheaper encoders) and has improved the simulation model to cover cases where the tooth deflection is a more significant part of the TE. Good agreement was obtained using nylon gears and the method should extend to precision gears. The original method was applied to quasistatic TE, but it has now been extended to include the dynamics of the gear train.
- Diesel engine diagnostics, using externally measurable signals such as accelerometers, and crankshaft torsional vibration. Part of this work is an attempt to reconstruct cylinder pressure from these externally measured sources and another part is to develop methods to recognise faults using time/frequency.
- One of the techniques being investigated for diesel engine cylinder pressure reconstitution is based on the cepstral techniques mentioned earlier. The method being developed more generally, in particular as a means of adjusting modal models, possibly measured under ideal conditions in the laboratory, to actual conditions in operation, using response measurements only, though having knowledge of the characteristics of the dominant force. A tentative conclusion from my work at KU Leuven is that as long as the largest force is bigger by a factor of at least 4 than the next largest, then principal components analysis can be used to obtain updated FRFs from those force to all measurement conditions. It is also hoped that the same techniques will be able to be used to adjust a modal model obtained on one object to all others of the same meaning that only one has to be fully instrumented and measured in the laboratory.

Monash University

Short impulses of sound, such as gunshot, have been used by a small group in the Physics Department, as a probe to investigate a number of environmental problems. These include the propagation of sound through the atmosphere, with a particular interest in the behaviour of the sound in the presence of wind and temperature gradients. More recently, this has led to a study of the way turbulence alters the shape of a pulse as it passes through the atmosphere. Simultaneously, the local meteorological conditions and the wavefonns of many hundreds of individual pulses have been recorded to study the relation between wind gusts and changes to the wave shape.

Other areas investigated have included the behaviour of cracks in acoustic barriers, where the timing between various components passing through the gap can be used to identify the path taken by the sound. The properties of soils have also been investigated using pulses of sound. By observing the change in waveshape when a pulse is reflected from a surface, the complex impedance of the reflecting material can be deduced. Similarly, the propagating constants of foams and wet soils have been deduced from the changes occurring when pulses travel in the medium. These latter studies have led to the development of an acoustic detector of buried objects, such as land mines. The fact that reflection of the pulse depends on there being an impedance discontinuity means that such a detector works equally well with plastic and metal objects.

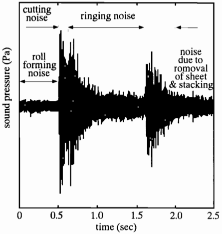
Investigation in the Mechanical Engineering Department include the development of 'frequency shifting techniques' for development of low frequency vibration, unconstrained and constrained layer damping treatments, impact vibration absorbers, motion sickness on high speed vessels and pre-natal heart sounds. The Centre for Machine Condition Monitoring uses vibration as a diagnostic tool in their investigations.

Australian Defence Force Academy

The following research projects are undertaken at the Acoustics and Vibration Unit located within the School of Aerospace and Mechanical Engineering at the University College, the University of New South Wales, Australian Defence Force Academy in Canberra:

Machinery noise

Collaborative projects with BHP Building Products have included noise reduction in the sheet metal industry and the reduction of noise in friction saws. This work has been sponsored by Worksafe Australia.



Noise signature due to shearing a corrugated metal sheet in a roll-forming production line.

Vibration Isolation

Several academics are carrying out a collaborative research program on vibration isolation with DSTO. The thrust of the program is to understand and ultimately optimise the design of machinery foundations in ships and submarines.

Human Vibration

Further, several academics have been developing instrumentation in collaboration with Worksafe Australia for the evaluation of the effects of vehicle vibrations in underground mining. Evaluation of the effects of vibrations on people is a field where standards and methods of measurement are rapidly evolving.

9. BUILDING ACOUSTICS

P. P. Narang
CSIRO Division of Building, Construction and Engineering
North Ryde, NSW

The CSIRO has a long history of scientific and industrial involvement in the building and industrial acoustics fields. The Division of Building, Construction and Engineering has two acoustics laboratories—one located at North Ryde in Sydney, and the other located at Highett in Melbourne—which are used for both research work and commercial activities. Both laboratories have reverberation chambers, and the Highett laboratory also has a vertical pair of chambers which can be used for measuring the sound insulation performance of floor systems. Areas of work covered by the two laboratories include sound transmission, sound absorption, impact sound, sound power level determination, noise emission from appliances and equipment used in water supply installations, and noise generation by mechanical ventilation equipment.

As part of the redevelopment of the North Ryde site, the acoustics laboratory was rebuilt in 1997. The new laboratory consists of two large reverberation chambers located side-by-side with a 3.6m wide by 3.0m high opening for the installation of test specimens. The two chambers are housed inside a building of conventional design which provides space for the storage of materials as well as a control room and an office area. The volume of both rooms is slightly in excess of 200 m^3 and the two volumes differ by at least 10%, in line with the recommendation of the Australian Standard 1191-1985. The concrete floor slab of each reverberation room rests on resilient vibration isolation pads and specially prepared footings. Both rooms have non-parallel surfaces and the walls are rendered and painted. The walls and roof of each room comprise double-leafed concrete and masonry construction, fully supported on the edges of the floating floor slabs. A 1.2m by 1.2m removable hatchway has also been built in one side wall for possible future work on the insertion loss measurements of mechanical equipment.

Some recent acoustics projects undertaken by the CSIRO are briefly described below.

Noise radiation by different pipe materials (including copper) attached to domestic-type wall construction, and the effectiveness of different methods of fixing pipes to the wall was investigated. The water-hammer problem and the extent to which it can be mitigated by the use of pressure limiting valves or by the installation of an air chamber in the system was studied.

Rain noise, particularly on uninsulated roofs, can be a source of significant noise annoyance. The CSIRO has been involved in the measurement of rain noise on different roof systems with real rain as well as using a mechanical simulator designed to generate spectra similar to that produced by real rain on metal roofs.

The acoustic performance of windows depends not only on the glass thickness and type, but also on the window size and type (e.g. double-hung, casement, sliding or awning), window frame, method used to mount glass, and the quality, location and type of seals used. A series of acoustic tests on single-glazed window systems of a given glass thickness showed significant variations in the sound insulation characteristics of the window units.

The opening of the third runway at the Sydney airport generated widespread community concern about aircraft noise, and as a result the Commonwealth Government decided to provide sound insulation upgrading to the worst-affected properties subject to certain financial constraints. The CSIRO has provided its technical expertise and review services for this work and has also carried out aircraft noise reduction measurements on some of the affected properties before and after sound insulation upgrading work.

Commercial work done in the acoustics area have also included: measurements of the acoustic performance of various floor underlay systems; evaluation of the performance of absorptive roadside noise barriers; and assistance to a door manufacturer to develop high performance acoustic doors with matching seals.

Sydney University

Architectural acoustics research at Sydney University covers the following areas.

Ventilation Openings

The growing movement to design "greener" buildings requires increased use of natural ventilation, which brings with it problems of noise ingress. The current research involves both passive methods, which use optimised openings and arrays of resonators, while the active system uses an "intelligent" window which opens and closes depending upon external noise conditions, such as aircraft flyover. The passive system can reduce noise levels by 10 dB(A) and the active system by as much as 20 dB(A).

Auditoria

This research is based upon neural network analysis of existing auditoria. Predictions of reverberation time using this technique are better than those using classical reverberation equations and ray-tracing software, while correlation coefficients of about 0.9 have been achieved for prediction of overall acoustic quality.

Sound in Small Rooms

Several projects are investigating the recording and reproduction of sound in small rooms. Preferences are linked to objective tests and to the physical dimensions of the rooms, and methods are being investigated to increase apparent reverberation time.

National Acoustic Laboratories

NAL has excellent acoustical measurement and testing facilities that are being used increasingly for tasks related to building acoustics. There has been particular interest in testing of windows, all types of secondary glazing, acrylic window barriers, and heavy single-glazed units for the upgrading of hotels and other community facilities.

Other tests have encompassed the behaviour of lagging and noise barriers, together with materials such as fibreglass, rockwool, polyester and cellulose fibre. There has also been testing of extruded plaster and concrete products and heavy walls and windows.

10. ENVIRONMENTAL ACOUSTICS

Renzo Tonin
Renzo Tonin & Associates Pty Ltd
Sydney

Power Industry

Colin Hansen from Department of Mechanical Engineering, Adelaide University SA is doing research on active control of electrical transformer noise. Funded under a collaborative ARC grant with Transgrid, ETSA, SEQB, United Energy, Integral Energy, Energy Australia, Powerlink QLD and AESIRB. The Project began in 1996 and is scheduled for completion in 1998. Its aim is to have a demonstration system in operation at a transformer installation by the end of the project. Research is focussed on effective sound sources, use of near field error sensors to control far field noise, use of tank vibration control, weatherproofing microphones and sound sources, effects of electromagnetic fields on system performance, development of a controller with a large number of interacting channels and solution of practical problems associated with on-site installation.

Mike Norton and Jie Pan from the Department of Mechanical and Materials Engineering at the University of Western Australia, Nedlands are also working on the development of practical techniques to control noise from existing power transformers, funded by Western Power.

Road Noise

Lex Brown and Joseph Affum at the School of Environmental Planning Griffith University, Nathan, Brisbane are working on integrating environmental noise evaluation directly into transport demand modelling. This research looks to integrate the output of travel forecasting procedures with land information systems, to provide an "automatic" assessment of the noise consequences of different scenarios in transport systems design.

Lex is also working on the development of a windows based user friendly model for traffic noise to evaluate different barrier positions, heights and window heights for use by architects, planners and students.

A significant proportion of Stephen Samuel's effort at the University of New South Wales, School of Civil Engineering, Department of Transport Engineering in Sydney is devoted to evaluating the noise characteristics of various rigid pavement surfaces. This ongoing work is assisting in the design and development of low noise pavements that also provide optimum drainage and skid resistance properties. Stephen is also studying the acoustic attributes of traffic speed control devices used in Local Area Traffic Management schemes.

Most of us are familiar with Stephen's interrupted traffic flow model he developed whilst at the Australian Road Research Board. He is proceeding, albeit at a low level, on enhancing this model. Stephen has also just about completed research on the fuel consumption characteristics of Australian Defence Force trucks. Outcomes of this work will include fuel saving recommendations and management plans that include issues such as the adoption of alternative fuels.

Jie Pan from the Department of Mechanical and Materials Engineering at the University of Western Australia, Nedlands, is supervising J.N. Guo, a PhD student who is working on active noise control of traffic barriers. They recently published promising results at the AAS 1996 annual conference in Brisbane.

Robin Alfredson Dept of Mechanical Engineering at Monash University, Clayton is preparing a paper for the WESTPRAC conference later this year in Hong Kong in which he will investigate the influence of surface impedance on the effectiveness of noise barriers for road traffic. The objective is to optimise that impedance and compare that effect with the effect of two other variables that can be easily be varied, namely barrier height and barrier shape.

Marion Burgess at the Acoustics and Vibration Unit at the Australian Defence Force Academy in Canberra is investigating new noise limit guidelines, in particular for Canberra which differs from other cities.

Peter Karantonis from Renzo Tonin & Associates Pty Ltd in Sydney has just completed a research study for the NSW RTA involving the measurement of service brake parameters in large road haulers typically used in the transportation industry. The aim of the exercise was to determine whether a ban on exhaust brake usage near populated areas, permitting only service brakes to be used, would compromise safety in respect of generating high brake pad temperature and wear. The study found that safety would not be compromised and reports the costs associated with additional brake pad wear. Therefore, the issue becomes one of whether industry or the community is willing to pay for the additional costs imposed. The results will be published later this year at the AAS annual conference in Adelaide.

Community Response

Fergus Fricke from the Department of Architectural and Design Science at the University of Sydney is studying annoyance predictions using neural network analysis. This work involves taking the results from a number of environmental noise annoyance surveys, such as the Bullen and Hede one on aircraft noise in the early 80's, and predicting the overall noise annoyance from the answers to individual questions in the surveys. The work is aimed at finding out whether the relationship between various factors is linear.

Renzo Tonin from RTA Technology Pty Ltd in Sydney has just completed two years research and development into developing a multi-media system for the visualisation and auralisation of EIS projects (road, rail, aircraft, mining etc) to the community. His first completed project was a multi-media display simulating the effects of the proposed long term operating plan for Kingsford Smith Airport announced by the Minister for Transport and Regional Development, John Sharp, as it affects the Hurstville community in Sydney. In the first four weeks, over 1000 people viewed the display and provided comments. This presentation method looks like it will be an important component of future EISs. Renzo is currently working on a traffic noise display for the M5 East. He has just spun off a new company called RTA Techvision Pty Ltd to promote the venture.

Aircraft Noise

Karl Mezgailis from the Federal Airports Corporation in Sydney is co-ordinating various projects primarily as a result of the DASETT recommendations for the Third Runway, the Sydney (Kingsford Smith) Airport. These studies focus on the effects of aircraft noise on human health. They are being undertaken by Norm Carter from the National Acoustic Laboratories and the University of Sydney, and include an evaluation of Airservices Australia's Noise and Flight Path Monitoring System, a study of the mental health and human reaction to aircraft noise and a study of the effects of aircraft noise on the blood pressure of primary school children.

Marion Burgess at the Acoustics and Vibration Unit at the Australian Defence Force Academy in Canberra is working on amelioration measures for residents exposed to high levels of aircraft noise. A current study on this topic involves an assessment of the effectiveness of the house insulation program for homes around Sydney Airport.

11. OTHER TOPICS

Because this review has been organised along sub-discipline lines, there are inevitably many topics that have not been included. We mention just a few of these here, to show the breadth of Australian interest in acoustics.

At the Australian National University there are several diverse projects in the acoustics area. Bob Williamson and Rod Kennedy are investigating microphone arrays and have developed signal-processing techniques that allow broad-band beam forming. These techniques are useful for speaker tracking, reverberation control and noise reduction in complex environments. A group working with Bruce Millar is concerned with computer speech recognition from both fundamental and applied points of view. This work can be applied both to speaker recognition and to the recovery of spoken information.

Elizabeth Lindqvist, with her group at RMIT, is investigating the propagation of sound through porous and fibrous materials and the applicability of the Biot model. Other projects involve the effects of low-frequency sound on fluidised beds and wind-induced turbulence noise in motor vehicles.

Other areas of interest include subjects as diverse as the acoustic properties of Australian natural timbers and phonon spectroscopy at liquid helium temperatures. Some of these more exotic fields will be the subject of another review.

Active Isolation of a Vibrating Mass

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ABSTRACT: Active vibration isolation can offer improved performance at low frequencies compared with passive isolation. Active control methods require the selection of a suitable cost function to be minimised. Experimental results are presented of the active vibration isolation of a simulated rotating machine mounted to a beam which uses two types of cost function, the force and acceleration respectively at the base of the isolator. The results show that minimisation of one type of cost function does not necessarily lead to the minimisation of the other cost function.

1. INTRODUCTION

Conventional passive vibration isolation of machinery from supporting structures, typically utilises springs, air mounts, rubber blocks or sheets of neoprene. An isolation system is usually selected based on the operating frequency of the machine. For example, an electric motor rotating at 1440 rpm has an operating frequency of 24 Hz. The machine mounted on the vibration isolators must have a resonance frequency less than the driving frequency for vibration isolation to occur. More specifically, the driving frequency of the machine should be at least $\sqrt{2}$ times the resonance frequency of the system. However, by selecting a vibration isolator of low stiffness, so that greater isolation occurs, the deflection of the mount will be large and this may result in unacceptable instability of the system. Consequently a compromise has to be made to balance the vibration reduction with the deflection.

By using active vibration control combined with passive isolation, deflections can be reduced compared with those required for passive vibration isolation and vibration levels can be reduced compared to those achieved only with a passive isolation system. Active vibration control utilises a control shaker (magnetic, piezo-electric or hydraulic) which provides a counteracting force to reduce vibration levels as well as one or more sensors to evaluate the performance of the control and to provide error signals to the controller.

As an illustration of the potential of active vibration isolation, an 8 kg mass supported by an active vibration isolator was excited using a shaker. The isolator was attached to a simply supported beam, 1.5 m long. Figure 1 shows the experimental set up.

This arrangement can be thought of as a vibrating machine mounted on an isolator. The top mass represents the machine to be isolated and the upper shaker provides a simulated out of balance which disturbs the system. The spring and control shaker are the passive and active isolation systems while the lower mass and beam represent the foundation, including its flexibility and mass. The intention of the active vibration isolator in this case was to reduce the vertical vibration transmitted into the supporting beam.

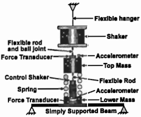

Figure 1. Beam experiment set up.

2. INSTRUMENTATION SETUP

An accelerometer and force transducer were placed on the top of the mass and between the isolator and the beam to measure the vibration transmitted into and out of the vibration isolator. Charge amplifiers were used to convert the piezo-electric transducer signals into voltage signals, which were recorded by the digital signal analyser.

In the example discussed here, feedforward active vibration control was used which employs a digital controller generating an appropriate control signal based on error and reference signals. The controller was basically an adaptive electronic filter, which had the objective of minimising the error signal. A Causal Systems EZ-ANC digital controller was used to provide a control signal which was amplified to drive the control shaker inside the active vibration isolator. The reference signal was provided by an electronic oscillator on the digital signal analyser. In practice, a suitable reference signal could be obtained from a tachometer attached to the rotating shaft of the vibrating machine, which can be used with additional electronics to generate a reference signal containing the shaft rotational frequency and its harmonics. The same reference signal was also used by the power amplifiers connected to the primary shaker to provide a disturbing force, which simulates the harmonic vibration from a rotating machine. The vibration isolation performance was compared for two different error signals. The first was the acceleration at the base of the isolator, and the second was the force between the lower mass and the beam. Figure 2 shows the instrumentation set up.

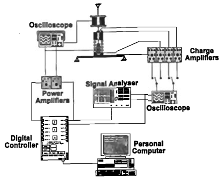

Figure 2. Instrumentation set up.

3. EXPERIMENTAL RESULTS

The driving shaker excited the mass at a single frequency and the amplitude was adjusted so that under passive vibration isolation (without the control shaker operating) the force into the top mass was 1 N.

Figure 3 shows the acceleration levels of the beam when the accelerometer in the base of the isolator was used as the error sensor.

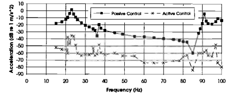

Figure 3. Acceleration level using passive and active vibration control - acceleration error sensor.

It took approximately 30 seconds for the system to stabilise and achieve the maximum attenuation using active control. When the measurements were taken, the adaptation was turned off.

Figure 4 shows the force levels exerted by the base of the isolator on the beam when the accelerometer in the base of the isolator was used as the error sensor.

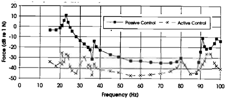

Figure 4. Force level using passive and active vibration control - acceleration error sensor.

Figure 5 shows the acceleration levels of the beam when the force transducer in the base of the isolator was used as the error sensor.

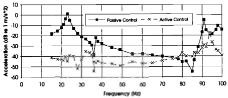

Figure 5. Acceleration level using passive and active vibration control - force error sensor.

Figure 6 shows the force levels of the beam when the force transducer in the base of the isolator was used as the error sensor.

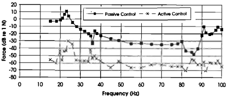

Figure 6. Force level using passive and active vibration control - force error sensor

These results show that the vibration isolation performance is dependent on the chosen error signal. When the acceleration at the base of the isolator was chosen as the error signal, the acceleration at the base of the isolator was reduced by between 20-65 dB. However, the force at the base of the isolator was reduced by between 0 and 35 dB. When the force at the base of the isolator was chosen as the error signal, the force was reduced between 5-55 dB. However, the acceleration signal was reduced by at most 40 dB and at some frequencies was actually worse than passive isolation. In each case, the controller tried to minimise the chosen error signal which is shown in Figures 3 and 6. These two figures show there is always some improvement in vibration isolation for the controlled parameter. What the results demonstrate is that controlling one parameter (say force) does not guarantee that the other parameter will also be reduced (say acceleration).

To improve the vibration isolation with active control, an error signal must be used which combines both acceleration and force. There are two methods which can use both acceleration and force signals. The first is to use two error signals (force and acceleration) and minimise both error signals. Intuitively this seems a reasonable solution and it is possible to improve the results by placing greater weighting on the error signal which would provide the greatest vibration isolation. This would give improved performance at one frequency, but would not necessarily give improved performance for the operating frequency range. Clearly this method is not suitable for general active vibration isolation applications as some manual adjustment is required to ensure that the best performance is obtained. The second method is to combine the force and acceleration signals into a vibration intensity or power transmission signal. This method has been used by Pan et al (1993) but the experimental work required manual adjustment of the amplitude and phase of the control signal. Recently an algorithm was developed by Kang and Kim (1997) which was used with an adaptive controller for controlling the acoustic intensity in a duct. This method could be applied to the reduction of vibrational power transmission in an active isolation system.

The rigid mass in the experimental setup described here was excited with harmonic vibration. This has computational advantages for a feedforward controller in that the repetitive nature of the signals means there is no need to calculate the required control signal faster than the time taken for the vibration signal to travel from the vibration source to the control source location. In other words, the system does not need to be causal. If the experimental setup were to be excited with random vibration, then unless the system were causal, the controller would never be able to generate an appropriate control force to prevent the disturbing vibration from reaching the support structure. Instead, the task of the controller would change to the minimisation of the modal response of the support structure once the vibration had disturbed the support structure. Alternatively if the system were causal, then feedforward control is likely to be successful over a frequency range of about two octaves. The actual frequency bands for which the controller would be effective would depend on the sampling rate used for the reference and error signals. For further information on active vibration isolation, see Hansen and Snyder (1997) and Fuller et al (1996).

The work described here has indicated that it is possible to reduce the vibration transmission from a harmonically vibrating machine by using active vibration control techniques. The results indicate that the degree of vibration isolation depends on the cost function chosen to be minimised. The acceleration and force cost functions give different results because their minima do not coincide, as a result of structural damping. Current work is underway to continue the investigation using vibrational power transmission as a cost function and to investigate the effect of moment excitation on the vibration isolation performance.

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Sound in the Animal World

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ABSTRACT: Energy relations involved in sound production by animals are examined, and it is found that different animals devote vastly different fractions of their available muscular energy to this form of communication. Typical sound energy output is found to range from a fraction of a watt for particularly noisy animals, through a typical value of around a milliwatt, and down to a microwatt or less for tiny insects. Consideration of atmospheric propagation and background noise suggests an optimal song frequency for a given available acoustic power, the preferred frequency for a power near 1mW being in the range 1 to 10kHz. Mechanical and pneumatic methods of sound production employed by animals are reviewed, and brief consideration is given to auditory systems and to the encoding of information in vocal utterances.

1. INTRODUCTION

Although vision, touch and smell are all important, the principal means of communication for most species in the animal kingdom is through sound. It is therefore interesting to examine the physical limitations to this form of communication and to see how various animals have adapted to exploit the possibilities. As we might expect, many different strategies are used, depending upon the habitat, size, and mode of life of the animal concerned, and it is not possible to mention all of these here. Examination of a representative sample, however, shows the wealth of variety that exists, and makes clear some of the physical principles involved. As we might expect, there have been many books and papers written about the subject from behavioural, anatomical and physiological points of view. The interested reader is referred to some of the more general books on the subject [1-5] which in turn lead to the more specialised literature. Not surprisingly, human hearing and speech [6-9] receive particular attention, as also does bird song [10].

2. ENERGY PRODUCTION

The amount of sound that an animal can produce is ultimately limited by its total available muscular energy, so it is useful to have an estimate of this quantity. Order-of-magnitude estimates suffice for this argument, since a few decibels more or less in sound power are not significant. For a human, the extreme of energy production is approached in exercises such as running up stairs. In rough terms, for a 100kg adult running so as to achieve a vertical ascent rate of 1 m/s, this amounts to about 1kW, or about 10W/kg of body mass. Of course this rate can be maintained for only a short time, and a more realistic continuous rate, corresponding to walking up an incline of about 1 in 10 at 1m/s is about 100W or 1W/kg (though a trained athlete could do rather better). For comparison, the energy production rate required simply to keep the body functioning is about 100W, so that the human machine is not a very efficient producer of continuous mechanical energy. Most vertebrates can do several times as well as this in terms of power output per kilogram of body weight, as we can see by noting that a dog or a horse can run uphill at least three times as fast as can a man, though perhaps this is in part because quadrupeds use the muscles of four legs, rather than only two, when they run. We might also note that one horsepower is 746W, which is about 1W/kg for a horse, and we might presume that this level of output can be maintained throughout most of a working day. A cursory examination of insect performance suggests relative performance significantly higher than that of other active animals, so that we can estimate about 10W/kg or 10mW/g as the maximum sustainable power output in this case.

Returning to available power, it is useful to relate this to sound production. As we shall see presently, the typical efficiency with which mechanical energy can be converted to acoustic energy is only about 1 percent, though it may be a good deal lower than this for some conversion systems. Against this figure, rather surprisingly, we must put the observed fact that many animals produce a maximum sound power of around a milliwatt–quivalent to an intensity of about 80dB at 1–almost independently of size. This is certainly true of humans, dogs, birds, and noisy insects such as cicadas. A human thus invests about 100mW, or only 0.1% of available energy, in sound production, while for a cicada weighing only about 1g the sound-production energy investment of about 10mW (allowing for a sound-production efficiency of nearly 10% in this case) is almost equal to the total available energy used for flying.

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3. SONG FREQUENCY

Another feature of sound communication that is, at first sight, surprising is that we can hear the known songs of nearly all animals (although this statement is itself perhaps a tautology!). Indeed it is only the echo-locating chirps of bats, typically around 60-80kHz, that lie outside our normal hearing range of around 20Hz to 20kHz. Is it that human hearing has an immensely wide frequency range, or is there some physical factor that mandates a restricted choice of frequency?

The object of sound production is, of course, to communicate, principally to members of the same species. This suggests that sound production organs and auditory organs will be similarly tuned, but does not influence the frequency band. On top of this comes the evolutionary advantage of being able to communicate over as large a distance as possible, since sound communication serves the dual roles of attracting mates and of defining territory. Large initial vocal power clearly helps here, but efficiency of sound transmission is also important.

Suppose that we start with a single-frequency source with a power of 1mW, which is typical for a "loud' biological source such as a large bird singing or a human shouting. If we assume the source to radiate equally in all directions then, as shown in Fig. 1, the sound-pressure level at 1m is about 80dB, and this falls by 6dB for every doubling of the distance from the source. It makes little difference, only 3dB overall, whether we assume radiation into a sphere or, more realistically, into a hemisphere bounded by the ground. This overall inverse-square-law behaviour is, of course, independent of frequency, but this is not the whole story. On top of simple spherical spreading, we have to consider sound absorption in the air, and this is quite strongly frequency-dependent, the absorption coefficient increasing as the square of the frequency.

When we put these two effects together, as shown in Fig. 1, we see that the curves for sound of high frequency soon drop well below the inverse-square-law line. The attenuation has a quite extreme effect at ultrasonic frequencies, and such sounds can scarcely propagate beyond a few tens of metres. Conversely, sounds with frequencies below 1kHz suffer very little extra attenuation out to ranges of several kilometres. This effect is dramatically demonstrated in the case of a thunder clap, which has a very high instantaneous acoustic power level and so can be heard over very large distances. The thunder impulse has a very wide acoustic spectrum and, close at hand, gives the impression of a sharp sizzling snap. At a distance of a kilometre or so, the snap is gone but the crash is still bright and clear. When the thunder is delayed by more than about 15 seconds after the lightning stoke, implying a distance of more than about 5km, the sound is a dull rumble with low-frequency components dominating.

In addition to these attenuation effects, which would appear to favour a very low song frequency, an animal must contend with the masking effect of background noise, largely created by wind in vegetation. This background noise will depend very much on the environment, but has the general property that its sound-pressure level rises with decreasing frequency. Indeed, natural background is one of those noise types for which the energy is approximately inversely proportional to frequency–so-called $1/f$ noise. If we consider one-third-octave bands as representing the frequency range over which background can mask a pure-tone signal, then the noise level in each of these bands increases by 10dB if the centre frequency is lowered by a factor 10. This effect clearly works in the opposite direction to the attenuation effect, since low frequencies are increasingly likely to be lost in the sea of background noise.

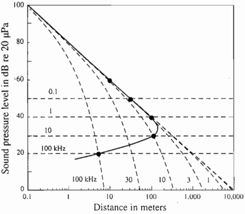

Figure 1. Propagation characteristics of sound of various frequencies (shown in kHz as a parameter) in air, from a source of power 1mW (broken curves), together with typical one-third-octave-band noise levels (about 40dB(A) overall) at the same frequencies (broken lines). The intersections of these two sets of curves (full curve) define the communication distance within which the signal-to-noise ratio is better than 0dB. (Modified from [1].)

This situation is illustrated also in Fig. 1, where the background noise levels in one-third-octave bands in a moderately quiet environment of about 50dB(A) are shown superimposed on the propagation curves for our 1mW single-frequency source. If we follow the propagation curve for a frequency of 100kHz, then we see that the signal becomes submerged in the background noise at a distance of about 6m from the source. Distances where the signal becomes less than the noise can be similarly identified for other frequencies, and the result is the curve shown, from which it is clear that greatest audibility distance is achieved if the signal frequency lies in the range 1-10kHz, the distance then being about 200m under the noise conditions considered.

The graph in Fig. 1 was drawn for a source of acoustic power 1mW, corresponding to a human shout, a moderately loud bird, or a very noisy insect such as a cicada. For a smaller and less powerful insect, say one with an acoustic power of only 1μW, the signal propagation curves are all lowered by

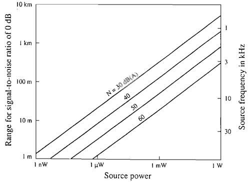

Figure 2. Optimal frequency and communication distance for a signal-to-noise ratio greater than 0dB for narrow-band sources of specified power in ambient noise of the level shown as a parameter. The figure is not meant to be quantitatively exact. (Modified from [1].)

30dB, and the intersections suggest an optimal frequency of around 10kHz and a range of about 10m. Of course, insects are gregarious, and many individuals of the same species will be singing at once, so the effective range is very much less than this because of the enhanced background in the song-frequency band. These conclusions are summarised in Fig. 2, which gives, in approximate terms, the optimal frequency and range as functions of source power under various conditions of background noise.

The association between low power and high optimal communication frequency has other obvious advantages. Within a given family of animals, we expect smaller species to have less power available and hence to be able to produce only quieter songs. At the same time, their lighter bodies and smaller size are better adapted to produce higher-frequency sounds, and high frequencies will tend to maintain the radiation efficiency.

When we examine the songs of typical animals, we see that they fit well into this framework. Humans have fundamental speech frequencies in the range 100-300Hz and song frequencies up to about 1000Hz, but most of the speech information is carried in the "voiced" vowels, which have formant bands–resonances of the vocal tract–in the range 500-2500Hz, and in the consonants, which are essentially wide-band noise with some formant shaping, extending up to about 5kHz and in some cases accompanied by a voiced component. Operatic singers have learned to produce a further vocal formant, centred at about 3kHz, which makes their voices particularly recognisable against an orchestral background. The human auditory system, quite naturally, has evolved to match the range of the human voice, with maximum sensitivity in the range 500-5000Hz. The "singer's formant" lies close to the frequency of maximum sensitivity of the human auditory system, and so is particularly effective.

Birds have fundamental song frequencies in the range 500-2000Hz, and vocal formants extending up to about 8kHz, depending on the size of the bird. Their auditory systems have similar range to the human ear, though extending to somewhat higher frequencies. Insects, on the other hand, generally have a song consisting of a modulated pure tone. The loud cicada has a song frequency of about 3.5kHz, which explains its particular insistence to human hearing, while smaller cicadas and other insects have song frequencies around 5kHz.

The one apparent exception to this scheme is the bat, which uses echo-locating calls with frequencies typically in the range 60-100kHz, depending upon the species. The animal's purpose, however, is not communication with other bats but rather the sonar location of obstacles and flying insects. For these purposes a range of 5-10m is all that is required, and a short wavelength λ is also necessary, since the echo strength varies as $1/\lambda^4$.

We could carry out a similar analysis for aquatic animals such as whales, seals and dolphins, though the results would be different because of the different propagation properties of the ocean. Two things enter here. Firstly, for long distances the ocean is essentially 2-dimensional rather than 3-dimensional, partly because of its limited depth, but also because of its layered thermal and haline structure. The attenuation due to spreading with distance is therefore only 3dB for a doubling of distance rather than the 6dB characteristic of the atmosphere. Secondly, although the attenuation of propagating sound in sea water increases roughly as the square of the frequency, as it does in air, the actual attenuation is very much less, the figures at 1000Hz being about 5dB/km for air and only 0.05dB/km for water. This, in turn, raises the background noise level very greatly. Aquatic mammals therefore have rather different acoustic problems to overcome, but generally adopt frequencies not too different from those of land-living animals of similar size. The exception, once again, is the high frequencies of the sonar clicks used for echo-location by dolphins, and this for similar reasons. Crustaceans also make high-frequency sounds, rather like insects.

4. SOUND PRODUCTION

Sound production mechanisms in animals can be divided into two classes. Insects, which have no lungs but absorb oxygen by simple diffusion through a tube-like spiracle system, necessarily make sound by mechanical means, while animals with lungs and associated muscles generally use pneumatic generation. Let us consider these in turn.

Insects have a stiff outer cartilage exoskeleton, membranous wings, and stiff wing covers, all of which can be induced to vibrate at their mechanical resonance frequency by rubbing one part against another. While simple friction might suffice, the mechanism generally involves scraping a file across a pic, or vice-versa, the tooth spacing and speed being adjusted to give mechanical resonance. While this simple mechanism is widely used, it is not very efficient, because the vibrating surface is small and acts as a dipole radiator. A simple estimate suggests an efficiency of order 0.01%, and

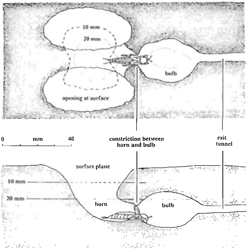

Figure 3. The mole cricket singing burrow. (From [11].)

indeed the sound energy produced is generally in the microwatt range.

There is one very interesting and efficient modification of this system, adopted by the mole cricket [11]. This insect digs a burrow in moist earth, the shape being roughly that of a curved exponential horn, terminated at its narrow end by a hollow bulb, as shown in Fig. 3. The cricket positions itself in the constriction between the horn and the bulb, and there vibrates its wings to produce its song. The dimensions of the horn (length about 45mm, throat diameter about 10mm and effective mouth diameter about 35mm) and of the bulb (length about 25mm and diameter about 17mm) are such that the cricket song at about 3kHz is resonant with the second horn-and-cavity mode, to which the cricket wings couple efficiently. The whole burrow gives an increase of nearly 20dB in radiated power over that of the insect in free air.

The cicada has developed a much more efficient singing mechanism, but at the expense of evolving a specialised sound production organ. The essential feature is an abdominal cavity, closed by two rather stiff ribbed membranes, called timbals, which can be flexed inwards by attached muscles, thus generating a train of pulses at the resonance frequency of the loaded cavity. This is an efficient radiator, since it is a monopole rather than a dipole source, and also since the resonator has a fairly high Q value. Calculations suggest an overall efficiency as high as 10%. One species of cicada, the green bladder cicada found on the coast and tablelands of Eastern Australia, has taken sound production to an extreme by evolving a huge abdominal bladder for the resonator. This has allowed it to use a much lower song frequency, around 800Hz, but the penalty is that the male, which is the singing partner, is scarcely able to fly. The reason why the low song frequency has been adopted is not clear.

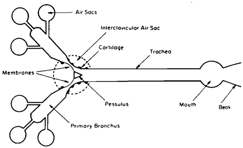

Figure 4. Simplified model of the avian vocal system, as used for calculation of acoustic performance. (From [13].)

When we come to animals with lungs, the sound production mechanism becomes pneumaticæair is forced between two membranes or folds of cartilage in the larynx in such a way as to cause them to vibrate at very nearly their mechanical resonance frequency [12]. The tube of the vocal tract between the larynx and the mouth opening acts as a resonator but, since its lowest resonance is generally at a frequency many times that of the vocal valve oscillation, the resonant pressure feedback does not greatly assist the oscillation but simply increases the relative level of harmonics lying close to the resonances. This is distinct from the situation in the otherwise similar case of playing brass instruments such as the trumpet, where the lip vibration frequency is tuned by the player to match a prominent resonance of the instrument horn. This distinction results in a lower acoustic conversion efficiency, which is typically less than 1% for vocal systems, compared with a value that can approach 10% for the trumpet.

There are many minor variants of this sound-production mechanism. In humans and other mammals, the symmetrical vocal folds of the larynx lie in the trachea above its junction with the two bronchi carrying air from the lungs. Some birds have a similar positioning of the vocal organ, or syrinx, but the folds are replaced by membranes that are made to protrude into the airway by means of air pressure in a surrounding sac. So-called song birds, on the other hand, have two of these vocal membranes located one in each bronchus just below its junction with the trachea, as shown in Fig. 4. Some birds use only one syrinx membrane in singing, but some use both and are able to produce two tones simultaneously, though they generally do so only on isolated notes of the song. In some birds, such as the familiar sulphur-crested cockatoo, the syringeal oscillation is actually chaotic, producing a loud raucous screech.

It is interesting to examine the energy input to the vocal organ. In ordinary human speech, the pressure below the vocal valve is of order 300Pa (3cm on a water manometer) and the flow rate is about 300ml/s, making a total pneumatic power input of about 100mW and giving an acoustic power output of about 0.1mW. the conversion efficiency is thus about 0.1%.

For a trained singer, the lung pressure may be about 1kPa and the flow rate about 500ml/s, giving an input power of about 500mW and an output power that may be as high as 10mW, implying an efficiency of about 2%. Similar calculations can be made for birds [1,13], which may use rather higher pressures and, because of their smaller size, smaller flow rates. Birds such as cockatoos and domestic roosters can achieve peak acoustic outputs of more than 100mW with an efficiency of around 10%, but for most species the output is less than 1mW and the efficiency less than 1%.

It is interesting to compare these figures with those for musical wind instruments, although, as remarked above, the resonance conditions are quite different from those of vocal tracts. Maximum power output for flutes, clarinets, oboes and bassoons is just a few milliwatts, and the conversion efficiency is around 1%. For brass instruments such as trumpets, maximum power output approaches a watt, and the conversion efficiency can be as high as 10%. These figures are thus surprisingly similar to those for natural pneumatic vocal systems.

When we come to consider aquatic mammals such as seals, dolphins and whales, the sound production mechanism is rather similar to that for land-based mammals, except that the air may be exhausted from one body cavity to another through the vocal folds, rather than being expelled. This works because of the good acoustic impedance match between body tissue and the surrounding water, which allows efficient radiation from body vibrations, a mechanism that is subject to a 30dB impedance mismatch loss in the case of animals in air. This air-conservation strategy has obvious advantages for animals that dive deeply.

5. HEARING

The varieties of hearing mechanism that have developed in various animals have been discussed in some detail before in this journal [14], as well as in other publications [1-5], and we therefore deal with this topic rather briefly. In all cases, the hearing mechanism is based upon the deflection of hairs embedded in sensory cells. Deflection of the hair by an amount comparable to an atomic diameter opens ion channels in the cell membrane, which allows it to depolarise and send a pulse along its axon towards the brain. In insects and crustaceans these hair cells on the outer parts of the body are often the primary means by which motion of the surrounding air or water is detected. Being velocity or displacement sensors, they give information about sound direction as well as about frequency and amplitude. If the hairs are tuned elastically, then they respond primarily to a limited bandwidth.

In higher animals, though also in many insects such as flies or crickets, there are additional specialised auditory organs consisting essentially of a membrane covering a cavity and conveying its vibrations through a mechanical link to an auditory capsule in which the hair cells are embedded. The appreciable area of the diaphragm improves the auditory sensitivity, while its mechanical properties tune the system response. It is, of course, basically a pressure sensor, and is so not sensitive to sound direction. A pair of such ears can, however, be coupled acoustically by means of a common cavity or by interconnecting tubes to give a cardioid response and thus good directional sensitivity. In the case of humans and other mammals, the acoustic connection between the two ears is, however, essentially inoperative because of the small tube size, and sound direction must be determined by neural analysis of the outputs from the two ears. There are also clues from the frequency-dependent directionality of the external ear [15].

The auditory capsule, for its part, may also perform a frequency analysis by means of some sort of tuning of its component hair cells. In the case of the human auditory capsule, the cochlea, this analysis function is carried out with the aid of a tapered and fluid-loaded membrane, the basilar membrane, to which the hair cells are attached.

The threshold sensitivity of most diaphragm-based animal ears is not very different, ranging from about 10dB to 30dB sound-pressure level at the frequency of maximum sensitivity. Simple insect ears, such as those of the fly or cicada, have a frequency range of less than an octave, to match the song of their species, while the range of efficient human hearing is around two decades or about 6 octaves. Animals such as dogs have somewhat wider hearing range, and bats, of course, have specialised hearing in a narrow range around their ultrasonic cry frequency.

6. CODING AND INFORMATION

The purpose of producing sounds is, of course, to convey information, and for this purpose the song or speech must be coded in some way. In the case of human speech, we are familiar with the coding of speech sounds that we classify as vowels and consonants. These differ in their spectral properties in characteristic ways, and feature detectors in the brain are able to recognise and decode the patterns. The fundamental voice frequency plays rather a small role in most languages, serving principally to express emotion, though there is an exception to this in the tonal languages of Asia, where variations in the fundamental pitch of vowel sounds are a primary encoder of meaning.

Birds also have songs that may be very complex, involving both rapid pitch variation, formant changes and other articulations. It is unlikely that these features have much information to convey, and they probably serve simply as markers of status or experience on the part of the singer, attracting a mate and advertising the ownership of territory.

Animals such as frogs, cows, and even dogs, have a very limited vocal repertoire, and presumably do not rely upon vocal utterances to convey detailed meaning to other members of the species. Insects, too, have very stylised songs, coded by carrier frequency and repetitive time pattern, which serve largely to broadcast the presence of a male of the species.

7. CONCLUSION

In this brief survey it has been possible to mention only a few of the fascinating features of animal acoustics. My purpose in doing so has been to emphasise that physical acoustics has a useful role to play in providing a quantitative framework to underpin the studies of biologists.

ACKNOWLEDGMENT

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Validation of Environmental Noise Model (ENM Windows)

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1. INTRODUCTION

The Environmental Noise Model (ENM) simulates outdoor sound propagation and predicts noise levels from known noise sources for close and distant locations. The Model calculates attenuation due to noise source enclosures and other noise control measures, for distance from the source to the receiver, for the noise source size, type and directivity, for barriers and natural topographical features and for sound absorption in the air.

Excess attenuation from ground absorption effects such as those due to vegetation, bare ground or hard surfaces are derived using the most recently available scientific theories. Weather conditions such as wind speed and direction and the vertical temperature gradient of the atmosphere are also accounted for. Program ENM provides both a detailed quantitative output of each algorithm for each source or plots a noise contour map predicted for the area of concern. Other ENM Windows features include the following;

- ENM capacity allows for 1000 sources.
- Source directivity spectra at any selected angular point or 20 ISO points. Horizontal and vertical angle increments can also be specified.
- Both a plan and elevation view of barriers can be drawn to take account of finite width barriers.
- Individual points in Map contours can have their own Z co-ordinate so that ridge lines and sloping barriers can be incorporated.
- Automatic batching is available to enable faster runs with different meteorological conditions. Output is immediately available in a window. Contours are automatically coloured and labelled with dB(A) values (see Figure 1, for example).
- Full hardware support for any device capable of running under Windows 3.1 and Windows 95 including digitisers, plotters and printers.

ENM was developed by RTA Technology Pty Ltd of Sydney, Australia [1]. Since its first released in 1986, it has found international acceptance. The introduction of ENM Windows results in a simpler and uniform user interface and makes the program simpler to learn using the on-line help system. In this paper, the program's features are described together with a review of its accuracy reported in practical situations.

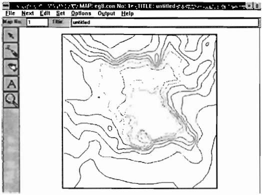

Figure 1. Example of Contour Output

2. ENM Calculation Algorithms

The basic format for the calculation in ENM is as follows;

$$L_p = 10\log_{10}\sum_n 10^{Ln/10} \qquad (1)$$

where the sound level from source n is

$Ln = Lw + D - A_1 - A_2 - A_3 - A_4 - A_5$

and Lw= sound power level dB re 10^{-12} watts, D = source directivity, A_1 = attenuation for geometric spreading, A_2= barrier attenuation, A_3 = attenuation for air absorption, A_4= attenuation for wind and temperature effects, and A_5 = ground attenuation.

Sound Power Level Lw

The ENM program allows the source sound power level to be input in spreadsheet format (see Figure 2). Sources may be enclosed or unenclosed. If the source is unenclosed then the sound power level is specified in the normal way. If the source (or a group of sources) is enclosed then one needs to specify both the sound power levels of the sources and the acoustic properties of the enclosure walls. Enclosures are defined as a collection of rectangular surfaces with an absorptive face on the side nearest the source and having a sound transmission loss. ENM works in both 1/3rd octave and 1/1 octave format from 25Hz to 20kHz.

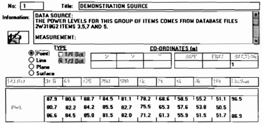

Figure 2. Noise Source Input Spreadsheet.

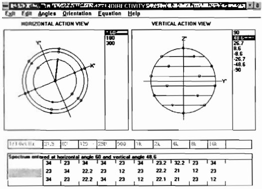

Figure 3. Directivity Correction Spreadsheet.

Directivity Correction

A frequency dependent directivity correction term is included in the ENM model and is based on either array co-ordinates recommended in ISO 3745 - 1977 or user selected angle increments (see Figure 3). These co-ordinates are points on the surface of a hypothetical sphere whose centre coincides with the acoustic centre of the source [2]. The program interpolates values for directions of source to receiver which do not coincide with these array co-ordinates.

Geometric Spreading - A_1

All sources are considered firstly in the absence of the ground, that is, as if they were suspended in a free field. Sources are of three types: point, line and plane. Traffic can be modelled by defining a series of point sources along the route, the spacing between them being set to a value no greater than three times the distance of the nearest residential receiver to the road. Other noise sources which can be modelled include trains, helicopters and aircraft.

Barrier Attenuation - A_2

The Maekawa theory for predicting noise reduction from barriers is commonly used today. New developments in this field [3,4,5], however, include the influence of the ground on both sides of the barrier. At certain frequencies, the ground effect can become more important than the barrier attenuation and hence the results based on an ideal half infinite barrier can be substantially in error. Other complications arise when

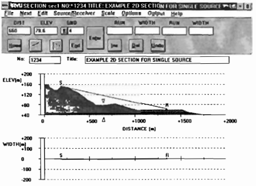

Figure 4. Ground Cross-section.

the barrier is not infinitely wide, as is assumed by Maekawa's theory. ENM Windows incorporates the usual method of calculating the noise contribution around the sides of the barriers by Maekawa's algorithm.

Ground contours are digitised in the ENM program as a sequence of co- ordinates (see Figure 4). The topography of the ground in a straight line between the source and the receiver is determined by scanning co-ordinate pairs A hypothetical thick barrier is then constructed according to the maximum angle subtended to the topographical feature as viewed alternatively from the source and receiver.

Air Absorption - A_3

The algorithm for the calculation of air absorption is based on American National Standard ANSI S1.26 [6]. The ENM program calculates the value of air absorption in third octaves and logarithmically sums the result to one-third octaves or octaves as required.

Wind And Temperature Effects - A_4

The effects of refraction of sound in the atmosphere can best be thought of in terms of sound ray propagation. Curvature of sound ray paths is a result of variations in the speed of sound with height. Sound speed variations can either be caused by changes in air density due to temperature or simply by the movement of the air medium itself. Intuitively, one would expect that sound speed variations caused by a combination of these two effects would be additive. Examination of measurements conducted by Parkin and Scholes shows there is some evidence to support this theory [7].

In the case of open terrain, data from Parkin and Scholes [8] as summarised by Piercy [7] for observed excess attenuation of ground-borne aircraft noise measured under a variety of weather conditions was classified in terms of the total vertical sound speed gradient. Values of A_4 are interpolated for other distances except that saturation is assumed to occur farther than 616 metres and for values of total sound speed gradient greater than 0.15. Wind and temperature effects on barriers are treated in a similar manner to DeJong [9]. In essence, the height of source and receiver are modified to take into account the ray curvature.

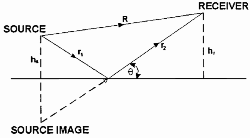

Figure 5. Geometry for ground absorption algorithm.

Ground Attenuation - A_5

Propagation of sound from a source placed above a semi-infinite ground plane has been extensively reviewed. Reference to Figure 5 shows that specular reflection may be considered simply by creating an image of the sound in the ground. The expression of the plane wave reflection coefficient R_p may be written as [10];

$$R_p = \left[\frac{\sin\theta - (\rho c / Z_g)}{\sin\theta + (\rho c / Z_g)}\right] \qquad (2)$$

where θ is the angle between the ground and the incident or specularly reflected wave, ρc is the characteristic impedance of air, 407 SI rayls, and Z_g is the impedance of the ground surface and is given by [10]

$$Z_g = \rho c\left[1 + .0571\left(\frac{\rho f}{\varphi}\right)^{-0.754} - i0.087\left(\frac{\rho f}{\varphi}\right)^{-0.732}\right] \qquad (3)$$

where f is the frequency and φ is the ground surface flow resistivity, SI rayls/m. The surface flow resistivity is defined to be the pressure gradient required to induce unit flow velocity in the bulk material. Eleven values of flow resistivity for various ground surfaces are incorporated in the model ranging from snow to grass, exposed earth to asphalt [11].

The sound pressure at the receiver is determined from;

$$p = \frac{e^{-ikR}}{kR} + R_p\frac{e^{-ik(r_1+r_2)}}{k(r_1+r_2)} + \left[1 - R_pF(\omega)\frac{e^{-ik(r_1+r_2)}}{k(r_1+r_2)}\right] \qquad (4)$$

The ENM algorithm calculates values of A_5 at one-ninth octaves and combines these to third-octaves or octaves as required.

In the ENM program, a ground type code is input along with other contour information. A vertical cross-section of the ground is taken from each source to receiver point in order to calculate barrier effects. In the ENM model, a choice is made to average the ground types in cases where there is not a single ground type. There is no physical justification for this decision, rather, it is a temporary measure to be replaced when more is known about the effects of changes in ground types.

Whenever a barrier is interposed between source and receiver, the reflection angle θ is calculated for two cases; first the receiver is placed at the top of the barrier and θ_s is calculated on the source side. Secondly, the source is placed at the top of the barrier and θ_r is calculated for the receiver side. The value of θ is then taken to be the average of θ_s and θ_r. Again, this methodology is taken to be a temporary measure until more is known about the performance of barriers in the presence of the ground.

3. Validation and Accuracy

a) Impulse Noise

Work on verification of the Environmental Noise Model began immediately after its release. Mitzia [12] set up an impulsive point source of sound and measured noise levels at various distances and for a number of meteorological conditions. The results are shown in Table 1.

Table I. ENM modelling accuracy reported by Mitzia [11].

Distance from source (m)	25	50	100	200	400	800
MET1 Lc-Lm std dev in measured Lm	0.7	3.0	0.1			
MET6 Lc-Lm std dev in measured Lm		4.8	4.4	2.8		
MET7 Lc-Lm std dev in measured Lm			3.7	1.4	5.1	
MET9 Lc-Lm std dev in measured Lm				2.7	8.5	3.4

Lc=Calculated dB(A) noise level, Lm=Measured dB(A) noise level, MET=Specific meteorological conditions encompassing wind speed, direction, temperature, humidity and vertical temperature gradient.

At most points, the difference between measured and calculated noise levels is less than 5dB(A) except for one point at 400m from the source. This point corresponds to a location just behind the apex of a hill where air is subjected to considerable local turbulence. The meteorological conditions at this point were different to that measured 400m from the source in another direction along the slope of the hill.

b) Industrial Noise

Validation of ENM at a steel works in an industrial area of a town in the North of Italy was reported by Cerrato etal [13]. The subject area is traversed by a railway and is close to the slope of a mountain. Sound pressure levels were measured at various locations both day and night.

The principal noise sources included the smelting furnace, smoke extraction system, the rolling mill and the pickling fans. In the first instance, sound power levels were determined using sound pressure level measurements close to the sources of noise. The paper shows good correlation between the measured and calculated third-octave band spectra at two of the locations chosen for checking the calibration of the model. The program was subsequently used to model noise contours around the steel plant for the purpose of determining best methods of noise control.

An intense long-term noise study was reported by Moller and Brown [14]. Boyne Smelters Ltd operates a modern aluminium smelter in Queensland, Australia. The smelter is located some 1000m from the nearby Boyne Island/Tannum sands community (5,000 people). ENM was used to calculate noise levels in the community - the modelling established the area of the community predicted to be "routinely affected" by noise from the smelter. In addition it allowed quantification of the few identified dominant noise source contributions to be made as well as the extent of practical attenuation that could be applied to each source.

Source sound power levels were first measured using directional microphone techniques. The features noted during the measurement process included plant layout, external elevations of buildings, cladding types, wall/roof ventilators, specific noise source locations and operation times of plant equipment.

A total of 104 noise sources were quantified but subsequent analysis showed that only 18 were significant. Modelling input data included topographical data at 5 metre contour intervals, vegetation density estimates and locations of natural and man made features. Noise contours were produced to determine the extent of the community exposed to excessive noise levels for various meteorological conditions.

The predicted noise levels were verified by taking a total of 287 measurements at 95 locations between the hours 2115 and 0515 every day. It was concluded that 75% of all predicted values were within ±3dB(A) of the measured value and 90% of all predicted values fell within ±4.9dB(A) of the measured value.

c) Traffic Noise

ENM has been used to predict traffic noise on most motorways and freeways in Sydney including the M2, M4, M5, M5 East and many other secondary transport corridors. The modelling method most commonly used [15] is to simulate traffic as a discrete series of point sources of sound power level L_{wi} spaced a distance b apart where;

$$L_{wi} = L_{po} + 10\log(r_o b) + 3 \qquad (5)$$

where, L_{po} is the sound pressure level at a distance r_o metres from an infinitely long line source of traffic noise. The value of L_{po} is taken from either CORTN [16] or FHWA [17] algorithms as required by the user. In most cases, the distance b in metres is selected to be between 20m and 50m and in any case is less than or equal to three times the minimum distance between any receptor point and the road.

Noise contours were produced for the M5 west of King Georges Road using ENM. The road surface and the adjacent landforms were digitised and input into ENM. For this section of the motorway, an 80km/hr design speed was used to generate vehicle sound power emission levels using the CORTN algorithms as described above.

Table II shows the accuracy of the model at multiple locations between Fairford Road and the King Georges Road intersection. It is clear from the table that the ENM/CORTN noise model is generally conservative.

Table II. Comparison of measured and predicted traffic noise levels.

POSITION	PREDICTED		MEASURED	
	Leq(24hr)	Leq(8hr)	Leq(24hr)	Leq(8hr)
15 Windarra St	54	44	52	46
56 Parry Ave	53	43	48	<41
28 Grove Ave	54	44	48	44
22 Iris Ave	56	46	53	45

The accuracy of the ENM model in predicting source-to-receiver attenuation was tested by comparing actual and predicted noise levels from a truck pass-by. Figure 6 shows a comparison of the measured and predicted noise level from a single truck pass-by on the M4 motorway at Sapphire Street, Pendle Hill in Sydney.

The measured truck sound power level was input into ENM and the sound pressure levels predicted at a receiver point for the case of the truck located at various chainage points along the road. By way of explanation, the metric distance measured along the centre line of the road referenced to the start of the road is called the "chainage". As the truck travels along the road, it passes each chainage point. The receiver point is located directly opposite chainage point 28025 (approximately) so that the sound level of the truck is at a maximum here. In most cases, the difference between the measured and calculated sound pressure levels at the receiver location is within measurement error.

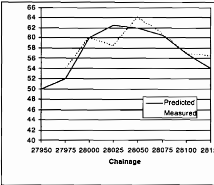

Figure 6. Comparison of Predicted and Measured Noise Levels of Truck Passby.

d) Train Noise

ENM was used to predict train noise on the East Hills railway line in the southern suburbs of Sydney. Measurements were conducted at three points on flat land on an imaginary line orthogonal to the rail track but at different distances from the railway line. The sound power level of the train was determined from the sound pressure level at the nearest point. The attenuated sound pressure levels at the other two locations was predicted using ENM and are shown in Table III.

Table III: Comparison of Measured and Predicted Train Noise Levels

Distance From Track	Measured Noise Level Lavmax	Calculated Noise Level Lavmax
15	89	-
65	80	81
148	75	74

CONCLUSION

ENM has proven to be a popular and useful acoustic tool to provide accurate prediction for a wide range of environmental noise sources. Improvements are being made to the algorithms as more information becomes available. Improvements are also being made to interfaces with other programs, such as Windows and graphic packages. Thus the program has become even simple to use, without any decrease in the accuracy of the predictions, and noise level contours can be clearly presented, see Figure 7 and front cover.

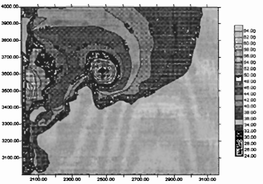

Figure 7. Example Contour Output.

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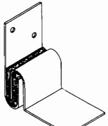

News...

Australian Excellence in Acoustics Award

The Excellence in Acoustics Award for 1996 was awarded to BHP Steel - Long Products Division and BHP Engineering in the category of Acoustic Design - Large Scale: Manufacturing Facilities for the Sydney Steel Mill at Rooty Hill, New South Wales.

The sound pressure levels within parts of the Mill reach 120 dB(A), with strong low frequency components, and in other sections of the building 110 dB(A) internal impulsive sound pressure levels are common. Designers, BHP Steel - Rod & Bar Products Division and BFI of Germany employed innovative plant design and advanced acoustic attenuation of the processes to achieve compliance with New South Wales EPA environmental requirements, a task requiring world's best practice for environmental noise control due to the proximity of the Mill to residential housing.

The award was presented by the President of the AAS Charles Don, and received on behalf of the BHP by Mr Colin Tickell of BHP Engineering during the Conference Dinner of the 1996 Australian Acoustical Society held aboard the Kookaburra Queen in Brisbane.

Applications were received from New South Wales, Queensland and West Australia and the standard of each was high. We look forward to the next Awards which will be held in 1998 and hope that projects from all Australian States are forthcoming.

Les Huson

VIC Meetings

The Victoria Division held a site visit to the Boral Plasterboard factory at Port Melbourne on March 12. First the acoustic performance of the various wall systems with STC of up to 50dB were discussed. The factory inspection covered the dry gypsum storage area, through the several hundred metres long production line. From the 'wet' end where the plastic plaster mix was inserted under controlled thickness between the paper liners, through the hardening area, to the 'dry' end where the continuous plasterboard was cut into manageable lengths for storage and eventual dispatch.

On June 4, there was a site visit to Lochard P/L which specialises in acoustical and flight track monitoring systems to help airport authorities predict and manage the environmental impact of aeroplanes. First **Richard Bell** described Lochard's core products as the Global Environment Management System (GEMS), the Environment Monitoring Unit (EMU), and the Environment Analysis and Reporting Systems (EARS). **Mike Osborne**, described EMU and **Prof Keith Adams** described development of the EARS after research into sound source recognition using neural logic. A demonstration of the various measuring instruments followed. Early work on developing the EMU showed the considerable superiority of digital over analog methods of noise measurement and the consequent data handling. The analog microphone output is immediately converted to a digital signal, providing greater reliable dynamics range (120 instead of 60 dB), freedom from electrical noise, and reliable frequency analysis and data handling and storage.

The neural network processing function now incorporated in products such as the EARS allows identification of aircraft noise sources and discrimination against unwanted noise such as that from road traffic.While the neural processor is still under development, an accuracy of 70 to 80 percent in recognising aircraft noise has already been achieved.

Louis Fouvy

Acoustics Australia Articles

The Editors are particularly pleased to note that other journals are interested in our articles. The article in the December 1996 issue by Narang and Butler on aircraft noise insulation has been reprinted with acknowledgment as a Special Feature in Noise and Vibration 1997. Similarly the article by Fletcher on the Didjeridu has been reprinted in the November 1996 issue of Acoustics Bulletin in the UK.

Science Popular

The poll of 1060 Australians, conducted by AGB McNair on behalf of the CSIRO, produced the surprising result that Australians would rather read about science, medicine and technology than sport or politics.

The poll showed 66 respondents were "very interested" in sport and 44 in politics, as compared to 92 in new technology and 87 in scientific discoveries.

But maybe part of science's attraction is its dark side - 42 per cent of respondents felt science had become so powerful it was dangerous.

Hearing The Light

A new underwater surveillance technique, dubbed "acoustic daylight", which relies on the ambient noise in the ocean to acoustically illuminate a target, is shaping up as new covert surveillance method.

Dr Mark Readhead of the AMRL Maritime Operations Division of DSTO who was awarded the inaugural RAN Science Scholarship for his proposal to investigate the concept has recently returned after spending nine months at the Scripps Institution of Oceanography near San Deigo learning about the method.

The technique originated from a group led by Professor Michael Buckingham at Scripps. The group use an acoustic lens that is similar to a satellite dish in appearance, consisting of a three metre acoustic reflecting dish with a 126 element hydrophone array at its focus.

Dr Readhead said that now that acoustic daylight had been established as a viable surveillance method, at least for near ranges, much systematic research was needed to characterise the noise field and identify the optimal equipment configuration.

For an acoustic lens Dr Readhead favours the use of the phased hydrophone array in place of the reflecting dish and its small array, but it comes at the cost of a greatly increased computing load.

From Australian Defence Science News, No 16, p5, 1997

Violin Octet Tour

The exquisite early violins are gradually losing power and wearing out under the demands of modern performance and being put in museums. The world of modern music is groping for new forms of expression, new sounds, new harmonies and dissonances. Our large concert halls are calling for increased sound from the strings. We need new and more powerful string instruments.

The acclaimed Violin Octet is the answer with eight octaves of balanced string tone never before heard, giving increased power, enhanced dynamics, and greater frequency ranges. They provide the clarity and projection of violin type sound in all octaves with new tonal combinations and enhanced pizzicatos where the large instruments sound like giant guitars. The Violin Octet can sound like a baroque consort or a whole orchestra.

For the past 30 years the Violin Octet of eight finely matched instruments has travelled thousands of miles to invited lecture/demonstrations and concerts, from USA to Canada, Europe, and Russia. Audiences are always enthusiastic. The collaboration with the Conservatory has led to an ensemble of high class professionals with an extensive and ever growing repertoire, new music composed and arrangements of classics made to show the best potential of the instruments. The Catgut Acoustical Society (CAS) is seeking support for the World Tour of the Violin Octet.

For details: Octet Fund of CAS, 112 Essex Avenue, Montclair, NJ 07042 Tel: +1 9737444029 Fax: +1 9737449197, CatgutAS@msn.com

NOISE-CON 98

The 1998 National Conference on Noise Control Engineering will be held in Ypsilanti Michigan on April 5-8, 1998. The conference is being organised and sponsored by the Institute of Noise Control Engineering (SAE). The theme of NOISE-CON 98 will be Transporting Noise Control to the 21st Century: Planning for a Quiet Future. Technical Papers in all areas of noise control engineering may be submitted for presentation. Papers on transportation vehicle sources, noise control materials, and noise control prediction are especially welcome.

NOISE-CON 98 will be followed by a SOUND QUALITY SYMPOSIUM on 9 April. Papers in all areas of sound are welcome. Topics to be covered include automotive sound quality, metrics for complex sounds, sound quality of motors, appliances, and components, and HVAC sound quality.

Details: Noise Control Foundation, PO Box 2469 Arlington Branch, Poughkeepsie, NY 12603. Fax: +1 9144630201,
email: noisecon98@aol.com,
http://users.aol.com/noisecon98/nc98_cfp.html

Causal CDs

Causal Productions Pty Ltd has recently released a number of conference CD ROMs. These include ICASSP 97, and the INCE 25th Anniversary CD ROM. This latter contains the proceeding of The Wallace Clement Sabine symposium; INTERNOISE'94 and'95; ACTIVE'95; Noise Control Engineering Journal, 1994 - 1996; Technical Product Information from companies in the field of Noise Control Engineering and selected patent abstracts from the field of Active Noise Control.

Contact: Tel: +61-8-82958200, Fax: +61-8-82958299,email:info@causal.on.net, http://www.causal.on.net.

OHS on WWW

The National Occupational Health and Safety Commission, Worksafe Australia, has recently updated its web site. New graphics assist with access to Information, Legal obligations, OHS Trends and Research Issues, Managing Work place hazards etc. http://www.worksafe.gov.au

Changes and initiatives

Acoustic Research Laboratories, also Rion distributors in Australia, have opened an office in Box Hill, Melbourne to improve service to their Victorian and Tasmanian clients. In addition to Rion equipment the new office will service higher requirements for Acoustic Research Laboratories' noise and vibration loggers. The State Manager is John Searle who has many years of experience in the noise control industry. John can be contacted on 03 9897 4711. ARL have moved to: Level 7, Building 2, 423 Pennant Hills 2120

New Company - Noise Control Australia Pty Ltd. has recently been formed. It is committed to excellence in design, manufacture and installation of noise control equipment. The directors are Ram Krishnaswamy, Robert Blackhall and Ron Cheong who can be contacted on Tel: 02 97432413.

Causal Productions Pty Ltd has the following new contacts: Tel: +61-8-82958200, Fax: +61-8-82958299, info@causal.on.net, http://www.causal.on.net. The address remains the same at PO Box 100, Rundle Mall 5000 Australia.

Robert Fitzell Acoustics Pty Ltd has changed its name to RFA Acoustics Design Pty Ltd. The location of its Sydney office has also changed to: Level 1, 280 Pacific Highway Lindfield NSW 2070 with postal address PO Box 544 Lindfield NSW 2070 Tel: 02 99100400 Fax: 02 99100419.

Beran Instruments recently appointed Davidson's as their sole Australian distributor. Beran Condition Monitoring Systems has experienced great success in the UK and are being used increasingly throughout Europe. As Australian industries expand, Beran sees extensive applications for their products here, especially the innovative 766. This is the fourth generation on-line Condition Monitoring System. It offers both portable and permanent monitoring for rotating plants and clearly demonstrates Beran's ability to meet the needs of today's condition-based maintenance strategies.

Reinforced Earth Company (previously located Somersby NSW) has experienced significant growth and as a result has relocated their head office to: Level 2, 20 George St, Hornsby NSW 2077 Tel: 02 99109910 Fax: 02 99109999.

Vipac in Newcastle - Caleb Smith Consulting, the leading acoustic consulting group in the Hunter Valley and Newcastle area, has joined international engineering consultant Vipac Engineers and Scientists. Established in 1979, Caleb Smith Consulting has achieved an outstanding and enviable record of acoustic project expertise in NSW. With its main focus on Newcastle, the Hunter Valley and the northern districts of the state, the practice grew and currently employs seven staff, five of them being engineers. Vipac's involvement ensures that the Acoustical Consulting Practice of Caleb Smith will continue as a reliable service for this region of Australia.

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STANDARDS

New Assistance Service

Standards Australia launched a new technical assistance service in July which will enhance its position as a specialised provider of advisory, training and education services in the Standards, conformance and technical markets.

The new service will cover all Standards-related issues and at the same time enable Projects Managers and committee members to concentrate on core Standards-writing activities. The scaling down of the technical information services provided by organisations such as the state regulatory authorities, CSIRO and the insurance Council of Australia has left the Australian industry and the community at large with few, readily available sources of technical information.

The opportunity has now arisen for Standards Australia to broaden its general Standards information and committee-based technical assistance which would service the community's expectation in this regard.

The service is not intended to operate as a consultancy in the normally accepted sense. It is primarily to provide responses to specific questions on Standards and Standards-related issues. Requests on the interpretation of a Standard, or the acceptability of a minor variation will also be considered and an opinion provided.

If the question is simple and can be answered on the phone in a short time, there will be no charge. If the question is more complicated or the caller wants confirmation in writing, an estimate of the cost and response date will be provided.

This service will deal with the provision of assistance and information relating to: application of requirements in Standards; testing and certification requirements;

regional and international Standardisation requirements; occupational health and safety; advice to exporter/importer; translation.

Building Standards

The Joint Building Standards Policy Board at its meeting on 13 March 1997 endorsed the following initiatives taken by Standards Australia: identification of 227 building Standards for withdrawal and 57 projects for deletion; a list of Standards will be sent to key organisations for their review; review of the main committees and subcommittees for possible amalgamation; all committees to be reviewed for alignment (ISO) committee structure; existing Standards will be reviewed for comparison with international Standards; amendments to building Standards are to be published only twice a year; a higher distribution of meetings need to be held in cities other than Sydney as well as more use of audio-conferencing facilities.

The following initiative with the Australian Building Codes Board are also being put in place: Director - Technical with the Australian Building Codes Board is working at Standards Australia's Head Office for one day a week; Standards amendments referenced in the Building Code of Australia (BCA) will be published twice a year; Standards Australia will provide training for projects managers on preparation of Standards for referencing in the BCA; Standardisation Guide - 9.1(Int) Preparation of Standards Referenced in the Building Code of Australia will be revised by June 1997; Primary referenced Standards are to be identified with the Australian Building Codes Board logo and appropriate wording is to be included in the Standards regarding coordination.

BCA on CD-ROM

The new performance edition of the Building Code of Australia is now available electronically on the 'Standards on CD ROM' service. Under an agreement with the Australian Building Codes Board (ABCB), Standards Australia will be providing two different services, tailored to the needs of the building industry. For customers subscribing to Standards on CD ROM service, the BCA can now be added to their subscription.

The second service, is a fixed price CD ROM which will include the BCA and all the Australian Standards it calls up.

The Australian Standards June 1997

Standards Online

Australian Standards are now available online thanks to a partnership deal between Standards Australia and IHS Australia Pty Limited. Australian Standards Online is a subscription service which provides subscribers with not just the full collection of Australian Standards on-line, but combines it with many additional document management features. Australian Standards Online will be available to subscribers from July.

Further information: IHS Australia on feecall Tel: 1800 062299.

Reengineering

One of the stated objectives of Standards Australia is the need to continuously deliver accurate, relevant and timely contemporary Standards. This objective has emerged as a direct response to many industry sectors which need presentation in ways which are more meaningful to them. To achieve this, Standards Australia will have to re-evaluate the processes it currently applies, the technology it uses and the way its staff work. A suitable method is "reengineering", something which many leading organisations are embarking on as an approach to successfully achieve long-term results. Reengineering is defined as: The fundamental rethinking and radical redesign of business processes to bring about dramatic improvement in performance.

Over this next financial year, it has been decided to reengineer the process of preparing Standards and other products.

What is hoped will emerge out of the program is a new customer driven culture where individuals become less protective of functional and professional boundaries, where talents are more explicitly recognised and where individuals become more accountable and responsible for delivering value to customers.

Consensus, May 1997

Car Alarms

Standards Australia has signalled the arrival of a new generation of "quieter" car alarms with the publication of a revised Standard for vehicle alarm systems. The Standards specifies minimum performance requirements and associated test methods for alarms installed both during and after the vehicle's manufacture. It covers alarm systems designed to signal the unauthorised opening of a vehicle as well as those which can completely immobilise a vehicle once it has been tampered with. AS/NZS 3749.1:1997, Intruder alarm systems - Road vehicles, Part 1: Performance requirements, was published to ensure passenger car alarm systems met a high standard of safety, performance and reliability. It ultimately aims to reduce false alarms and decrease the associated noise pollution. The second part of the Standard, covering the installation of vehicle alarm systems, is due for publication later this year.

2000 CRISIS

In the year 2000, well before the excitement of athletes and gold medals, another event of Olympic proportions will take place. It's all a simple matter of dates, but the first day of the new millennium could potentially wreak corporate chaos with horrendous consequences for business and administration.

The century date change (also known as the Year 2000 or Y2K) problem is a real and serious one concerning virtually the entire information technology industry.

"It arises from the almost universal practice of using only two digits to record the calendar year, for example DD/MM/YY". The use of two-digit recording was intended to save valuable storage space and data entry time.

Programmers assumed that the software applications they were producing would be replaced long before the calendar change could cause problems. "Remarkably, many of those old programs are still in use."

In response to the Y2K crisis, Standards Australia has published a handbook called SAA HB99, Addressing the comparison of dates for the year 2000 and beyond. The handbook explains the year 2000 date change and offers two algorithms for organizations to use to resolve the mathematical calculation issues associated with the problem. Although HB99's solutions originated from the cards-issuing industries, the logic underlying the approaches is still applicable with some modifications to suit specific environments.

New AS 1055

Standards Australia has recently released the 1997 versions of AS 1055.1, AS 1055.2 and AS 1055.3. These three standards cover the description and measurement of environmental noise and replace the 1989 versions. This series of standards has been referred to in most environmental noise assessments throughout Australia.

New Members...

The following new members, or upgrades, are welcomed to the Society.

NSW
Subscriber Mr J Baxter

VIC
Member Mr C Huybregts
Subscriber Mr T Eames
Mr J Antonopoulos

SA
Subscriber Miss A Robinson

Noise Effects '98 ICBEN

Preparations for the 7th International Congress on Noise as a Public Health Problem, Noise Effects '98, are proceeding satisfactorily. It will be held at the Sydney Convention Centre, Darling Harbour from 22-26 November 1998. A Preparatory Meeting, arranged by the Congress Organising Committee, and attended by Commissioners of the International Commission on Biological Effects of Noise (ICBEN) and the leaders of each of its nine International Noise Teams, is always held 12 months or so before each Congress. This Meeting reviews preparations for the Congress, and considers its scientific, social and cultural programs, exhibitions and budget. The Preparatory Meeting for the 7th Congress will take place in Budapest preceding Internoise 97. Dr. Norm Carter and Dr. Soames Job, President and Vice-President respectively of Noise Effects '98, will represent the organising Committee at this Meeting.

Further information: Noise Effects '98, GPO Box 128, Sydney NSW 2001 Australia Tel: 02 92622277 Fax: 02 92622323, tourhosts@tourhosts.com.au

inter-noise 98

16 - 18 November 1998

Christchurch, New Zealand

SOUND AND SILENCE: SETTING THE BALANCE

Technical Programme - Distinguished Lectures, invited and contributed papers and posters

Major Exhibition of equipment, materials and instruments

Social program for all delegates and accompanying persons

Abstracts, approx 250 words, must be received by 16 February 1998.

Authors will be notified of the acceptance by 16 April 1998.

Manuscripts must be received by 16 June 1998.

Each submitted paper must be accompanied by at least one registration fee.

Satellite Symposium on "Recreational Noise" 20 November in Queenstown, NZ

Inter-noise 98, PO Box 1181, Auckland 1001 NZ
Tel +64 9 623 3147, Fax +64 9 623 3248,
internoise98@auckland.ac.nz
http://www.auckland.ac.nz.internoise98

INTERNATIONAL CONGRESS ON ACOUSTICS

The 16th International Congress on Acoustics will be held in Seattle, Washington, on 20-26 June 1998 in conjunction with the 135th meeting of the Acoustical Society of America.

The meeting will consist of plenary lectures, invited and contributed papers, poster sessions, and exhibits. Topics to be covered include acoustical oceanography, animal bioacoustics, architectural acoustics, biomedical ultrasound, bioresponse to vibration, engineering acoustics, musical acoustics, noise, physical acoustics, psychological and physiological acoustics, signal processing in acoustics, speech communication, structural acoustics and vibration, and underwater acoustics.

The conference program will be supplemented by technical tours, scenic tours, and a salmon dinner, and there will be a two-night post-conference whale-watching excursion for the nature enthusiasts.

For further information:

ICA/ISA'98 Conference Secretariat
Applied Physics Laboratory
1013 NE 40th St, Seattle, WA 98105-6698, USA
e-mail: ICA-ASA98@apl.washington.edu

INTERNATIONAL SYMPOSIUM ON MUSICAL ACOUSTICS

The Acoustical Society of America and the Catgut Acoustical Society will combine to present the next symposium in this international series immediately following the joint ICA-ASA meeting in Seattle in June 1998. The meeting will be held June 26 - July 1 in a resort and conference retreat in the Cascade Mountains area, east of Seattle. About 100 participants are expected.

Papers will be presented in all areas of musical acoustics, including instrument and voice acoustics, music perception and cognition, computers and music, and interdisciplinary topics. Workshops are planned for luthiers, researchers and students.

For further information:

The Catgut Acoustical Society
112 Essex Avenue
Montclair, NJ 07042, USA
e-mail: catgutas@msn.com

The home page for ISMA98 is:

http://www.boystown.org/isma98/

VALE - Kenneth Martin

The South Division of the Society lost one of its founding and long-serving members when Ken Martin passed away in July this year.

Elected to the Committee of the SA Division at its inaugural meeting in 1976, Ken became the Division's first treasurer/registrar and retained these offices continuously from his initial election until a few weeks prior to his death at the age of 74 years. In addition to the meticulous and timely attention which he gave to the treasurer/registrar's functions, Ken also took an active role in accounting for the financial affairs of each of the Society's Annual Conferences which were held by the SA division and for the Satellite Symposium held in Adelaide prior to the ICA held in Sydney in 1980.

Ken's involvement in acoustics began while he was an officer in the SA Health Commission, investigating noise levels and hearing conservation methods in government workplaces in the 1960s. A transfer to the Noise Control Section of the Department of Labour and Industry in the mid 1970's provided experience in noise control engineering and the administration of hearing conservation regulations in government and private industry. Ken worked for the SA Environment and Planning from the early 1980's until he retired in 1983.

During his retirement Ken and his wife travelled frequently overseas especially to China. As a Justice of the Peace he found time to do voluntary work in his capacity with the Marion City Council.

Ken is survived by his wife Shirley and his son Shane to whom the Society extends its condolences. His contribution to the functioning of the SA Division will be sorely missed.

Robert Boyce

Books...

Handbook of Condition Monitoring

B.K.N. RAO.

Elsevier Science Ltd., 1996, 603 pp, hard covers, ISBN 1 856172341. Australian Distributor, DA Information Services, PO Box 163, Mitcham Vic. 3132, Tel 03 9873 4411, Fax 03 9873 5679. Price A$187.75

Weighing in at almost 1.5 kg, the Handbook of Condition Monitoring provides over 600 pages of reading on this diverse topic. Although the word Handbook appears in the book's title, this work does not appear to be a purpose written document but rather a wide ranging collection of twenty two articles written by a variety of authors. The advantage of this is that a number of viewpoints are provided (although this may leave the reader feeling swamped by alternatives). The disadvantage is that the handbook lacks consistency in its format and presentation style from one chapter to the next. Furthermore, there is some overlap and repetition between several chapters (tables showing faults in rotating equipment etc). The standard of the writing is generally quite acceptable although naturally varies from one chapter to the next. In many instances, diagrams contained annotations which were illegible to the reviewer's naked eye. (The reviewer does not require sight correction.)

The handbook begins by presenting arguments for the use of condition monitoring and looks at where condition monitoring is going. The second chapter ('The Way Forward') presents an objective review of the somewhat chequered history of condition monitoring and makes interesting reading. This is followed by a number of chapters which concern the application of condition monitoring to various engineering components or systems. For example, one chapter deals with 'Condition Monitoring of Machine Tools' and another 'Condition Monitoring in Hydraulic Systems'. These chapters typically begin with a discussion of the need for condition monitoring, a review of available methods, a discussion of problems particular to the plant concerned and finally a brief case study.

Interspersed throughout the book are chapters devoted to the discussion of various condition monitoring techniques such as 'Vibration Monitoring' and 'Oil Debris Monitoring'. These chapters provide the reader with valuable introductions to these techniques and an understanding of the pertinent issues. The chapter on vibration monitoring includes a useful listing of the Standards relating to the vibration analysis of different machinery.

The later chapters of the handbook concern maintenance and maintenance management systems (of which condition monitoring is just one aspect). These chapters will be useful to those wishing to understand the various maintenance strategies that may be employed such as 'Total Productive Maintenance', 'Reliability Centred Maintenance' etc. The Handbook also includes a chapter which gives brief descriptions of patents relevant to condition monitoring and should make interesting general reading for engineers. The final chapter lists in excess of 600 selected bibliographies organised into a number of categories. The bibliographic entries include journal and conference articles, reports and theses and should provide a valuable resource to those wishing to further their knowledge in a particular area. The handbook includes a 15 page editorial index, an advertiser's index and buyer's guide.

The Handbook of Condition Monitoring is recommended to those wishing to further their broad understanding of condition monitoring techniques and applications without necessarily delving deeply into a particular topic area.

Michael Harrap

Michael Harrap is a lecturer with the School of Aerospace and Mechanical Engineering, Australian Defence Force Academy.

Sound Transmission Through Buildings Using Statistical Energy Analysis

Robert Craik

Gower Publishing, 1996, pp 260, hard cover, ISBN 0 566 07572 5, Gower, 43 Albert Rd, Avalon NSW 2107 Tel 02 9918 2325 Fax 02 9973 1223. Price A$132.

This book provides a comprehensive summary of the principles of Statistical Energy Analysis. Whilst the title would suggest that the book be applicable to only buildings it has a much broader appeal. Of the eight chapters, the first six represent a thorough discussion of the general theory and application of SEA to arbitrary structures. It is the last two chapters which focus on the application of SEA to buildings.

The book begins with a simple prediction of a single monolithic construction and compares the SEA formulation to the classic formula for the transmission loss of an element installed between two reverberation rooms. This may seem an abrupt start but may comfort persons unfamiliar with SEA by illustrating that traditional methods have their roots in, or can be traced to, the fundamental concept of power balance.

Chapter 2 provides a detailed discussion of how to break the system into a series of subsystems by considering modal energy, stiffeners, and size of the potential system as well as defining subsystems for the different wave types and frequency ranges. A discussion of the interconnections between subsystems and the transmission types; resonant and non-resonant, are also given here. Perhaps the most enlightening for users of SEA packages is the discussion on accuracy which considers the impact of errors in CLF's and the impact of inadequate modal overlap.

The properties which define a subsystem are given in Chapter 3 and include discussions of wavespeed, bending stiffness, critical frequency, energy, damping, modes, and mobility. The relationship between the fundamental material properties for a homogeneous plate are thoughtfully summarized in a table for easy reference.

A complete chapter is devoted to derivation and discussion of coupling loss factors room to wall, wall to room, common joints (cross, tee, corner, inline, and column/plate for simple bending waves). Extensive references are given for more complex joints involving elastic interlayers, beams, and other wave types. Particular attention is paid to plate radiation efficiency and the effect of anisotropy which should be especially useful for people applying SEA to framed buildings where even the finish building materials, such as gypsum board and plywood, are anisotropic.

Chapter 6 provides useful information on numerical techniques to improve speed and accuracy when solving the set of simultaneous equations defining the subsystem energies. Also included is a very informative discussion of the bias error associated with measuring the coupling loss factor between two connected subsystems when there are multiple paths between the two subsystems.

The last two chapters are devoted to

prediction of direct and flanking transmission and will certainly be of great interest to experienced SEA users. The chapter on direct transmission includes suggested models for predicting airborne transmission through double masonry walls (with consideration to coupling between the leaves in the form of cavity air stiffness, point connections due to masonry ties, line connections due to window and door frames as well as foundations), airborne transmission through lined masonry walls, and also lightweight timber frame walls.

The final chapter on flanking transmission provides worked examples which result in simple equations for the sound reduction of common flanking paths between adjacent rooms. There is a discussion of predicting level differences in large models and the error associated with considering only bending wave transmission.

The book draws on Professor Craik's fifteen years of SEA experience and presents it in a well organized and concise manner. It provides theory at a level which would make it an ideal graduate level textbook, but unlike a textbook, it provides numerous practical examples making it a very useful tool for SEA practitioners. The book also provides a unique opportunity to learn of the power and limitations of SEA that are often taken for granted when using commercial SEA packages. In short, this book is highly recommended for both the experienced SEA user and persons wishing to learn more about the technique.

Trevor Nightingale

Trevor Nightingale is a research officer at the Institute for Research in Construction of the National Research Council Canada. His main interest has been the measurement and prediction of flanking sound isolation in wood frame constructions.

Noise Its Measurement, Analysis, Rating and Control

J S Anderson & M Bratos-Anderson

Avery Technical Ashgate Publishing, 1993, pp 494, Hard cover, ISBN 0 291 39794 8, Australian Distributor: Gower, 43 Albert Rd, Avalon NSW 2107 Tel 02 9918 2325 Fax 02 9973 1223. Price A$122.75

This book is intended as a text for students studying noise and the engineering aspects of acoustics, either in Universities or by private study. It has grown from notes associated with a five day short course for workers in industry. The authors have attempted to bridge the gap between the practical and theoretical approaches.

The eight chapters cover: Principles of Sound Propagation; Measurement and Analysis of Sound; Noise Scales; Indices and Rating Procedures; Sound Insulation and Sound Absorption; Room Acoustics; Silencers; Ear and Hearing Loss; and Noise Sources Identification and Control. In each section are the explanations, relevant mathematical formulae, clear diagrams and references. For more information, some detailed material is included in Appendices and there is a comprehensive Glossary of Terms and Index.

For any book attempting to cover such a wide area there are bound to be some limitiations where it would seem advisable to give just a little more information. For example in the early section on enclosures it is stated that ideally there should be no apertures but no guidance is given for enclosures when there is a need to get material into and product out of an enclosure around a machine. One problem with the use of the book in Australia is that the discussion on criteria are based on UK and European legislation.

Overall this book seems to have achieved its aim and it would be a useful text for students. The style of presentation makes it easy to use by the student studying alone and for the practicitioner wishing to check up on concepts.

Marion Burgess

Encyclopedia of Acoustics

Malcolm Crocker, Editor

John Wiley & Sons, 1997, 4 volumes, Hard cover, ISBN 0 471 80465 7, Australian Distributor: Jacaranda Wiley, PO Box 1226, Milton Qld 4064, Tel 07 3859 9755, Fax 07 3859 9715. Price $608.00

The concept for this magnificent four volume set was initiated in the 1980s. The considerable coordination that was necessary to bring it to fruition was provided by the Chief Editor Malcolm Crocker supported by the Editorial Board. I understand that it started out as a "Handbook of Acoustics" but then grew. It is really a collection of reviews articles rather than a conventional encyclopedia.

It is divided into eighteen main parts and a member of the Editorial Board has in most cases written the first chapter to serve as an introduction to that part. Each chapter has been written by contributing authors and was subject to review by other experts in the field. Thus there has been the involvement of 180 contributing authors and almost 500 reviewers so the coordination has been a mammoth task.

The extent of the coverage can be gauged from the titles for the 18 parts and the number of chapters in each part: General Linear Acoustics (16), Non Linear Acoustics and Cavitation (10), Aeroacoustic and Atmospheric Sound (7), Underwater Sound (20), Ultrasonic, Quantum Acoustics and Physical Effects (8), Mechanical Vibrations and Shock (14), Statistical Methods (3), Noise Effects and Control (11), Architectural (9), Signal Processing (4), Physiological (11), Psychological (10), Speech Communication (6), Music (10), Bioacoustics (6), Animal (8), Measurements and Instrumentation (4), Transducers (9).

Each of the chapters 'stand alone' as they have been written by different authors. This means there are different styles and methods for presentation of the material. However this is where the experience of the Editor and his Board can clearly be seen in the consistency of the layout and the quality of the text, figures and tables and the inclusion of a reference list for each chapter. The user of an encyclopedia can be assumed to have very little knowledge in the topic and there is not the space that there would be in a text book to explain all the fundamentals first. In the sections that I have read the authors have certainly overcome this problem by focussing on the essentials. This means that a specialist in that area may consider that important things have been left out but it should be remembered that an encyclopedia is just a starting point, to be followed by reading of appropriate text books and articles. However I did find it surprising that the chapter on surface transportation noise included no information on the noise from railways and no doubt there would be similar important omissions in other sections.

For the reader seeking information on a particular topic, the chapter headings provide good guidance for the coverage. If that is not sufficient then there is a comprehensive index at the end of volume four.

This Encyclopedia would be of immense value to students embarking on studies in acoustics, to those already working in one area of acoustics and wish to know more about other areas and to those who are just seekers of knowledge. The cost may preclude personal purchase but it should be in the reference collection of the library of every educational establishment that has any involvement with any aspect of acoustics.

Marion Burgess

Marion Burgess is a research officer at the Australian Defence Force Academy in Canberra.

Sound Intensity - 2nd Ed

Frank Fahy

E & FN Spon, 1995, pp 295, Soft cover, ISBN 0 419 19810 5, Aust Distributor: Thomas Nelson 102 Dodd St, South Melbourne 3205, Tel 03 9685 4111 Fax 03 9685 4199 Price A$69.95.

This book is the second edition of the book first published in 1989 and reviewed in Acoustics Australia 18, 1, 1990. Since then, the sound intensity technique has seen rapid developments and field applications. The IEC standard 1043 *Instruments for the measurement of sound intensity* was published in 1993. ISO 9614 on the *Determination of sound power levels of sources using sound intensity* Part 1 *Measurement at discrete points* Part 2 *Measurement by scanning* have already been published. The draft of part 3 of ISO 9614 *Precision method for measurement by scanning* is currently being considered. More and more portable commercial sound intensity measuring systems have become available at lower costs which, coupled with the advantage of the sound intensity technique over conventional sound pressure measuring instrumentation, are making sound intensity measurements more attractive for field applications.

It is, therefore, timely and appropriate to have an updated edition of the only monograph on the theory and measurement of sound intensity. The author himself is the pioneer in the field and until recently has been chairing the ISO/TC43/SC1/Working Group 25 to develop the sound power standards.

The book has now been reorganised into eleven chapters instead of nine in the first edition. The first four chapters cover the history and development of sound intensity measurements, the nature of sound and the behaviour of sound waves, the flow of energy in sound fields and the derivation of complex intensity. The original sections on transient intensity, instantaneous intensity and complex intensity have been expanded considerably. The principles of measuring sound intensity and their practical implementation with hardware are described in Chapters 5 and 6. The errors in sound intensity measurements and the significance of sound field indicators are treated in Chapters 7 and 8. Chapters 9 and 10 are devoted to various applications of sound intensity measurements from the determination of sound power to the location of noise source and measurement of acoustic properties of materials. Summaries of the key components in ISO 9614-1 and 2 are also included here. The measurement of sound intensity in flow ducts formerly covered in Chapter 9 has been retained in Chapter 11 and remains a very difficult topic which is still very much being researched. A list of intensity standards is included in the Appendix. The number of references has been expanded from 148 in the first edition to 186 in this edition.

The basic ingredients for the successful application of the sound intensity technique were covered very well in the first edition. The revisions made in this second edition have provided improvements on the understanding of the sound intensity field as well as the recently published ISO standards. It can be noticed from the revisions made to the first edition that the sound intensity technique has now matured. This excellent book is an essential reference for anyone (beginner or expert) who needs to make sound intensity measurements. It is certainly a worthwhile purchase for engineering/physics libraries.

Joseph Lai

Engineering Noise Control: Theory and Practice 2nd Ed

David A. Bies and Colin H. Hansen

E & FN Spon, 1995, pp 640, Soft cover, ISBN 0 419 20430 X, Aust Distributor: Thomas Nelson 102 Dodd St, South Melbourne 3205, Tel 03 9685 4111 Fax 03 9685 4199 Price A$69.95

This book is the second edition of the book first published in 1988 and reviewed in Acoustics Australia 17, 3, 1989. The material covered in the first edition has been substantially revised with the addition of some 200 pages.

Although the book follows the same style as the first edition, there is now a list of learning objectives in the beginning of each chapter to indicate what is to be achieved. The book is divided into 13 chapters compared with 12 in the former edition, the new chapter giving a brief introduction to the basics of active noise control. It is pertinent to include this new chapter considering the substantial research and development undertaken in this rapidly growing field in the past decade.

Chapter 1 deals with the basic terminology and fundamentals of the wave equation including plane and spherical waves. The anatomy of the ear and its response to sound are discussed in chapter 2. The basic instrumentation for noise measurements from sound level to sound intensity meters is introduced in chapter 3. This is then followed by a discussion of various criteria for hearing damage, speech interference, room acoustics and environmental noise in chapter 4.

The characteristics of various types of sound sources, the determination of the sound power of a sound source, the propagation of sound outdoors and in enclosed spaces are covered in chapters 5, 6 and 7. Noise control devices such as enclosures, barriers and mufflers are treated in chapters 8 and 9. No treatment of noise control techniques would be complete without including vibration control which is the subject of chapter 10. Procedures primarily based on empirical formula are introduced in chapter 11 for estimating the noise radiated by some mechanical and electrical equipment such as fans, compressors, pumps, electrical motors and generators.

Although chapters 1 to 11 retain most of the headings of the first edition, they have been substantially revised to include new material. Chapter 12 is the new chapter on active noise control. Chapter 13 is retained from the original chapter 12 which is essentially a brief survey of mathematical techniques for prediction. Considering the growing use of computer prediction procedures, it is a bit surprising that chapter 13 has not been revised to include examples that illustrate the use of these numerical methods to enhance effective noise control.

There are interesting problems for chapters 1 to 10 which are good exercises for students. A new appendix F on spectral analysis is included. In addition to over 300 references, there is also a list of Australian, American and International acoustical standards at the end of the book.

The book is very well written and the authors have treated each topic with care. This second edition has improved significantly the already excellent quality of the original work. Having adopted this book for teaching acoustic noise since 1989, I have found it very suitable for undergraduate and postgraduate course work. This is an excellent book which I highly recommend to students. Although the book is not a handbook, I have no doubt that professionals would also find it extremely useful. Even in times of stringent library budgets, this is one of the few books that engineering libraries can ill afford to miss.

Joseph Lai

Joseph Lai is an Associate Professor in the School of Aerospace and Mechanical Engineering at the University College at the Australian Defence Force Academy in Canberra.

INTERNATIONAL CONGRESS ON SOUND AND VIBRATION AND 1997 AAS CONFERENCE

The 5th International Congress on Sound and Vibration to be held on December 15-18, 1997 at The University of Adelaide, South Australia is the 5th in a series which began at Auburn University, USA in 1990. The 5th congress is sponsored by The International Institute of Acoustics and Vibration, The Australian Acoustical Society, The University of Adelaide and Vipac Engineers and Scientists.

The University of Adelaide is located close to the entertainment centre of a city with over one million people. Adelaide is well known for its lack of traffic jams, cleanliness and clean air as well as for parks and gardens, pure beaches and natural wildlife parks. The organising committee and The University of Adelaide would like to extend a warm welcome to all delegates.

All previous congresses in the series have been very successful and with over 400 abstracts already accepted, the 5th Congress looks set to exceed previous attendance records. The 5th Congress is being held jointly with the Australian Acoustical Society 1997 Annual Conference. Exciting technical and social programs have been planned for delegates as well as unique pre and post congress tours and accompanying persons activities.

The technical program includes seven distinguished keynote plenary addresses, a number of specialist keynote addresses in specially organised sessions and seven two-hour tutorials on current topics in acoustics and vibration from eminent international experts.

The plenary distinguished keynote addresses are:
A Century of shock wave dynamics Sir James Lighthill, UK
Helicopter rotor aeroacoustics Hanno Heller, Germany
Recent developments in acoustics Malcolm Crocker, USA
Vibration suppression through smart damping Dan Inman, USA
Active control of structurally radiated sound Chris Fuller, USA
Digital analysis techniques for bearings and gears Bob Randall, Australia
Hearing protectors Samir Gerges, Brazil

The seven tutorial topics are:
Active vibration control Chris Fuller (USA)
Active noise control Osman Tokhi (UK)
Dynamics of vibro-impact systems V.I. Babitsky (UK)
Force limiting in vibration tests Terry Scharton (USA)
Sound intensity Malcolm Crocker (USA)
Statistical energy analysis Paul Bremner (USA) and Ken Heron (UK)
Wavelet transforms David Newland (UK)

Information http://www.icsv5.on.net.
e-mail: icsv5@mecheng.adelaide.edu.au FAX: +618 8303 4367 TEL: +618 8303 5460

Letters...

Membership Grading

I wish to comment on several aspects of Ken Cook's article, (vol 25 no.1 April 97), on AAS Membership Grading.

The whole thrust of the article is disturbing to me. The approach seems to me to be how to keep people out. My concept would be how to encourage people in. Simplify the system, consider guidelines rather than rules. Take a realistic and open approach to individual applications.

The concept that directors of companies spend all their time on administration and no time working on acoustics is inconsistent with my twenty years experience in the acoustical consulting industry. The directors often do more acoustic work than their staff.

Several well known leaders in acoustical consultancy in Sydney would not now be eligible for membership under this regime. Their contribution to the industry has been valuable.

The need to submit examples of work done rather than take the word of a verifier is also of concern. This indicates that the opinion of existing members who verify the work of potential members is under question. The opinion of more than one verifier could realistically be required.

Let us not get into the loop of **WHO CHECKS THE CHECKER?**

Paul Bridge, BSc MAppSc MIEAust CPEng MAAS.

Reply on Membership Grading

The following constitutes a reply to "Letters to Editor" submitted by Paul Bridge concerning the article by Ken Cook on "AAS Membership Grading" in Volume 25 (1997), No. 1, 31-32.

I reply to the letter by Paul Bridge who made comments on my article "AAS Membership Grading" (Vol 25 No.1 (1997), 31-32). Paul, we're not trying to keep people from joining the Society. To help you in particular, and members in general I'd like to explain some of the history of the grading of applications.

Articles of Association 15 to 23 deal with membership of the Society. At the 30th Meeting of Council on 26 February, 1983 Guidelines for admission and grading of members were established, and these guidelines appeared in the Bulletin of the Australian Acoustical Society at Vol 11(1), 1983, 28-30. In June 1989 administrative procedures for membership (Admission of new members) were established. On establishment of Council Standing Committee on Membership, applications for membership have been dealt with in accordance with the published "Gates". The existence of the Articles require acceptance of "rules", so preclude Paul's alternative of "guidelines" on admission of members.

Council established the above guidelines, and CSCM is bound to follow this procedure unless instructed by Council to do otherwise. Members are reminded that members of the Society are represented on Council, through their divisional committees. Councillors are therefore people who bring to notice matters which have been of concern to members. Further, members have the authority to cause a change in the Articles of Association via a Council meeting and a properly constituted Meeting of Members. To my knowledge, no change to the Articles with respect to the grading of applicants has been put forward.

I turn now to the application form for admission to the Society and to the Membership Information leaflet. I firstly draw particular attention to the section "Professional and technical experience". One column is labelled "Proportion of time spent in acoustics", and means for the grade of Member the proportion spent engaged in acoustics at a professional level. In this regard it does not recognise accreditation for activities such as administration, sales or non-professional work in acoustics. In effect, for proportions less than 100 per cent, it will require an applicant to spend more time in a field until the effective period of 2 years is fulfilled.

The application form clearly indicates the need for "Applicants for the Grade of Member or Associate" to "include details of involvement in acoustical aspects, e.g. in design, analysis, drawing, specification, report, papers". People are reminded that Council Standing Committee comprises 3 people. Additionally, in verification of the standard of work details, the opinion of people outside the Committee has been sought.

New Products...

LARSON DAVIS

Sound Level Meter

The Larson Davis model 814 is a totally modern implementation of the classic sound level meter, with 1/1 and 1/3 octave filters and real time octave band analysis functions. The 814 provides a number of state-of-the-art features such as dual peak detectors and versatile data logging capabilities unique to the Larson Davis range of hand held sound level meters.This type 1 precision integrating sound level meter has dynamic range up to 110dB. The multi-tasking processor continues to measure whilst the data can be viewed, transferred or printed. The 814 with its multiple instrument function can be used as a simple sound level meter, as a logging sound level meter or as a octave band analyzer.

Further Information: Vipac Engineers & Scientists Ltd, 275 Normanby Road, Port Melbourne VIC 3207, Tel: 03 96479700, Fax: 03 96464370.

BRUEL & KJAER

Signal Conditioning Amplifiers

Bruel & Kjaer has introduced NEXUS, a new range of four channel conditioning amplifiers. NEXUS offers a dynamic range of up to 120dB, advanced overload detection facilities and transducer tests. This provides the flexibility to make different measurements whatever the signal or measurement situation. An extensive array of built-in filters makes it easy to focus on the signal of interest. The NEXUS range can interface with five main types of transducers, microphones, a sound intensity probe, charge accelerometers or with integral electronics and force transducers. The conditioning channels can be mixed and put in the same NEXUS 4 channel unit. This means a model can be tailored to a customer's specific requirements, eg. a triaxial accelerometer plus a microphone and preamplifier.

Further Information: Bruel & Kjaer, 24 Tepko Rd, Terrey Hills, NSW 2084, Tel: 1800 802852, Fax: 02 4502379.

RION

Sound Level Meter

A new Rion sound level meter is now available. The NA-27 is a precision, integrating, type 1 sound level meter with full and third octave measurement capacity in real time. This new meter offers a range of measurement modes and calculates reverberation times. The meter is user friendly with most functions being accessed by the simple pressing of clearly identified function keys. Dual measurement with different frequency and time weighting settings - all in real time - are features of the new NA-27. Rion has included infra-red communication ports for input and output for cordless data communication and remote control.

Further Information: Acoustic Research Laboratories Tel: 02 9484 0800, Fax: 02 94840884 or your local branch of ARL.

PYROTEK SOUNDGUARD

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A system employing the use of Pyrotek Soundlagg™ 4525 wrapped over the pipes and one layer of plasterboard will satisfy the requirements of most building owners and is now in wide use.

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Further Information: Pyrotek branches around Australia or Tel: 02 9631 1333 Fax: 02 9896 7711 nicmcg@pyrotek-inc.com

AUSTRALIAN ACOUSTICAL SOCIETY ENQUIRIES

NATIONAL MATTERS

* Notification of change of address
* Payment of annual subscription
* Proceedings of annual conferences

General Secretary
AAS– Professional Centre of Australia
Private Bag 1, Darlinghurst 2010
Tel/Fax (03) 9887 9400
email: watkinsd@melbpc.org.au
http://www.adfa.oz.au/~mxb/aa

SOCIETY SUBSCRIPTION RATES

From 1 APRIL 1997 membership subscriptions are:

Fellow and Member	$92
Associate and Subscriber	$74
Student	$20

DIVISIONAL MATTERS

Enquiries regarding membership and sustaining membership should be directed to the appropriate State Division Secretary

AAS - NSW Division
Professional Centre of Australia
Private Bag 1,
DARLINGHURST 2010
Sec: Mr D Eager
Tel (02) 9514 2687
Fax (02) 9514 2665
D.Eager@uts.edu.au

AAS - Queensland Division
PO Box 150,
OMMANEY 4074
Sec: Mr J Carter
Tel (07) 3806 7522
Fax (07) 3806 7999

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University of Adelaide
SOUTH AUSTRALIA 5005
Sec: Carl Howard
Tel (08) 8303 5460
Fax (08) 8303 4367
cqhoward@mecheng.
adelaide.edu.au

AAS - Victoria Division
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ACOUSTICS AUSTRALIA ADVERTISER INDEX - VOL 25 No 2

Diary...

* Indicates an Australian Activity

1997

September 1-4, JAPAN
IMAC-XV Japan, 'Bridge Over Virtual & Real Design'
Details: IMAC-XV, Dept. of Precision Mechanics, Chuo University, 1-13-27 Kasuga, Bunkyo-ku, Tokyo, 112 Japan. Fax 81 3 3817 1820 jmac@okubo.mech.chuo-u.ac.jp

September 10-12 , NEW ZEALAND
Biennial Conference - NZ Acoustical Society
Details: NZ Acoustical Society, PO Box 1181, Auckland, NZ Fax +64 9 623 3248

September 10-12, STUTTGART
Biomechanics of Hearing
Details: EUROMECH Colloquium 368, W. Schiehlen, Institute B of Mechanics, Uni of Stuttgart, 70550 Stuttgart, Germany.
wos@mechb.uni-stuttgart.de

September 12-13, USA
Symposium on Sonoluminescence.
Detail: M. brenner, MIT, Dept of Mathermatics, Cambridge, MA 02139, USA,
Fax +1 617 2534358, brenner@math.mit.edu

September 15-17, ENGLAND
Whole-Body Vibration Injuries.
Details: Institute of Sound & Vibration Research, Uni Southampton, SO17 1BJ England.
Ph: +44 1703592277 Fax: (+44) 17035 92927.
hfru97@isvr.soton.ac.uk

September 17-19, ENGLAND
32nd Meeting of the UK Group on Human Response to Vibration.
Details: Institute of Sound & Vibration Research, Uni Southampton, SO17 1BJ England.
Ph: +44 1703592277 Fax: (+44) 17035 92927.
hfru97@isvr.soton.ac.uk

September 18-19, MEXICO
4th Mexican Congress on Acoustics
Details: Mexican Instit. of Acoustics, PO Box 75805, 07300, Mexico City, Mexico, Fax: +52 55234742, sberista@vmredipn.ipn.mx

September 18-20, GREECE
Intonation: Theory, Models and Applications
Details: ESCA Workship, Dept. of Informatics, Uni of Athens, Fax: +30 17228981, tonesca@di.uoa.gr

September 21-23, USA
Product Sound Quality 1997
Details: PSQ'97, RH Lyon Corp, 691 Concord Av, Cambridge, MA 02138, USA,
Fax: +1 6178640779, rhlyon@mit.edu

September 27-28, GREECE
Audio-Visual Speech Processing
Details: ESCA, ICP-Université Stendhel, BP 25X 38040 Grenoble Cedex France, sca@icp.grenet.fr

*** October 1-3, QUEENSLAND**
(CM)2 Forum - for more effective condition monitoring
Details: Centre for Machine Condition Monitoring, Monash University, Wellington Road, Clayton, Victoria 3168 Australia.
Ph: +61-3 9905 5699, Fax: +61 3 9905 5726
maltezos@eng2.eng.monash.edu.au,
http://www.monash.edu.au/cmcm

October 8-10, WINDSOR
Acoustics Week in Canada 1997
Details: R Ramakrishnan, Vibron Ltd, 1720 Meyerside Drv. Mississauga, Ontario, L5T 1A3 Canada. Fax: +1 905 670 1698

October 23-26, UNITED KINGDOM
Reproduced Sound 13
Details: Inst. of Acoustics, Agriculture House, 5 Holywell Hill, St Albans, Herts AL1 1EU, UK
Fax: +44 1727850533, acoustics@clusl.ulcc.ac.uk

November 9-13, KYONGJU
Asia Pacific Vibration Conf 97
Details: APVC97, Intercom Services, 4Fl Jisung Bldg, 645-20 Yoksam 1-dong, Kangnam-gu, Seoul 135-081, Korea. Fax +82 2 3452 7292
intercom@sobak.kornet.nm.kr

November 19-20, HONG KONG
WESTPRAC '97
Details:Dept. of Building Services Engineering, The Hong Kong Polytechnics Uni., Hong Kong.
Fax +852 27746146 besktang@polyu.edu.hk
http://www.polyu.edu.hk/~westprac

December 1-5, SAN DIEGO
Meeting of the ASA
Details: ASA, 500 Sunnyside Blvd., Woodbury, NY 11797 USA. Fax +1 516 576 2377, asa@aip.org

December 15-18, ADELAIDE
* 5th Int Conf on Sound & Vibration
Details: Dept Mech Eng, University Adelaide, SA 5005, Australia. Tel +61 8 303 5698, Fax +61 8 303 4367, icsv5@mecheng.adelaide.edu.au

1998

***February 24-26, SYDNEY**
UDT Pacific 98
Details: Nexus Information Technology, Nexus House, Swanley, Kent BR8 8HY UK, Tel: +44 1322660070, Fax: +44 1322661257,
UDT.Pacific@nexusmedia.co.uk

March 23-27, ZURICH
DAGA 98 - German Acoustical Society Meeting
Details: DEGA, Physics/Acoustics Dept., Universität Oldenburg, 26111 Oldenburg, Germany. Fax: +49 441 798 3698,
dega@aku.physik.uni-oldenburg.de

April 5-8, MICHIGAN
NOISE-CON'98
Details: INCE, PO Box 3206 Arlington Branch, Poughkeepsie NY 12603, Fax: +1 9144624006,
inceusa@aol.com,
http://users.aol.com.noisecon98/nc98_cfp.html

May 12-15, SEATTLE
IEEE Conf. on Acous, Speed & Signal Processing
Details: L. Atlas, Dept. EE (FT 10), University of Washington, Seattle, WA, USA.
Fax +1 206 543 3842, atlas@ee.washington.edu

May 25-27, ITALY
Noise and Planning 98
Details: Noise & Planning, via Bragadino 2, 20144 Milano, Italy, Fax: +39 248018839,
mdl467@mclink.it

June 8-10, TALLINN
Transport Noise and Vibration
Details: East-European Acoustical Assoc., Moskovskoe Shosse 44, 196158 St. - Petersburg, Russia. Fax: +7 812 127 9323,
krylspb@sovam.com

June 9-12, SWEDEN
8th International Conf. on Hand-Arm Vibration
Details: National Institute for Working Life, Conf. Secretariat HAV98, PO Box 7654, 90713 Umeå, Sweden, Fax: +46 90165027, hav98@niwl.se

June 20-28, SEATTLE
16th International Congress on Acoustics
Details: 16th ICA Secretariat, Applied Physics laboratory, Uni of Washington, 1013 NE 40th St. Seattle, WA 98105-6698, USA.

June 21-26, USA
13th U.S. National Congress of Theoretical and Applied Mechanics.
Details: M. Eisenberg, AeMES Dept., Uni of Florida, PO Box 116250, Gainesville, FL 32611-6250, USA, Fax: +1 3523927303,
meise@eng.ufl.edu

June 26 - July 1, LEAVENWORTH
Tone and Technology in Musical Acoustics
Details: Catgut Acoustical Society, 112 Essex Avenue, Montclair, NJ 07042 USA,
Fax: +1 2017449197, catgutas@msn.com,
http://www.boystown.org/isma98/

September 16-18, BELGUIM
Int. Conf. on Noise and Vibration Engineering
Details: Ms L Notré, KU Leuven, Division PMA, Celestijnenlaan 300B, 3001 Leuven, Belgium,
Fax: +32 16322987, lieve.notre@mech.kuleuven.ac.be,
http://www.mech.kuleuven.ac.be/pma/events/isma
/isma.html

October 12-16, AMERICA
Meeting of ASA
Details: ASA, 500 Sunnyside Blvd., Woodbury, NY 11797 USA. Fax +1 516 576 2377, asa@aip.org

November 16-20, CHRISTCHURCH
INTER-NOISE 98
Details: NZAS. P.O. Box 1181, Auckland, NZ, Fax +64 9 309 3540

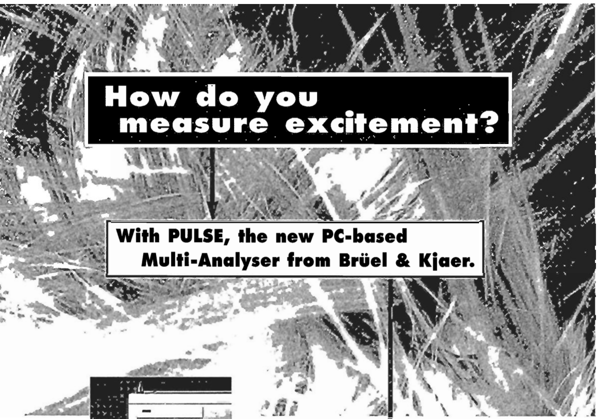
November 20, QUEENSTOWN
Recreational Noise
Details: P. Dickenson, NZ Ministry Health, PO Box 5013, Wellington, NZ Fax +644 4962340,
philip.dickenson@mohwn.synet.net.nz

***November 22-26, SYDNEY**
Noise Effects 98 ICBEN Congress
Details: Noise Effects '98, GPO Box 128, Sydney NSW 2001 Australia Tel: 02 92622277
Fax: 02 92622323, tourhosts@tourhosts.com.au

***November 30 - 4 December, SYDNEY**
5th Int. Conf. on Spoken Language Processing
Details: Tour Hosts, GPO Box 128, Sydney NSW 2001 Australia, Fax: 02 92623135,
tourhosts@tourhosts.com.au,
http://cslab.anu.edu.au/icslp98

***December 8-11, TASMANIA**
COMADEM 98
Details: Centre of Machine Condition Monitoring, Monash Uni. Dept. of Mechanical Engineering, Wellington Rd, Clayton VIC 3168,
Tel: 03 99055699, Fax: 03 99055726,
maltezos@eng2.eng.monash.edu.au,
http://www.monash.edu.au/cmcm/

December 15-17, INDIA
"Designing for Quietness" an Int. Symp.
Details: Prof. ML Munjal, Senter of Excellence for Technical Acoustics, Dept. of Mechanical Engineering, Indian Institute of Science, Bangalore 560 012, India,
munjai@mecheng.iisc.ernet.in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