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Acoustics 2005: Acoustics in a Changing Environment
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Keynote Paper

Virtual Acoustic Prototypes: listening to machines that don't exist

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ABSTRACT
The concept of Virtual Acoustic Prototypes (VAPs) is explained and is illustrated with examples. A VAP is a computer representation of a machine (e.g. a lawnmower), such that it can be heard without it necessarily having to exist as a physical assembly. It is argued that, whereas visualisation tools are well developed in the field of visual design, equivalent tools for auralisation, such as VAPs, are still in their infancy. Examples of VAPs for a fridge, a telecommunications base station and a washing machine are presented, through which it becomes clear that considerable sophistication is required to include all the various excitation and transmission mechanisms found in real machines. It is explained that VAPs cannot be purely 'virtual' and that some measured data will be needed for the foreseeable future, particularly to characterise active components. Some of the advantages of working with VAPs are outlined.

Plenary Speakers

Seaweb Acoustic Com/Nav Networks

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ABSTRACT
Seaweb networks interconnect fixed and mobile nodes distributed across a wide area in the undersea environment. Acoustic communications between neighboring DSP-equipped telesonar modems is the basis for the physical layer. Node-to-node ranging is a by-product of telesonar signaling, permitting localization of sensor nodes and navigation of mobile nodes such as submarines and autonomous vehicles. The unusual characteristics of the physical-layer medium constrain the design of the link and network layers. Seaweb data-packet communications are achieved through the ancillary use of compact channel-tolerant utility packets. Measuring the available acoustic channel permits link optimization by adapting the

data-packet signal parameters to the prevailing channel attributes. Link-layer methods including forward error correction, handshaking, and automatic repeat request provide reliability. Network-layer mechanisms such as distributed routing tables, neighbor-sense multiple access, packet serialization, and return receipts enhance quality of service. This paper reviews the concept of operations for undersea networks with illustrative examples of actual Seaweb deployments.

Acoustic systems in biology: from insects to elephants

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ABSTRACT
Nearly all animals use sound for communication, for seeking prey, and for avoiding predators. What physical principles govern their choice of frequency? What are their mechanisms of sound production and directional hearing? Why are cicadas so loud? How do birds produce those beautiful, or sometimes not-so-beautiful, sounds? Quantitative analysis of the acoustic mechanisms involved reveals (nearly) all: the action of the sensory hairs on caterpillars, the hollow bodies of cicadas that act as resonators, the horn-shaped burrows dug by crickets and their remarkably human-like auditory anatomy, the inflatable vocal sacs used by "pure tone" songbirds and by frogs, and the chaotic structure of the shrieks of sulphur-crested cockatoos. This lecture will explore all these matters and perhaps some more.

Challenges facing Acoustics in Australia

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ABSTRACT
The Australian Acoustical Society is a professional society with membership from all aspects of acoustics (including vibration). One important concern, from an investigation of the top ten issues for the Membership, was the future for acoustics in Australia as a whole. This was further investigated and two major areas were identified: changes in the approach of the government regarding support for publicly funded facilities and opportunities for education in acoustics. This paper provides an overview of the findings thus far and is intended to be an introduction to the workshop discussion on this topic.

Theme: Active Noise and Vibration Control

Investigation into the feasibility of using a parametric array control source in an active noise control system

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ABSTRACT
Conventional Active Noise Control (ANC) systems that minimise pressure at a point in space have typically used loudspeakers as control sources, which are virtually omnidirectional within the low frequency range of interest. One obvious disadvantage of this is that locations remote from the desired control point may actually experience an increase in sound pressure level. The parametric array is capable of producing a highly directional beam of low frequency sound via the nonlinear interaction of emitted ultrasonic waves with air. Although significant research and development of the parametric array for use in audio systems has been undertaken, the feasibility of using a parametric array as the control source in an ANC system has not yet been fully investigated. Within this paper, the theory governing the operation of the parametric array and the resulting restrictions upon the production of low frequency sound are discussed. Experimental testing of a commercially available parametric array indicates that although highly directive low frequency noise of sufficient amplitude for some ANC applications can be produced, there are a number of practical concerns. The noise floor of the parametric array is high at low frequencies, resulting in a poor signal to noise ratio. The nonlinear nature of the sound production process means that the precise control in amplitude and phase required for ANC cannot, as yet, be achieved. In addition, there are concerns regarding the safety of the high amplitudes of ultrasound emitted by the parametric array. These limitations would all need to be overcome before the parametric array could be successfully implemented as a control source in an ANC system.

Active modal control of hull radiated noise

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ABSTRACT
A theoretical analysis of the active modal control of radiated pressure from a finite cylindrical pressure hull is presented. The control action is implemented through a Tee-sectioned circumferential stiffener driven by a pair of PZT stack actuators. The actuators are located under the flange of the stiffener and are driven out of phase to

produce a control moment. This paper examines the effects of control actions, both structurally and acoustically, for a control moment applied around the circumference of the hull. The model considered is a water-loaded finite stiffened cylindrical shell with rigid ends caps. One end of the shell is excited by an axial force while the other end is free. Control action is achieved by using the PZT actuators and stiffener to minimize the structural response and radiated pressure. It was found that the control system was capable of reducing the radiated pressure by approximately two-thirds for the first three axial modes.

Global control of sound radiation from a plate using several adaptive vibration neutralisers with local control schemes

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ABSTRACT
Adaptive tuned vibration neutralisers are common solutions to controlling a single but variable frequency disturbance, such as the interior sound field in a turbo prop aircraft. This paper presents a study of feedback control of several adaptive vibration neutraliser to minimize tonal sound radiation from a modally dense rectangular plate. It is shown that several adaptive vibration neutraliser's using local feedback loops can be managed by a simple global algorithm to minimize the sound radiation from a plate. As an adaptive passive approach is used, each individual adaptive vibration neutraliser can be constrained to be stable and the resulting global system is also stable. Spatially averaged single frequency reductions of up to 22dB are experimentally demonstrated in the radiated field.

Measured dynamics of a thin cylindrical shell subject to axial excitation

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ABSTRACT
One source of structural vibration in a submarine is the fluctuating axial thrust force applied to the thrust block by the propeller shaft. This paper describes the initial stages of experimental work being undertaken to validate an existing mathematical model for the sound radiation from a submarine excited by this mechanism. A thin cylindrical shell 1500mm long and 400mm in diameter made of 2mm thick steel with its ends capped by 20mm thick steel discs is examined. The shell was suspended from eyelets welded at either end and was excited axially by a modal

shaker mounted inside the cylinder on one of the end caps. The first few modes with significant axial content were extracted from frequency-response functions measured at a number of points on the surface of the cylinder and the end caps and are described. This work will lead into the development of a sound radiation model suitable for use in the active vibration control of the cylinder.

Robust virtual acoustic sensing

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ABSTRACT
The aim of the paper is to develop a robust virtual sensing method where dynamic variations in the actual acoustic system would not degrade the sensing performance. The approach here is to consider the possible uncertainties in the systems and to take into account this information to develop a virtual sensing method that is robust against these uncertainties. A certain sensing performance can be enforced and the task is formulated as an optimal robust control problem that includes uncertainty modelling. Numerical studies are performed on an acoustic duct system with varying properties, which show a satisfactory performance of virtual sensing when the system varies within a particular range. The proposed approach guarantees a certain level of performance robustness for virtual sensing when the systems are expected to vary during operations. Therefore, the approach can be used for practical implementation in actual acoustic systems where it is possible that the systems might vary during the sensing and control operation.

Active broadband control of vibrating panel structures with multiple structural sensors

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ABSTRACT
The aim of the research presented in this paper is to actively control broadband vibration on panel structures using multiple sensors. The broadband vibration profile of a panel structure is estimated by using spatial interpolation functions and vibration measurements from the surface mounted sensors. The control objective is then achieved by deriving 'spatial' error signals whose energy represents the spatially-weighted vibration energy over the structure. An optimal H-2 control design using this spatial control approach is discussed to demonstrate the effectiveness of the broadband spatial control on a panel. Numerical results show that the broadband vibration profile can be spatially controlled, not just by minimising the strength of each vibration mode, but also by controlling the relative strength of each mode.

Six-Axis Vibrational Power Transducer for Active Vibration Isolation

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ABSTRACT
A transducer is described which can be used to measure the translational and rotational vibratory power transmission from a source to a receiving structure. A description of the procedure used to calibrate the device is also included. The results from the calibration show that whilst the amplitude of the forces, moments, translational and rotational displacements can be measured accurately, it is the phase accuracy of these measurements that limit the accuracy of measurements of vibratory power transmission. The transducer was used in active vibration isolation experiments to reduce the vibration energy transmitted into a beam from a vibrating rigid mass. The results show the occurrence of vibratory power circulation where translational vibration is converted into rotational vibration.

Beam steering of sound from flat panels using spatially-averaged objective functions

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ABSTRACT
The paper proposes a beam steering method for regulating sound radiation from flat panel structures using multiple structural velocity sensors. Velocity measurements from the structural sensors are used to estimate the velocity profile of the panel, which is then used to estimate the acoustic beam pattern of radiated sound. An objective function is defined for active beam steering purposes, representing the spatially-averaged error between the reference beam pattern and the estimated beam pattern of sound radiation in the far-field. Numerical studies on a rectangular flat panel are used to demonstrate the ability of the proposed method to regulate a beam pattern of sound for steering a beam to different directions in the far-field. It is demonstrated that the proposed method can modify the beam pattern of tonal sound radiation by modifying the vibration velocity profile of the panel.

Active Vibration Control of a Magnetorheological Sandwich Beam

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ABSTRACT
Sandwich beam structures constructed with MR fluids can be implemented as distributed vibration absorbers to suppress unwanted vibrations. This paper introduces an analytical model for MR structures based on the Kelvin-Voigt model and Hamilton principle. The relationship between the magnetic field and the complex shear modulus of MR sandwich beam in the pre-yield regime is presented. The governing partial differential equations describing the dynamics of MR sandwich beam are derived and a model analysis is performed. An active vibration controller based on Lyapunov stability theory is designed. Simulations show the stable response and improved transient performance provided by the control system.

Theme: Acoustic/Vibration Measurement/Modelling

An optical 3D sound intensity and energy density probe

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ABSTRACT
In this paper, an optical sensor capable of measuring pressure and the three orthogonal particle velocities at a point is presented. This sensor can be used to measure three-dimensional sound intensity or energy density in the presence of strong electro-magnetic and radio-frequency fields. The benefits of the sensor compared to traditional p-p intensity probes is discussed, as well as the design, construction and performance of the sensor. It will be seen that this new type of sensor has many advantages compared to traditional sensors.

Road Traffic Noise Prediction: An Artificial Intelligence Approach

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ABSTRACT
Present road traffic noise prediction models, such as TNOISE, use semi-empirical adjustments to account for factors that influence the noise level impacting a receiver. Most adjustments are based on actual sound level measurements, for example of noise attenuation by different ground types, and hence present models perform satisfactorily for the simple situations in which the measurements were made. However, accurate noise prediction in more complex situations is beyond the ability of such models, because determination of a comprehensive set of adjustments is defeated by the numerous possible variations in terrain characteristics, building geometries, and so forth. This paper describes how this problem can be overcome using a neural network approach to road traffic noise prediction. We demonstrate how a simple neural network easily mimics one of the present road traffic noise models, and how neural networks trained on grid-based data can learn to predict road traffic noise in complex situations.

Theme: Architectural Acoustics

Auditory Room Size Perception for Real Rooms

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While research on hearing and perception of room acoustics has produced a great deal of information concerning the qualitative auditory sensations imparted on listeners in rooms (reverberance, clarity, etc), little is known about the quantitative information that listeners obtain concerning the rooms encountered in their everyday lives. Information about room size, floor construction, room shape, and many other aspects is transmitted acoustically to listeners in their environments, but it is the sense of vision that is erroneously assumed to provide all of this information to humans. A common listening task which has been left behind in research, however, is the ability of perceiving the size of rooms. In this study, subjective experiments with blindfolded people were conducted to obtain room size ratings. Anechoic speech was reproduced over loudspeakers in three small rooms and the relationships between the room acoustical parameters and the room size judgements were investigated. The results were compared with results from previous studies where modelled and measured rooms were used for subjective testing.

Reproduction of Room Sound-fields for Subjective Assessment

Densil Cabrera

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ABSTRACT
This paper reviews techniques for the recording and reproduction of room sound fields used by the author in a variety of room acoustics research projects. The paper approaches this first through discussion of various criteria for assessing the usefulness of sound-field reproduction/simulation systems. The paper highlights issues in the recording of impulse responses for audio reproduction (through convolution) including in the design of the sound source, the design of microphone arrays, measurement signals, treatment of impulse responses and larger problems with this process. The greatest focus of this paper is on audio reproduction methods, with an emphasis on non-individualized two-channel techniques.

Theme: Electro-acoustics

A Loudspeaker Response Interpolation Model based on One-twelfth Octave Interval Frequency Measurements

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ABSTRACT
A practical loudspeaker frequency response interpolation model is developed using a modification of the Tuneable Approximate Piecewise Linear Regression (TAPLR) model that can provide a complete magnitude and phase response over the full frequency range of the loudspeaker. This is achieved by first taking standard one-twelfth octave frequency interval acoustic intensity measurements at a one meter distance in front of the loudspeaker. These measurements are inserted directly into the formulation, which then requires only minimal tuning to achieve a magnitude response model to better than +/- 1 dB error as compared with the magnitude of the Fourier transform of the impulse response for typical hi-fi loudspeakers. The Hilbert transform can then be used to compute the corresponding phase response directly from the resulting magnitude response. Even though it is initially based on consecutive piecewise linear sections this new model provides a continuous smooth interpolation between the measured values that is much more satisfactory than normal piecewise linear segment interpolation and much simpler to do than polynomial interpolation. It only requires the tuning of a single parameter to control the degree of smoothness from a stair step response at one extreme to a straight mean horizontal line at the other. It is easy to find the best tuning parameter value in between these two extremes by either trial and error or by the minimisation of a mean squared interpolation error.

Resolution enhancement of a general HRTF library

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ABSTRACT
Head Related Transfer Function (HRTF) libraries enable the generation of virtual acoustic sources in arbitrary spatial positions. In experiments with a large number of test subjects, general or non-personified HRTF libraries are used, measured with human-shaped dolls. The resolution of azimuth in the frontal area is much better than in lateral areas. To improve resolution in lateral areas, Principal Component Analysis (PCA) on 37 HRTF magnitudes at elevation 0° was performed. The 1st and, in part, the 2nd weight were found to be monotonic functions of azimuth, with greater slope at an azimuth of around 0° and smaller in lateral areas. To enhance resolution in lateral areas, the weights were linearly interpolated and the slope was increased to become constant over all azimuths in the median plane (from -90° to 90°) and reconstructed HRTFs using those modified weights. Localization tests performed with original and modified HRTFs showed that resolution in the frontal area remains the same, while there is a noticeable improvement of resolution in the lateral areas (azimuths ±90° and ±45°).

Coding of Elevation in Acoustic Image of Space

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ABSTRACT
Spectral features of sound are believed to be the primary cues for the human perception of spatial sound elevation. It has also been observed that people connect higher frequencies of sound with a higher elevation of the sound source and lower frequencies with lower elevations. The most common approach to creating an acoustic image delivered by headphones is to use Head Related Transfer Functions (HRTFs). Unfortunately, satisfactory perception of elevation can only be achieved with personalized HRTFs which are impractical to measure. This paper describes an alternative method of sound coding for representation of the virtual sound source elevation in an acoustic image. Our method is based on coding particular elevations with sound stimuli which differ in spectral content. Sound stimuli were created by various signal processing techniques (e.g. filtration, modulation). Experiments show that, in certain cases, test subjects were able to perceive up to 60 different elevations in the range of –40° to 90°.

Theme: Engineering Noise/Vibration Control

General Design Principles for an Automotive Muffler

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ABSTRACT
This paper discusses the general principles of muffler design and explains the main advantages of various styles of mufflers. When designing a muffler for any application there are several functional requirements that should be considered, which include both acoustic and non-acoustical design issues as detailed in this paper.

An Adaptive Chimney Stack for Noise Control

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ABSTRACT
Radiation of noise from exhaust stacks is a significant source of community disturbance. In this paper an exhaust stack with an adaptive length is proposed. The effective length of the stack is changed by altering the level of water in a sump at the base of the stack, this level is controlled as a function of the radiated noise from the top of the stack. The system is modelled as a pipe with an adaptive side branch. A gradient descent algorithm is used to minimise the radiated sound. The response to a step change in frequency and a chirp signal is shown. A simple heuristic controller is compared to the performance obtained with the gradient descent algorithm and is shown to be acceptable and computationally simpler.

Noise Reduction of a Rocket Payload Fairing Using Tuned Vibration Absorbers with Translational and Rotational DOFs

Carl Q. Howard, Colin H. Hansen, and Anthony C. Zander

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ABSTRACT
Numerical optimisations were conducted to reduce the noise levels inside the payload bay of a rocket by using vibration and acoustic absorbers attached to the fairing walls. The vibration absorbers act in both translational and rotational axes.

The acoustic absorbers were modelled as simplified Helmholtz resonators. A Finite Element model of the vibro-acoustic system was created in ANSYS and the uncoupled structural and acoustic modal responses were calculated. The combined response of the acoustic and vibration absorbers, the acoustic cavity and structural modal responses were coupled using modal coupling theory in Matlab. The optimisation of the parameters and locations of the absorbers were conducted using a semi-synchronous parallel genetic algorithm and a large number of networked desktop computers.

Optimisation of Design and Location of Acoustic and Vibration Absorbers Using a Distributed Computing Network

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ABSTRACT
A distributed computing network was created using the software called Condor and a large number of networked desktop computers. This computational tool was used to optimise the design and location of passive vibration and acoustic absorbers attached to the payload fairing of a rocket launch vehicle. This paper describes a mathematical model to calculate the coupled vibro-acoustic response of a system from the uncoupled structural and acoustic modal responses obtained from finite element analysis. A genetic algorithm was used in conjunction with the distributed computing network to optimise the parameters of the absorbers. The optimisations using the computing network could be completed in significantly less time compared to a single desktop computer.

Optimisation of Stiffener Layout On Shell-like Structure

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ABSTRACT
This work is concerned with defining a methodology for adjusting the design of gearbox casings so that the radiated noise for constant speed operation is minimised. A baffled rectangular plate having a dimension similar to that of radiating surface of the gearbox casing was used in the study to develop the technique. Structural changes such as the number and arrangement of stiffening ribs were simulated on the plate and the differences in the radiated sound studied. A valid modal model of the plate was developed by correlating experimental data with numerical results. The same updating technique can later be used on the gearbox model with internals. Pseudo-inverse method was used to determine the excitation

force from the measurement of the surface vibration and the updated FE model. The same forcing function was used in the subsequent optimisation studies for which an optimal stiffener layout was sought for minimising the weighted vibration energy. The optimisation was performed over a band of frequencies centred on the dominant excitation frequencies in order to make it less sensitive to the accuracy of the model as well as the variations from one unit to another. A procedure for determining an optimal configuration using genetic algorithm was proposed.

Predicting the Acoustic Performance of Mufflers using Transmission Line Theory

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ABSTRACT
The effectiveness of a reactive muffler results from the destructive interference of acoustic waves travelling within the device. Cross-sectional area changes within the device produce the interfering acoustic waves. In this paper, plane wave transmission line theory is used to predict the acoustic performance of simple expansion chamber mufflers. The performance is quantified by the frequency-dependent sound transmission loss. The presence of dissipative materials has also been considered by the inclusion of a simple model describing wave propagation in porous materials. The predicted acoustic performance is obtained for various mufflers and compared with results obtained experimentally.

Control of building vibration against earthquakes

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ABSTRACT
An aseismic hybrid control system was employed to protect a five-storey benchmark-building model against strong earthquakes. The hybrid control system consists of a base isolation system (laminated rubber bearings) connected to an active control system (a tuned mass damper and an actuator). A five-storey benchmark model is developed to study the effectiveness of the hybrid control system against different ground motions: El-Centro 1940, Hachinohe 1968, Kobe 1995, and Northridge 1994 earthquakes. It was found from the numerical results, that the rubber bearing system alone can perform well against Hachinohe and Northridge ground motions, but not well enough to protect the lower floors of the

model against El-Centro and Kobe ground motions. After an active control system was implemented to the rubber-isolated model, further improvements in earthquake resistance against these four earthquakes were obtained, especially against the El-Centro and Kobe. It is shown that a combined use of active and passive control systems, (referred to as hybrid control system), is more effective in reducing the building response under strong earthquakes.

Improvement of Sound Absorption of Honeycomb Panels

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ABSTRACT
Honeycomb panels are commonly used in ship, aircraft and building industries because of their lightweight, high-stiffness and non-combustibility properties. However, they provide very little absorption to sound approaching to them. This paper reports a significant improvement of the sound absorption in a broad frequency range when one of the surface sheets of honeycomb panels is micro-perforated. Acoustical analysis and test have been used to select the panel parameters for achieving the optimal sound absorption performance of the perforated honeycomb panels. One practical outcome of this study is a new type of micro-perforated honeycomb panels, and their successful test results for noise reduction in ship building industry is also presented.

Theme: Environmental Acoustics

Noise mapping an entertainment precinct

David Borgeaud

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ABSTRACT
Brisbane's Fortitude Valley is an inner city area combining retail, commercial, residential, and entertainment uses. For many years it has been the melting pot for new groups and has been the starting point for several major Australian bands. The Valley has seen a large increase in the number of residential apartments over recent years as part of Brisbane's inner city urban renewal, which has led to concerns regarding the impact this may have on the future of live music in the Valley. To address this issue, the Brisbane City Council is developing the Valley Music Harmony Plan that includes entertainment precincts with specific noise criteria within the

Valley, and will allow informed decisions to be made regarding future development while minimising potential noise conflicts. A picture of the existing noise climate in the Valley was required to provide background information for the project. The aim of the study was to provide a noise contour map of the Fortitude Valley Local Plan area for the day, evening and night time periods, and to determine suitable times for these periods given the different nature of the noise climate within the Valley (eg. traffic jams at 1am, evening and night time levels higher than day time noise levels). Modelling and monitoring approaches were considered to produce the noise contours, however monitoring was chosen as the preferred approach as it would incorporate sporadic sources such as people's voices, music, and randomly located mechanical plant. A monitoring strategy was developed and implemented, including safety procedures. Measurements were taken at over 330 locations. The resulting data was used to produce dB(A) and dB(C) contours and provide specific levels outside venues, which provided a clear indication of hot spots and areas to be considered for the entertainment precinct. The work concluded that: road traffic noise dominates the ambient levels in many areas; the Valley Heart Precinct has the largest number of entertainment venues and experiences the highest noise levels; in areas with live entertainment the evening period may effectively extend to 1.00am; and patrons and pre-recorded music venues may maintain relatively high ambient noise levels for several hours after the live music has finished. The noise mapping work has proved an invaluable tool in the development of the Valley Music Harmony Plan, which was released in draft form in 2005 by the Brisbane City Council.

Entertainment noise in Western Australia

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ABSTRACT
Noise exposure to people working in the music entertainment industry has long been recognized as a workplace hazard in Western Australia. The Occupational Health, Safety, and Welfare Commission of Western Australia first issued a Code of Practice "Control of Noise in the Music Entertainment Industry" in 1992. This has been updated several times, most recently in 2003. To promote the use of this Code of Practice and noise control in the music entertainment industry, an inspection project was carried out in late 2004/early 2005 by WorkSafe. This was a follow-up of a previous project conducted in 2000. In this present study, a total of 17 music entertainment venues were visited, 3 of which had been inspected during the previous project. In each venue, employees' noise exposures were assessed and noise-related information was collected via a questionnaire. Information on noise control, hearing protectors and the Code of Practice were provided to management at each venue and some law-enforcement actions were taken where required. Results were analysed and compared to those obtained in 2000. It has been found from this study that although the awareness of noise and need for hearing protection has increased in the industry, noise is still a major hazard. More work is required to promote practical noise controls, select suitable hearing protectors and ensure that these are worn.

Influence of music genre and composition on entertainment noise limits

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ABSTRACT
Liquor licensing authorities across Australia typically require an entertainment noise test to be conducted before a venue can host amplified entertainment. The purpose of this test is to simulate live entertainment in order to determine the maximum permissible noise source limits allowed for the venue. In this paper, several disadvantages of the current method used for entertainment noise testing are identified and discussed. It was found that the choice of music can affect the resulting source noise level limits. An alternative approach has been suggested which involves playing band-limited pink noise across the 63 to 2kHz octave bands. A correction is then applied to determine the source noise level limits associated with different genres of music. The advantages of this method are that it reduces the time required to conduct the test, the nuisance caused to neighbouring premises is reduced and the variance in source noise level limits caused by different choice of test music is eliminated.

Challenges in our changing soundscape

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ABSTRACT
Many changes have occurred in the last seventy years, not least of which are the changes in our environment and interdependently our intellectual and technological development. The problems that faced our predecessors at that time were quite different from those of today, perhaps not as great but, with the limited tools at their disposal, no less demanding - particularly so in the economic and political situation of the time. The difficulties they faced were mainly technological. It was the developmental period of acoustical measurement and assessment, and they provided the basis on which we rely for our present day work. The one thing technologically that was not solved is the lack of accuracy in the measurement of sound. No doubt this too will be solved in time but a still greater challenge faces us today - perhaps the most difficult acousticians have ever had to face. Our problems not only involve sound, but also culture, possibly genetics, and the side-effects of developments in communication and mobility.

The acoustics of church bell-towers for change ringing

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ABSTRACT
In a changing urban environment the tradition of ringing bells in church bell towers has, in some circumstances, been significantly curtailed by the complaints of residents. This paper examines some of the issues involved in treating bell towers in order to balance the longstanding tradition of change ringing against the need to minimise neighbourhood complaints.

Application of Acoustic Techniques in the Management of a Threatened Migratory Bird (Orange-bellied Parrot)

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ABSTRACT
The Orange-bellied Parrot Neophema chysogaster (OBP) is a threatened, obligate migrant. The species breeds in south west Tasmania (Oct-Feb) and migrates along the Tasmanian west coast and western Bass Strait to South Australia and Victoria where it spends the winter months foraging in a range of coastal habitats. A method to estimate the total population and habitat usage during migration and at wintering sites is difficult for this mobile species which often frequents rugged and remote areas. The possibility of using long-term audio recording at various strategic locations throughout the OBP's range is being investigated as a survey technique. At this stage it is believed that long-term recording followed by laboratory-based signal analysis offers significant advantage over, and is a precursor to, a call-triggered data logger approach. If successful, the method has the potential to greatly extend the data collection effort compared to direct observer methods. The acoustic method can operate at night (OBPs are known to fly at night) and can be used where continuous observation is beyond personnel resource availability. Preliminary field trials indicate that the flight call of the OBP, at between 6 and 8.5 kHz, can be successfully recorded and subsequently identified by a skilled ornithologist. The next stages of the investigation are an assessment of the 'uniqueness' of the OBP call compared to closely related species; development of recording devices and power supplies suitable for operation in remote locations; and a review of field trials to determine the potential for development of call-triggered data loggers.

Theme: Transportation Noise

Traffic Noise Control Using Acoustic Screens

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ABSTRACT
New residential development was recently established in Coomera at the Gold Coast to Brisbane urban corridor. The development has an extensive frontage to a sub-arterial road with an ultimate capacity of 14,000 vehicles per day (Annual Average Daily Traffic - AADT). The houses in the first row along the road were affected by traffic noise exceeding the free-field traffic noise criterion of 60dB(A)$L_{10(18\ Hour)}$. The design of the dwellings (all low-set houses) includes large patios with pergolas facing the traffic noise source. Considering that the elevation of the dwellings was at least 2 metres higher than the elevation of the road it was considered impractical to construct a noise barrier fence along the property boundary. Instead, acoustic screens (1.8m high) were recommended along the perimeter of the patios. Post construction investigation of the efficiency of one of the acoustic screens was carried out. The aim was to determine the noise reduction achieved as well as to determine the compliance with the relevant free-field traffic noise criterion for formal open space of 60dB(A)$L_{10(18\ Hour)}$ considering ultimate traffic flow of 14,000 vehicles AADT. The investigated 1.8m high acoustic screen has attenuated the traffic noise to below the free-field criterion of 60dB(A)$L_{10(18\ Hour)}$. The noise reduction achieved for the L_{10} parameter is 6dB(A), as expected from similar noise barrier fence. It is considered that an acoustic screen, not higher than 1.8m, can be viable alternative to standard noise barrier fences to provide noise protection for the formal open spaces of dwellings along sub-arterial roads with a maximum design traffic flow of not more than 15,000 vehicles AADT.

The impact of the geometry of rail welds on noise level in urban environments

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ABSTRACT
Noise is one of the main causes of reduced quality of life, especially in urban environments, where noise is constantly present. Complaints from citizens living and working in urban zones near traffic routes with intense road and tram traffic are

more and more frequent. A study on the impact of tram traffic, which is one of the greatest generators of increased noise levels in the City of Zagreb (Croatia), is presented in this paper. According to data from the International Union of Public Transport, tram traffic is much more intense in Zagreb than in other European cities where trams form the backbone of the municipal public transport system. Since the interaction of the wheel and rail has the highest impact on the noise levels, the impact of the geometry of rail welds as a noise contributing factor was studied. Measurements of noise levels were performed in two phases. The first phase addressed noise measurements for tracks with irregularities at the weld zone. The geometry of the irregularities section was first recorded. The second phase involved measuring noise levels at the same locations, but after the irregularities of the rail running surfaces were repaired. The measurements took the tram type and travelling speed into account. That way it was possible to analyse the results to determine to what extent tram type and speed influences increased noise levels. This study was conducted in cooperation with the Zagreb Streetcar Company, the company in charge of reconstruction and maintenance of the tracks in Zagreb. The study results helped to define the impact of the rails running surface geometry in the weld zone on the increased noise levels, and also to determine permissible tolerances for weld geometry on tram tracks in Zagreb.

A Follow Up Investigation of the Long Term Road Traffic Noise Attributes of Some Pavement Surfaces in Townsville

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ABSTRACT
This paper presents a follow up investigation of the noise attributes of several pavement surfaces currently in service in and around Townsville. The investigation aimed to examine the acoustic performance of the set of pavement surfaces over time. A previous similar investigation, which was reported to the 2004 AAS Annual Conference, involved two extensive data collection exercises which were conducted in 2002 and 2003. In the present investigation more data were collected in 2004. Analyses of the data produced values of a parameter known as the Statistical Passby Index which was applied to quantifying the acoustic performance of the pavement surfaces over time. It was found that the acoustic attributes of most of the pavement surfaces remained reasonably stable over the two year period from 2002 to 2004. This was not, however, always the case and some explanations for variant behaviour are presented in the paper. In further exploring these observations, a subset of the 2004 data set was compared to a theoretical model of pavement surface noise generation developed by the first Author several years ago. In addition this data set was compared to some empirical data also previously collected by the first Author elsewhere in Australia. These comparisons facilitated explanations of the acoustical attributes of the Townsville pavement surfaces.

The Queensland Department of Main Roads Pavement Surface Noise Resource Manual

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ABSTRACT
Since road pavement surface type is such an important factor in the generation of traffic noise, much research has been conducted in Australia and internationally on this topic. Over the last several years, the Authors have collaborated on a series of investigations for the Queensland Department of Main Roads (QDMR), which have been directed at determining the acoustic attributes of various Queensland pavement surface types. Some of these investigations have been presented at recent AAS Annual Conferences. The conduct and outcomes of these investigations, along with their applications, have been brought together in a document known as the QDMR Pavement Surface Noise Resource Manual (PSNRM). Throughout the investigations, collection of the required pavement surface noise data was undertaken according to the statistical passby technique. In total, 33 Sites of varying pavement surfaces were included in the investigations and of these 24 were in South East Queensland and 9 were in the Townsville environs. These data have been analysed to determine the values of the Statistical Passby Index for the each of the pavement surfaces. The Statistical Passby Index may be used to quantify the overall effects of pavement surface type on traffic noise. Thus the paper introduces the QDMR Pavement Surface Noise Resource Manual, presents some of its key contents and explains some of its applications.

Development and evaluation of roadside barriers to attenuate road traffic noise

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ABSTRACT
As part of a continuing program of investigations into roadside traffic noise barrier optimisation, the NSW Roads and Traffic Authority (RTA) funded a research and development study to develop and evaluate several full size prototype barrier designs. Of particular interest to this study was a design known as a Random Edge Profile Barrier since there was a body of published evidence which indicated that a barrier of this type can cause a substantial degradation of the noise diffracted over

the barrier edge. As a consequence, it has been suggested that such barriers are capable of providing improved traffic noise attenuation compared to conventional barriers. The present study involved an empirical evaluation of a prototype Random Edge Profile Barrier and the comparison of its performance with that of conventional barriers and also with that which is known as a T-Top barrier. In total four barriers types were constructed alongside a major rural freeway in NSW and were 80m long by either 2.4m or 3.0m high. A substantial body of empirical data were collected at various receiver locations in front of, behind and adjacent to each barrier. Analyses of these data showed that for the receiver locations investigated, the random edge barrier out-performed the conventional barrier of the same nominal height for most frequencies associated with broadband tyre/road noise. The T-Top barrier was found to perform the best for frequencies greater than 3.15 kHz whilst the conventional barrier offered the most practical solution for attenuation of low frequency noise.

Noise monitoring program for assessing the impact of maximum traffic noise levels

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ABSTRACT
Maximum $L_{A,(Max)}$ Traffic Noise Events are reported in the literature as contributing to sleep disturbance in the community. The New South Wales Department of Environment and Conservation (DEC) has undertaken a noise monitoring program to measure maximum traffic noise levels at night using specialised “Mad Max” Noise Monitoring Equipment. The aim of the study is to better understand the characteristics of maximum noise events at night for selected roads and to investigate the behaviour of the Sleep Disturbance Index (SDI) as proposed by Bullen et al (1996) in these situations. The noise monitoring program involved selection of six noise monitoring sites, two sites each for low, medium and high anticipated maximum noise impacts. Maximum noise levels were measured in conjunction with concurrent traffic counts and classifications, using an Acoustics Research Laboratories EL215 data logger and Hewlett Packard Personal Data Assistant (PDA) configured with “Mad Max” software. The instrumentation and measurement methodology is explained to indicate how the SDI is evaluated using this system. SDI values calculated from the monitoring program are discussed with observations on what road traffic components appear to be significant in changing SDI values. Prediction approaches are discussed to indicate how SDI values may be evaluated as part of an impact assessment process.

Managing Aircraft Noise within an Air Traffic Environment

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ABSTRACT
Airservices Australia (AA) and its predecessors have provided air traffic control services throughout Australia since the late 1930's. In 1995 Airservices Australia was established when the air traffic control functions were separated from the Civil Aviation Authority. In addition to operating throughout Australia AA now provides air traffic control services to other countries. Internationally there is a push to reduce the number of air traffic service providers as a more efficient system is constantly being argued by the airline industry. When AA was formed in 1995 it had clear environmental responsibilities and specific environmental regulatory functions. AA has established a comprehensive Environmental Management System which runs parallel with the Safety Management System. Managing the environmental impact is considered a core AA function, crucial to this is the ability to report and disseminate useful information on the impacts of aircraft operations. This paper discusses how AA performs these tasks with respect to aircraft noise. Recent developments of credible environment performance metrics to enable AA to report on its environmental performance will also be discussed.

Theme: Musical Acoustics

Musical Notes Quotient

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ABSTRACT
Author worked for three years on resolution of human ear. The resolution was defined as "just noticeable difference" detected at a given base frequency. Large numbers of observations (10299 no of observations of 522 persons) were segregated into two groups, musicians and non-musicians. Statistical analysis showed 'significant' difference between the two groups. This gave the clue to define, formulate, and establish a quotient – Musical Notes Quotient (MNQ). Later, after defining MNQ author identified a method of training, which improved this MNQ considerably, in a very short period. The subjective opinion that participants (116 & 3079 no of observations) started singing better after the training programme was tested objectively. The statistical analysis confirmed the subjective opinion of better singing. The MNQ showed 'significant' improvement, which established the usefulness of MNQ as a measure of progress in music.

Spectral and Temporal Changes in Singer Performance With Variation in Vocal Effort

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ABSTRACT
A singer's vocal output has to vary depending on the musical work being performed, the size of the auditorium used for the performance and other factors. In the work reported on in this paper the small hall and the large hall voices of professional opera singers were investigated to determine the spectral and temporal changes in their vocal output. Recordings of 8 opera singers were made in an anechoic chamber. Singers were asked to imagine they were in a small hall for one set of recordings and in a large auditorium for another set. The recordings were then analysed to determine spectral changes between the large hall and small hall renditions. Temporal changes were investigated looking at performance timings of the songs (under different projection conditions). Psychoacoustical models were also used to evaluate the recordings.Overall, it was found that large hall song renditions produced greater amplitude in the 1kHz-4 kHz region as well as faster tempos compared to small hall performances.

The role of vocal tract resonances in singing and in playing wind instruments

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ABSTRACT
The different vowel sounds in normal speech are produced by adjusting the position of tongue, lips and teeth so that the vocal tract resonates at certain specific frequencies. In voiced speech, these resonances interact with the harmonics of the lower frequency signal from the vibrating vocal folds to produce associated peaks, or formants, in the output spectrum. Singers sometimes use these resonances in musical rather than linguistic ways. For sopranos, the vibration frequency of their vocal folds may be much higher than the normal values for the lowest resonance, and consequently a reduced interaction would cause a loss of power. Direct measurements of the resonance frequencies of the vocal tract of classically-trained sopranos during singing show that they consistently increase them to match the frequency of their singing. This significantly increases the loudness and the uniformity of tone, at the expense of comprehensibility. The fundamental frequency of other singers is usually less than the value of the lowest resonance and so they would experience no advantage in tuning this resonance. However the power could be increased if the resonance frequency were tuned to a harmonic of the fundamental frequency. Our measurements indeed show that some altos, tenors and baritones use this strategy when appropriate. The role of the vocal tract resonances is quite different when playing a wind instrument. The sound is then generated by the vibrating lip or reed valve rather than by the vibrating vocal folds. The frequency of vibration is then primarily determined by one of the strong resonances of the wind instrument itself. Our measurements show that varying the resonances of the vocal tract can then still slightly alter the vibration frequency and

change the harmonic structure or timbre of the produced sound. The described research has involved several members and associates of our Acoustics Laboratory.

Theme: General

Learning acoustics through the boundary element method: an inexpensive graphical interface and associated tutorials

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ABSTRACT
The Boundary Element Method (BEM) is a powerful tool which has become an important and useful numerical technique applied to problems in acoustics. It is particularly useful for analysing sound radiation and acoustic scattering problems. Numerous commercial BEM codes with graphical user interfaces (GUIs) and mesh generators exist; however these are relatively expensive, which discourages their use by academic institutions and smaller companies. Helm3D is a three-dimensional BEM code available with purchase of a relatively inexpensive book, but the command file driven interface is difficult to learn and some mechanism to generate the mesh is required. In addition, there is a limited availability of suitable tutorial material, so the uptake of BEM throughout the acoustics community has so far been limited. In this paper, the development of both a mesh generator / GUI interface for the Helm3D code and an associated tutorial are described. The interface links the Helm3D code to a freely available numerical simulation pre/post processor. The tutorial demonstrates the capability of BEM in two application areas: interior acoustics and external acoustic radiation. It is envisaged that the availability of the interface and tutorial will accelerate the uptake of BEM by the wider acoustics community.

Wake and acoustic responses of a circular cylinder to freestream fluctuations

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ABSTRACT
An upstream turbulence/fluctuation has been shown to increase the unsteadiness in the wake of a three-dimensional bluff body (Mittal, 2000). This inevitably will influence the radiated acoustic waves in the far field. In this paper, the effects of fluctuating freestream disturbances on the wake structure and sound radiation from a two-dimensional flow over a circular cylinder are investigated. The flow field is obtained by numerically solving the incompressible Navier-Stokes equations. At a Reynolds number of 40, the addition of fluctuating disturbances in the freestream causes the otherwise steady wake to oscillate at the frequency of the disturbance. This oscillation is enhanced with increasing energy and frequency of the fluctuations. The corresponding acoustic field is obtained by using an Expansion about Incompressible Flow (EIF) method. The computed acoustic field shows a dipole directivity, which is similar to that of a natural vortex shedding. Moreover, using the rms plot of the fluctuations of the EIF source terms, the location of the dipole source in the wake of the cylinder is accurately identified.

A portable data acquisition system for the measurement of impact attenuation of playground surfacing

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ABSTRACT
Gone are the days when children's playgrounds were erected on concrete and asphalt. Impact attenuating playground surfacing has been common place in most children's playgrounds for many years. Unfortunately there is not a strong correlation between the expected reduction in the frequency and severity of playground injuries. Until recently testing of playground undersurfacing was restricted to the laboratory. This paper details the development and description of a portable data acquisition system for use in playgrounds.

Acoustic Standards developed by Standards Australia

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ABSTRACT
Acoustic standards produced by Standards Australia are developed under set procedures and policies. My presentation aims to clarify Standards Australia's procedures and policies as well as provide information on current acoustic projects at Standard Australia. General information regarding Standards Australia will be provided. The following list questions that will be answered in the presentation: what is a standard?, who develops the standards?, why are standards important?,

are standards mandatory?, how are standards funded?. The steps that apply in creating a new Australian standard will be spelled out. For example, the rules required for a draft to be published - that is, there must be no major sectional interest maintaining a negative vote and there must be 80% agreement from committee members. The periods for committee comment and public comment will also be detailed, as well as, how the public is encouraged to actively participate in the commenting process. Statistical information on Standards Australia will also be listed - for instance; how many standards are published, what percentage of standards published are made mandatory etc. Logistical information such as how does someone become a committee member, and how can someone request for a new standard to be developed, will be explained. Current acoustic projects at Standards Australia will also be provided. This will include the name of existing committees and some of the projects that are currently being undertaken by those committees.

Theme: Occupational Noise

Acoustic shock in call centres

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ABSTRACT
An estimated 220,000 telephone headset using workers are employed in about 4000 Call Centres across Australia. Call Centres annual attrition- and average turnover rate (23%), is higher than the general industry average of 18%. This has been attributed to poor working conditions, health and safety issues, and stress. Occasionally Call Centre telephone operators experience acoustic incidents such as a sudden loud shriek or piercing tone through their headsets. Where these cause symptoms like; a startle reflex, tingling, dizziness and nausea, headaches, fullness of hearing or tinnitus, the operator has experienced an acoustic shock. The sounds originate either from line faults, misdirected faxes, power supply failures, or manmade sources, e.g. frustrated customers. Despite these sounds seldom being loud enough to cause physical damage to the inner ear's hair cell structures, their effects on the operator can be devastating and considered directly related to the level of stress the operator experiences. Effects range from simple annoyance to incapacity to continue work or never again being able to work with headsets. Audits of Call Centres revealed inadequate (acoustic) environments, and acoustic incident protection, follow up measures and training. Call Centre managements must ensure that adequate control measures are in place.

Review of Current Recommendations for Airborne Ultrasound Exposure Limits

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ABSTRACT
The standards for airborne ultrasound exposure limits were derived from research conducted by three independent groups in the late 1960s. Recently, a regulatory body in the USA has proposed increasing the generally accepted exposure limits by 30dB. This paper contains a review of the literature concerning the effects of exposure to airborne ultrasound impinging on human ears and the suggested exposure limits that are used in several countries.

Evaluation of Occupational Noise Exposure - Advantages and Disadvantages of Noise Dosimetry versus Sampling Using a Sound Level Meter

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ABSTRACT
There are two methods for evaluating noise exposure in the workplace: dosimetry using a Personal Sound Exposure Meter (PSEM) and sampling using a sound level meter (SLM). This paper discusses the advantages and disadvan-tages of both methods in the context of the fundamental objectives of an occupational noise survey, i.e. identification of exposed workers, determination of exposure magnitude, and identification of the noise sources, processes and ac-tivities that contribute to exposure. Exposure evaluation using a sound level meter is quick and reliable when noise levels are relatively low and when exposure varies little as a function of time. When noise levels are very high, how-ever, even very small changes in assumed exposure duration can have a significant effect on the calculated exposure. On the other hand, dosimetry avoids having to estimate exposure durations but can take much longer to assess an en-tire workforce. These aspects, as well as equipment and measurement considerations are discussed and it is concluded that a well designed measurement strategy is likely to incorporate both methods.

Improved calculation for hearing protector performance

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ABSTRACT
A variation in the method of calculating the attenuation performance of hearing protectors can produce a simple relation between overall performance and a single standard deviation. This outcome facilitates easier comparison of the statistical performance between hearing protectors and allows for a less complex error analysis procedure. For example, one such comparison reveals a strong negative correlation between attenuation and standard deviation which has important implications on the perceived performance of hearing protectors for the end user and may partially explain why, particularly in 'low' noise environments, hearing protector programs are not as successful as they should be. This method of analysis is compatible to any single number rating such as NRR, SNR or SLC_{80}.

Theme: Thermo-acoustics

Review of flow-through design in thermoacoustic refrigeration

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ABSTRACT
The design and functionality of thermoacoustic refrigerators has been the focus of considerable attention from the re-search community since the 1980's. This environmentally friendly technology has the potential to become another option for refrigeration, as improvements in the design and technology are realised. Heat-exchangers are used to in-crease the efficiency of thermoacoustic systems, however they are typically complex to manufacture, expensive, and limitations of heat-exchangers exist in terms of efficiency and durability. Reducing or eliminating the use of heat-exchangers through the use of flow-through designs dramatically reduces the cost and complexity of thermoacoustic systems, potentially with minimal efficiency loss. In this review paper of flow-through thermoacoustic refrigeration, the developments of flow-through design and its potential benefits will be discussed.

Feasibility Study of an Automotive Thermoacoustic Refrigerator

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ABSTRACT
Concerns regarding the environmental impact associated with the use of current

vapour-compression refrigeration systems in automobiles have led to the investigation of alternative 'green' technologies. Thermoacoustic refrigeration, an emerging 'green' technology based upon the purposeful use of high-pressure sound waves to provide cooling, is the most promising replacement investigated so far. Thermoacoustic refrigerators use environmentally benign gases, are relatively simple and inexpensive to manufacture and can operate using a heat source, which leads to their appeal as a sustainable waste heat recovery device. In this paper, the feasibility of a thermoacoustic refrigerator driven by recovered heat from the waste exhaust gases of an automobile is investigated. Practical considerations and calculations incorporating typical performance characteristics indicate that an automotive waste-heat driven thermoacoustic air-conditioner is potentially feasible and warrants further investigation.

Development of a Low-Cost Loudspeaker-Driven Thermoacoustic Refrigerator

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ABSTRACT
Thermoacoustic refrigeration is an emerging 'green' technology based upon the purposeful use of high-pressure sound waves to provide cooling. This paper describes the development of a thermoacoustic refrigerator built with the aim of using domestic 'off the shelf' parts where possible. The key considerations and tools used in the design and development of the thermoacoustic refrigerator are discussed, and results detailing the performance of the device obtained from direct measurements and computer modelling are compared.

Theme: Underwater Acoustics - Biological

The Ambient Sound Field in Three Freshwater Environments

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ABSTRACT

A number of ambient sound recordings took place in three clear-water wetlands in Perth, Western Australia for one month in summer, 2003. The wetlands differed in terms of their degree of enrichment, habitat structure, substrate material and water depth. Temporal and spatial variations were evident in the macroinvertebrae distributions and the biologic calling activity, with seven distinct calls recognised in this study. Noise levels were greatest at dusk and to a lesser extent at midnight with chorusing only evident at the most enriched wetland. Biologics used frequencies ranging from 3 kHz up to around 14 kHz with the exception of the 'bird-like song' which extended from 500 Hz up to around 10 kHz. There was negligible sound contribution to ambient noise at low wind speeds of Beaufort Wind Scale 0,1 & 2.

Sonar termination as a cause of mass cetacean strandings in Geographe Bay, south-western Australia

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ABSTRACT
Geographe Bay, south-western Australia has been host to several past mass live cetacean (whale and dolphin) strandings. It is noticed that the majority of stranded whales tend to be healthy, toothed cetaceans (Odontoceti) which employ echolocation as a method of navigation. This paper explores a bioacoustic mechanism known as sonar termination as a major factor in the occurrence of these strandings in Geographe Bay. Sonar termination occurs when a navigational echolocation click projected towards the coast critically attenuates to a point where it is not detectable. The paper proposes two mechanisms contributing to sonar termination: first, the presence of a gently sloping shore and second, the presence of continuously created stagnant micro sized bubbles (microbubbles). By depicting a wedge shaped coastline as a perfect flat reflector the attenuative effect of multiple reflections and resident microbubbles in a coastal water column on a cetacean echolocation signal is calculated, and a limiting distance that a cetacean may be able to detect the presence of a shoreline is determined from these results. A brief review of the most recent mass strandings at Dunsborough (03/04/05, 02/06/05) is presented and the plausibility of the bioacoustic mechanism's role in the strandings is investigated.

An exploratory analysis of non-Poisson temporal behaviour in snapping shrimp noise

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ABSTRACT
Snapping shrimp are a well known interference source for underwater sonar and communication systems, particularly in shallow and harbour waters. The noise produced by snapping shrimp is highly impulsive and the amplitude statistics are non-Gaussian. Impulsive noise is most often modelled in a way that implicitly assumes that the temporal statistics are Poisson. The Poisson assumption implies that a snap from any shrimp is completely independent of snaps from other shrimp. This paper reports on an exploratory analysis of non-Poisson temporal behaviour in snapping shrimp noise using real acoustic data from different geographic locations in Australian coastal waters. The analysis makes use of various statistical techniques applied to snaps detected in high-pass filtered data using a threshold technique. Attempts are made to eliminate multi-path effects, which can introduce correlations between snap arrivals, from other possible effects such as interactions between shrimp. The results are compared and contrasted between different geographic locations.

Preliminary Analysis of Single-Beam Acoustic Data of Fish Spawning Aggregations Along the Western Australian Coastline

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ABSTRACT
Coastal waters of Western Australia and their associated habitats are home to many species of demersal fish that migrate to form short-lived aggregations in order to spawn. These spawning aggregations form at the same sites over successive, predictable spawning seasons. Due to the exploitation of demersal finfish spawning aggregations within the West Coast Bio-region, recent attention has been paid to using acoustic techniques for assessments of these aggregations, to help evaluate their sustainability. This management process has been raised as an important issue. A well established tool for biomass estimates, used in these evaluations, is single-beam echosounding. As part of the Management and Monitoring of Fish Spawning Aggregations project of the Department of Fisheries, acoustic data on fish aggregations have been recorded during 2004 and 2005, using a SIMRAD EQ60, single-beam echosounder, operating at frequencies of 38 kHz and 200 kHz. These recordings were made at various locations around Rottnest Island, where recurring spawning aggregations have been reported. At selected sites, towed video and physical sampling techniques were employed to ground-truth acoustic results. Initial analysis of acoustic backscatter measurements from selected sites is presented, and possible correlations between targets and individual species are discussed.

Preliminary conclusions are drawn in respect to the use of a single-beam echosounder for estimating fish stocks within dense and sparsely populated aggregations.

High Frequency Biophysical Oceanography in Western Australia

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ABSTRACT
As part of a multi-disciplinary research effort off the West Australian coast, acoustic methodologies are being developed to characterise fine scale vertical distributions of mesoplankton (0.1 to 20 mm in length) using high frequencies: 265, 420, 700, 1100, 1800, 3000 kHz. This study combines the use of multi high frequency acoustics with discrete biological samples and physical water column parameters (temperature, salinity, fluorescence) over a multi year period. The physical samples were obtained with a specially designed Discreet In-situ Plankton Sampler (DIPS) that collects 6 samples within the water column at targeted depths. The Tracor Acoustic Profiler System (TAPS) attached to DIPS was operated at a fixed range of 1.5 m with a 5 litre sampling volume. We present our initial investigations of comparing the plankton samples to the observed values of acoustic reverberation (Sv dB re 1 m. We examine both the affect of system noise and low densities of plankton and how they might affect our strategy for estimating distribution based on acoustic models. This comparison highlights limitations in the methodology due to the low densities of plankton generally obtained in the oligotrophic waters off Western Australia>, their patchy distribution and potential heterogeneity of scattering types.

The Controlled Exposure Experiment – Development of an Experimental Methodology for Assessing the Impact of Noise on Marine Mammals

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ABSTRACT
While there is concern about the potential effects of noise from human activities on marine mammals, it is very difficult to determine whether a particular noise exposure has an effect, and if it does, to assess the long term consequences. So many variables affect the behaviour of marine mammals in relation to the use of sound that it is difficult to distinguish behavioural reactions in response to a particular noise exposure from unrelated behaviour. A lot is known about the sounds produced by marine mammals, but much less is known about how these are used, particularly for baleen whales. This paper describes the methodology and some results of "Controlled Exposure Experiments" developed by the Humpback Whale Acoustic Research Collaboration (HARC), a multinational project studying the effects of noise on humpback whales migrating along the Queensland coast. It combines the different methods of experimental control used in the physical sciences with those of the biological sciences. Part of the methodology is to minimise the effects of as many variables as possible by choice of the conditions of experiment, and to allow for the effects of other variables by establishing baseline knowledge of their effects on normal acoustic behaviour and then to measure these variables during noise exposure. This involves a wide range of multidisciplinary and multiplatform measurements and observations, including the behaviour at and below the surface of subject animals, the movements and vocal behaviour of all other conspecifics in the area, as well as the environmental acoustic conditions (propagation, ambient noise) affecting the use and reception of sound.

Theme: Underwater Acoustics - Communications

Generalised differential encoding for underwater acoustic communication

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ABSTRACT
We study the efficacy of a generalised form of differential encoding of binary phase shift keyed (BPSK) signals transmitted through a shallow underwater acoustic communication channel. Using simulations involving a fixed source and a receiver moving about with the surface waves, we show that no advantage arises from using the generalised differential encoding methods. On the contrary, the best results in our study arise from simple second-order differential BPSK (DBPSK) signalling. This is in contrast to an earlier study that showed the promise of the generalised differential encoding methods via simulations. The previous study did not address the issue of inter-symbol interference (ISI), whereas we include ISI. It appears that the added complication of removing ISI significantly reduces the benefits of generalised differential encoding.

The Effect of Forward Error Correction on the Performance of Underwater Telemetry Systems

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ABSTRACT
A low probability of intercept (LPI) underwater acoustic telemetry system (UATS) is proposed to transmit sonar products from seabed arrays to submarines and surface relay buoys. A UATS simulator has been developed to implement all the steps in the processing chain. Underwater LPI systems have low transmitter power and hence low data rates. Techniques have been developed in DSTO to compress sonar products (2D images) to enable transmission at lower data rates without significant degradation. This paper studies bit error rates (BERs) and achievable bit rates for transmitting random messages and compressed sonar products (CSPs) from the standard UATS, with no channel coding, through Gaussian and fading channels. It also assesses the quality of the received and uncompressed CSP images. The effects of applying two types of forward error correction (FEC) - convolutional and turbo coding - in Gaussian and fading channels are then evaluated. A significant improvement in performance for both random messages and CSPs and hence data rates arises from using convolutional coding in Gaussian channels, but this improvement is lost in some fading channels. A greater improvement arises from using turbo coding in Gaussian channels. For fading channels, this improvement is less but still significant.

Theme: Underwater Acoustics - General

The effect of incident angle on statistical variation of backscatter measured using a high-frequency multibeam sonar

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ABSTRACT
Multibeam systems are capable of recording acoustic backscatter signals received from a wide swath of the seafloor. Backscatter characteristics are well correlated with morphological and physical properties of the seabed. Thus, a multibeam sonar system is a potentially useful tool for seafloor characterisation work. As part of the Coastal Water Habitat Mapping project, a subproject of the CRC for Coastal Zone, Estuary and Waterway Management, multibeam data and ground-truthing video

data have been collected from various sites around Australia, including Cockburn Sound in Western Australia. One of the aims of the project is to investigate the capability of multibeam systems to map seafloor habitats. Initial work has concentrated on the processing of the backscatter pulse form. However, for the backscatter to be a useful tool in tracking changes in seafloor habitats it needs to be invariant to system settings, oceanic conditions and beam geometry. Most of these parameters can be easily corrected for, except for angular dependence of backscatter. Variation in backscatter due to incident angle is commonly seen in swath sonar images, typically as higher intensities at nadir angles than for oblique incidence, which can be hard to compensate. Here a new angular dependence correction algorithm, developed by the CWHM project, is examined to see how effective it is at correcting for this phenomenon. The results have implications for the use of multibeam sonar in seabed classification, which are discussed.

Detection and localization of ice rifting and calving events in Antarctica using remote hydroacoustic stations

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ABSTRACT
Global warming induced by the greenhouse effect will affect the Antarctic ice sheet primarily in the form of disintegration of the ice shelves surrounding the continent. Calving of large icebergs can be observed post factum from satellites, whereas numerous ice shelf breaks of smaller volumes and ice rifting processes that precede the calving events are not well monitored and analysed. Detection and localization of acoustic signals emitted by ice rifting and calving in Antarctica, using remote hydroacoustic receive stations in the ocean, can be an efficient and cost-effective way to monitor disintegration of the Antarctic ice sheet. An analysis of acoustic noise recordings at the hydroacoustic listening station installed off Cape Leeuwin, Western Australia as part of the International Monitoring System of the Comprehensive Test Ban Treaty, has shown that the majority of the signals arriving from Antarctica have a pulse-like waveform, a frequency band limited within 5 - 30 Hz, and spectrograms that reveal strong waveguide dispersion typical for long-range propagation in the Polar environmental conditions. The azimuthal location of the detected events is not uniformly distributed along the observed sector of the Antarctica coast, and the rate of events varies with the seasons of year. The results of numerical modelling of acoustic propagation from Antarctica to the Cape Leeuwin station show that the origin of the observed signals is short, pulse-like physical processes on the Antarctic shelf, which are most likely ice rifting and calving events.

Reduction of the acoustic signature of a submerged vessel

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ABSTRACT
This paper examines the reduction of the low frequency acoustic signature of a submarine by optimal passive tuning of a resonance changer. The propeller-shafting system is modelled with a combination of lumped parameter and continuous parameter systems utilising the transmission matrix method. The submarine hull is modelled as a ring stiffened finite cylindrical shell submerged in a fluid undergoing axial excitation from the propeller-shafting system. The total sound pressure radiated into the far-field from the hull is obtained by using an approximate closed form solution to the Helmholtz integral equation. Optimal parameters for the resonance changer are obtained by minimising the maximum far-field radiated sound pressure using a genetic algorithm.

Mobile Submarine Target Strength Measurement

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ABSTRACT
A methodology is proposed for the measurement of submarine target strength whilst in transit, utilising submarine navigation systems and sonobuoys. Direct sequence spread spectrum signals are transmitted via VHF to a telemetry relay sonobuoy, which re-transmits the signal acoustically. A standard sonobuoy receives the signal and relays it to the data recorder. Using high stability clocks for the synchronisation of the transmitter and receiver, accurate time-of-flight measurements can be made between sonobuoy transmitters and receivers via direct and reflected acoustic paths. The positions of the three objects need to be known to discriminate between target and surface reflections and to measure the bistatic angle between the source, target and receiver. The positions of the target are estimated by the submarines inertial navigation system, and the positions of the other objects are estimated using the submarine position as a reference, and constructing a baseline over time as the submarine moves. Target strength is calculated by comparing the correlation of the signals received from the direct path and reflected paths, with reference signals. This technique enables target strength measurements in negative SNR environments. The implementation of this methodology is described and the results of a simulation of an operational scenario are presented.

Theme: Underwater Acoustics - Propagation

Difference in signals from a mid-ocean shot at hydrophones near Diego Garcia and Cape Leeuwin

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ABSTRACT
Oceanic sound velocity profiles can vary so as to change important characteristics of transients propagated over long distances. Staff of the Scripps Institution of Oceanography fired a series of deep shots during a transit across the Indian Ocean in 2003. The shot to be considered was a Signal Underwater Sound (SUS), fired on 29 May at a depth of 0.9 km in the middle of the ocean. The acoustic signals were recorded with hydrophones south of Diego Garcia (DGS), and off Cape Leeuwin (CL). These hydrophones were respectively 1600 km and 4260 km from the shot. It was noted that the DGS signal had its peak near the start, whereas the peak of the CL signal was at the end. For a frequency of 100 Hz, the mode travel times and attenuations along each path have been computed, using sound velocity profiles based on average temperature and salinity profiles. Since the source and receivers were near the SOFAR axis, the transmission losses of the modes generally increase as the mode number increases. Along the path to DGS, the sound velocity profile is relatively blunt. As a result, the low-order modes travel faster than the contributing (non-attenuated) modes of somewhat higher order. Along the path to CL the sound velocity profile is relatively sharp and Mode 1 is slow, regardless of seafloor depth. The difference between the signals can thus be attributed to the different sound velocity profiles along the respective paths.

Simulation of Time Series Received Underwater from Small Explosive Detonations in Shallow Ocean Regions

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ABSTRACT
The sound pressure time series received at medium ranges from small underwater explosives, known as "SUS" charges, have been under close study in recent years in relation to the potential impact of the use of such devices on marine fauna, in particular, marine mammals. Past work has centred on investigations of time series measured in shallow oceans in the Australian region. Here, at-sea measured data showed, consistently, received peak levels which were considerably less than published weak shock theory would have suggested. This paper shows the results from the analysis of an extended data set, which includes measurements of SUS

signals received along a shallow ocean track in an additional ocean region. Further, this paper shows the results of simulations of the time series received along all these tracks. These simulations of received SUS waveforms, carried out at Curtin University, have been obtained by generating an inverse Fourier transform of the product of the oceanic transfer function and the Fourier transform of an input SUS waveform. The oceanic transfer function has been based on the use of the SCOOTER model at low frequencies and a ray model (BELLHOP gaussian beam ray model) at remaining frequencies. By simulating the received time series in this way, reasons for the discrepancies between measured peak data and expectations based on weak shock theory have been investigated and are presented in this paper.

Sound propagation through the Antarctic Convergence Zone and comments on three major experiments

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ABSTRACT
Long-range hydroacoustic propagation at low frequencies is determined by: (a) the sound velocity profile (SVP) of the ocean as a function of depth and position on the spheroidal geoid, (b) seafloor topography, and (c) the acoustic properties of the seabed. Neglecting transverse refraction, an acoustic path follows a great ellipse on the geoid. The Antarctic Convergence Zone (ACZ) defines a front between two water masses with different types of SVPs. It is circumpolar and its latitude varies between −60° and -50°. The path from an acoustic pulse emitted in high southern latitudes to a hydrophone at a temperate latitude is likely to cross the ACZ. This is expected to change the shape of the signal and increase its dispersion and complexity. For Transmission Loss (TL) along a path that crosses the ACZ, it is expected that there would be no discontinuity in TL at the ACZ, but there would be a discontinuity in the rate of change of TL with range. There have been three major experiments that have involved propagation through the ACZ: (1) Perth to Bermuda in March 1960, (2) Project Neptune (Cape Town to New Zealand) in April 1964, and (3) the Heard Island Feasibility Test in January 1991. For the first two, which involved the firing of shots, both the sources and receiver were north of the ACZ so there were two crossings of the zone. For the third, the projector (which emitted tones near a frequency of 57 Hz) was located within the ACZ, so there was a partial one-way crossing. The results of these experiments have been reviewed, and it is concluded that the observed signal shape and TL are broadly consistent with the expectations listed above.

Theme: Underwater Acoustics - Sonar

Adaptive Beamforming for Sonar Audio

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ABSTRACT
Sonar audio is a major tool used by sonar operators to assist in classifying acoustic contacts. In this paper we discuss some issues that arise when adaptive beamforming is used for sonar audio. Frequency domain beamforming is used to reduce computational cost, and diagonal loading of the cross-spectral matrix is used to obtain the best quality out-put. The effectiveness of a robust Capon beamformer (RCB) with nonuniform loading is compared with that of a minimum variance distortionless response beamformer with uniform loading (MVDRUL). For the tests described in this paper, which involve a signal together with a strong interference and background noise, RCB produced the high-est quality output and was more robust than MVDRUL. On the other hand, conventional beamforming (CBF) failed to provide a satisfactory output for any test.

Expectation Maximisation Algorithm for Detection of High Bandwidth Sonar Pulses

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ABSTRACT
The use of high bandwidth pulses in active sonar systems can reduce interference from reverberation and variability due to channel fading. However, the matched filter detection performance is degraded more by acoustic multipath when the bandwidth is increased. The performance degradation due to multipath distortion results when the destructive interference of the paths cancels some frequencies reducing the similarity between the echo and the transmitted pulse required for matched filter operation. Increased bandwidth means that more frequencies are cancelled so distortion and degradation increases. If the acoustic properties of the channel are known well enough to predict the acoustic multipath characteristics, detection can be improved by matched filtering for the distorted signal rather than the transmitted signal. In cases where the channel properties are unknown, acoustic path delays and amplitudes must be estimated from the data itself. In this paper the acoustic path delays and amplitudes are first estimated using the Expectation Maximisation (EM) algorithm. The estimates are then used to integrate the return from each path recovering part of the loss caused by multipath distortion.

Design and Implementation of Sonars for Underwater Inspection with ROV

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ABSTRACT
Two inspecting sonar-High Resolution Multi-beam Sonar (HRMS) and Profiling Sonar (PS) - mainly presented in this paper. The ROV which carries them will also be briefly described. Some experimental results have shown that the ROV equipped with the developed sonars under control of the movement programs can give accurate maps for either the surface shape or the internal structure of underwater objects, so it is applicable for many underwater engineering cases.

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