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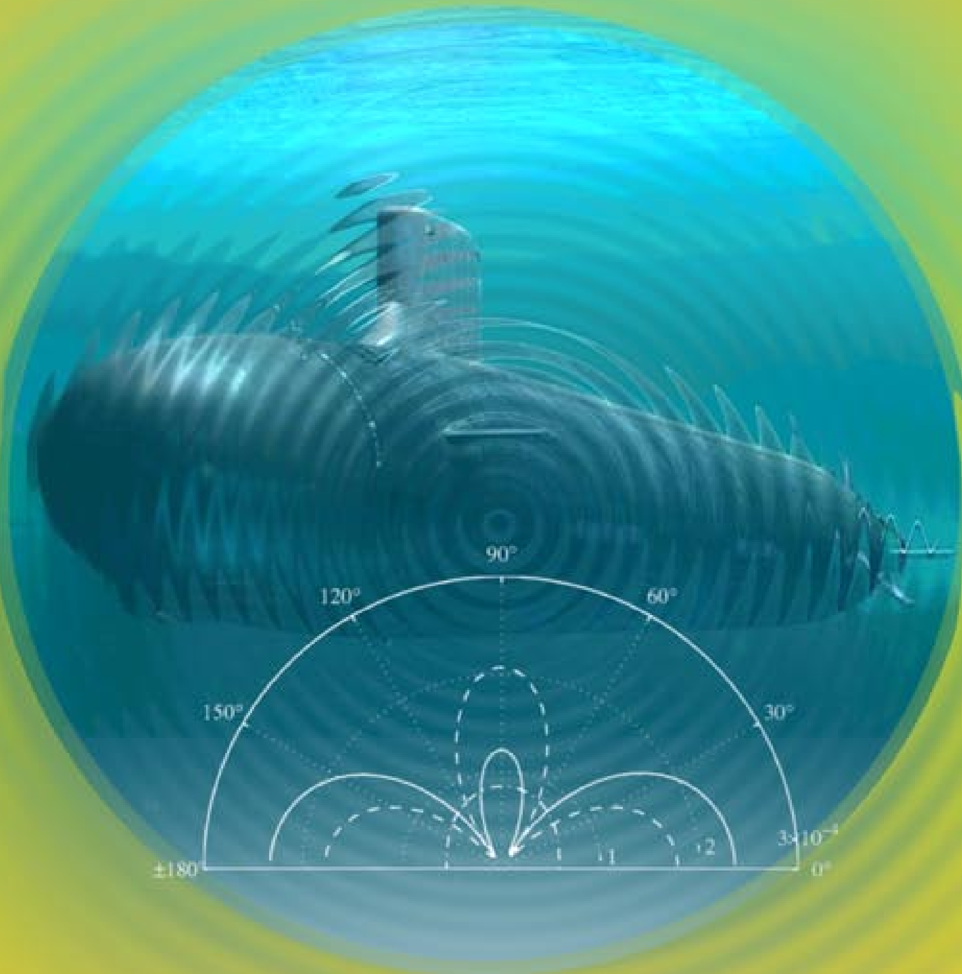

- **Submarine noise**
- **Source separation**
- **Hearing protectors**
- **Child care centres**

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PAPERS

Cover illustration: Heidi Hereth.

Message from the President

Our long serving General Secretary, David Watkins informed the Council in November 2007 of his desire to retire from his position. David has been an invaluable member to the Society in his tenure as General Secretary. His diligence and perseverance in the performance of his duties have been exemplary, as can be attested by numerous federal council committees. David was asked to delay his retirement so we could advertise the position and appoint a new person to the position. David agreed and also undertook to provide some training and hand over of the role.

After due process and interviews, Byron Martin has accepted the role as our new General Secretary. Accordingly, he will resign from his role as Federal Treasurer at the November 2008 Federal Council meeting. Byron brings to the position many years experience working at committee level in the SA division and at federal Council levels as well as experience in the role of teaching and consulting.

I wish David a long and happy retirement and thank him most sincerely for his work in the past and assistance during my term as President. It has most certainly made the running of the society much easier. To Byron, welcome as the new General Secretary and I look forward to working with you in a different role on Council.

Work is progressing on the National conference in November (Geelong). I urge all readers to make sure they have marked in their schedules the conference dates, whether they intend to attend as participants or attendees. The effort required by the teams putting together conferences is very high, considering it is all done in an honorary capacity in their limited free time. A national conference usually takes over a year to organise while the larger international conference/congress can take upwards of four years. A significant workload all considered.

Many members may feel the pressure of work is so high that they just cannot afford to take the time out of their busy schedules. While this maybe true for many projects, the benefits of these conferences is that they provide the time to reflect, to learn, to network and to relax. The benefits of these forms of professional development are usually long term rather than short term and are part of your effort required to remain current in your field.

I urge everyone to plan to attend and to participate in the National conference in November.

Terrance Mc Minn

From the Editors

Combinations of sounds with the right frequency and intensity enter the ear and activate all sorts of pleasure responses in the brain, evoking nostalgic memories, the thrill of a forte tutti from the orchestra, or a tear from the ballad of the crooner: An extraordinary and wonderful reaction.

But this sensitivity to musical signals can have its down side: think of all those poor people (most of us) who suffer at times from infections spread acoustically. The unwilling human host can be struck down by a nasty case of ‘cognitive itch’. A contagious viral tune, transmitted freely through the atmosphere, becomes lodged in the brain of the host and for some reason repeats over and over and over again. Episodes may continue for days. It can be a debilitating experience. This ‘earworm’ has no definitive cure.

Why does our auditory system allow such things to happen? Maybe such a high performance system inherently has some imperfections, and we should simply accept it as it is. The research community is starting to take notice of this phenomenon, and it is mentioned in *Musicophilia*, the recent book by Oliver Sacks. A number of traditional remedies have, however, been handed down. One suggested musical solution is simply singing the song through to the end, while an ‘alternative medicine’ recipe involves the eating of spicy food (this sounds like complex reasoning, but it is intended to get the recipient’s mind off the music).

Prevention is another approach: one can try to avoid music that is likely to cause the itch—i.e. repetitive, familiar pieces and jingles: Hard to do if you ever go shopping. But there is a better remedy still: those lucky enough to have a broad music background and a large mental repertoire of can simply pick and choose another piece with which to combat the invader. Like auditory white cells, these therapy tunes can envelop and destroy the virus by replacing it with something more pleasant.

So, instead of a broken needle in the head (a reference for readers old enough to remember gramophone records, and how they worked, or sometimes didn’t) you can then have an audio stream with a large, web accessible library; Lots of music. An earworm vaccine. Best administered throughout life.

Emery Schubert

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LOW FREQUENCY STRUCTURAL AND ACOUSTIC RESPONSES OF A SUBMARINE HULL

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ABSTRACT: A model to describe the low frequency dynamic and acoustic responses of a submarine hull subject to a harmonic propeller shaft excitation is presented. The submarine is modelled as a fluid-loaded, ring stiffened cylindrical shell with internal bulkheads and end caps. The stiffeners are introduced using a smeared approach. The bulkheads are modelled as circular plates and the end closures as truncated conical shells. The propeller introduces a harmonic axial force that is transmitted to the hull through the shaft and results in excitation of the accordion modes only if the force is symmetrically distributed to the hull. Structural and acoustic responses for the axisymmetric breathing modes are presented in terms of frequency response functions of the axial and radial displacements and directivity patterns for the radiated sound pressure.

1. INTRODUCTION

Vibration modes of a submerged hull are excited from the transmission of fluctuating forces through the shaft and thrust bearings due to the propeller rotation. These low frequency vibration modes of the hull can result in a high level of radiated noise. A hull can be idealised as a finite cylinder submerged in a fluid. The dynamic responses of cylindrical shells has received much research attention, ranging from the free vibrational characteristics of isotropic cylindrical shells subject to various boundary conditions [1, 2], to the effect of structural discontinuities such as stiffeners, a junction or changes in diameter on the wave propagation [3-5]. Thin cylindrical shells are often periodically stiffened in order to both increase stiffness and strength and reduce weight. Cylinders may be stiffened by circumferential rings, longitudinal stringers or both, in which the stiffeners are modelled as discrete elements [6-11] or their properties are averaged over the surface of the shell [12]. For submerged vessels, the effect of fluid loading on the structural and acoustic responses of cylindrical shells have been investigated [13-15].

In previous work by the authors [16], the submerged body was modelled as a ring-stiffened cylindrical shell with finite end closures and separated by bulkheads into a number of compartments. Excitation from the propeller/propulsion is idealised as an axial excitation acting at one end of the hull. This gives rise to excitation of the hull axisymmetric breathing modes associated with the zeroth circumferential mode number (n=0). This paper expands on this previous work to include the effect of end closures which are modelled as truncated conical shells. The forced response of the structure is calculated by solving the cylindrical shell displacements in the form of a wave solution and the conical shell in terms of a power series. An analytical expression for the radiated sound pressure from the structure is presented and accounts for the contributions from both the cylindrical hull and the end caps. Once the radial displacement of the structure is determined, the sound radiation in the far field is evaluated by modelling the submarine as a slender axisymmetric body for which the closed form solution of the Helmholtz equation is possible. The radiating surface is considered continuous. The scattering from the curvature discontinuity at the junction between the cylindrical and conical shells is neglected as well as the scattering at the external plates closing the conical shells. At low frequencies (<100 Hz), these effects are considered negligible.

2. DYNAMIC MODEL OF THE SUBMARINE HULL

Cylindrical shell

The submarine is modelled as a fluid loaded cylindrical shell with internal bulkheads and ring stiffeners. The hull is closed by means of end plates and truncated conical shells. The truncated cones are also closed at each end by circular plates. The model is illustrated in Figure 1. The main part of the submarine consists of a finite ring stiffened cylindrical shell closed at each end by two circular plates. The hull is partitioned into three parts by two equally spaced bulkheads. The ring stiffeners are modelled using smeared theory [12].

In Figure 2, u, v and w are the orthogonal components of displacement in the x, θ and z directions, respectively. a is the mean radius of the cylindrical shell and h is the shell thickness.

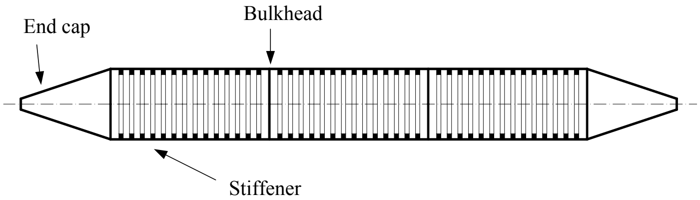

Figure 1. Schematic diagram of the submarine.

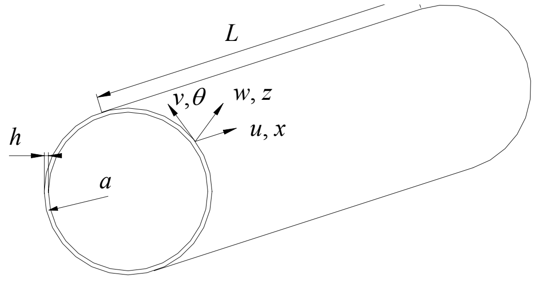

Figure 2. Coordinate system and displacements for a thin walled cylindrical shell.

Variation to the differential equations of motion for thin cylindrical shells have been summarised by Leissa [1]. Flügge equations of motion were used and can be written in terms of a differential operator L_{ij} by [17]

$$L_{11}u + L_{12}v + L_{13}w = 0 \tag{1}$$

$$L_{21}u + L_{22}v + L_{23}w = 0 \tag{2}$$

$$L_{31}u + L_{32}v + L_{33}w - \frac{p}{\rho h c_L^2} = 0 \tag{3}$$

The elements of the matrix differential operator L_{ij} used in Eqs. (1) to (3) according to the Flügge theory can be found in the Appendix. $c_L = [E/\rho(1-\upsilon^2)]^{1/2}$ is the longitudinal wave speed. E, ρ and υ are respectively the Young's modulus, density and Poisson's ratio of the cylinder. The external pressure loading p due to the fluid acting normally to the surface of the cylindrical shell can be approximated using an infinite model and expressed in terms of a fluid loading parameter F_L by [18]

$$p = \frac{\rho h c_L^2}{a^2} F_L w \tag{4}$$

$$F_L = -\Omega^2 \frac{a}{h} \frac{\rho_f}{\rho} \frac{H_n(k_{nr}a)}{H_n'(k_{nr}a)} \tag{5}$$

where $\Omega = \omega a/c_L$ is the non dimensional ring frequency, ρ_f is the density of the fluid. H_n is the Hankel function of order n and H'_n is its derivative with respect to the argument. k_{nr} is the radial wavenumber [18]. The general solutions to the equations of motion can be written as

$$w = \sum_{n=0}^{\infty} \sum_{i=1}^{8} W_{n,i} e^{jk_{n,i}x} \cos(n\theta) e^{-j\omega t} \tag{6}$$

$$u = \sum_{n=0}^{\infty} \sum_{i=1}^{8} C_{n,i} W_{n,i} e^{jk_{n,i}x} \cos(n\theta) e^{-j\omega t} \tag{7}$$

$$v = \sum_{n=0}^{\infty} \sum_{i=1}^{8} G_{n,i} W_{n,i} e^{jk_{n,i}x} \sin(n\theta) e^{-j\omega t} \tag{8}$$

where $C_{n,i}=U_{n,i}/W_{n,i}$ and $G_{n,i}=V_{n,i}/W_{n,i}$. $k_{n,i}$ is the axial wavenumber and n is the circumferential mode number.

End plates and bulkheads

The end plates and bulkheads were modelled as thin circular plates in bending and in-plane motion. The axial w_p, radial u_p and circumferential v_p plate displacements are shown in Figure 3. h_p is the plate thickness.

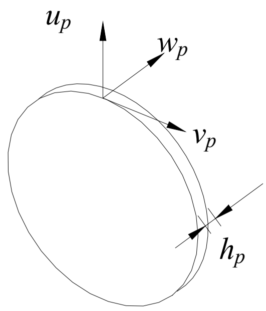

Figure 3. Displacements for a thin circular plate.

Displacements for the end plates and bulkheads can be written as [3]

$$w_p = \sum_{n=0}^{\infty} \left(A_{n,1} J_n(k_{pB}a) + A_{n,2} I_n(k_{pB}a) \right) \cos(n\theta) e^{-j\omega t} \tag{9}$$

$$u_p = \sum_{n=0}^{\infty} \left(B_{n,1} \frac{\partial J_n(k_{pL}a)}{\partial a} + \frac{n B_{n,2} J_n(k_{pT}a)}{a} \right) \cos(n\theta) e^{-j\omega t} \tag{10}$$

$$u_p = \sum_{n=0}^{\infty} \left(B_{n,1} \frac{\partial J_n(k_{pL}a)}{\partial a} + \frac{n B_{n,2} J_n(k_{pT}a)}{a} \right) \cos(n\theta) e^{-j\omega t} \tag{11}$$

where k_{pB} is the plate bending wavenumber and k_{pT}, k_{pL} are the wavenumbers for in-plane waves in the plate [3]. J_n, I_n are respectively Bessel functions and modified Bessel functions of the first kind. The coefficients $A_{n,j}$ and $B_{n,j}$ (j=1,2) are determined from the continuity equations at the cylinder/plate junctions.

Conical shell

Dynamic modelling of the conical shells can be found in [19]. The displacement of the conical shell was described using a power series solution following the procedure presented by Tong [20]. The displacements and coordinate system for the conical shell are shown in Figure 4, where u_c and v_c are respectively the displacements of the shell's middle surface along the x_c and θ_c directions. w_c is the displacement normal to the surface along the z_c direction.

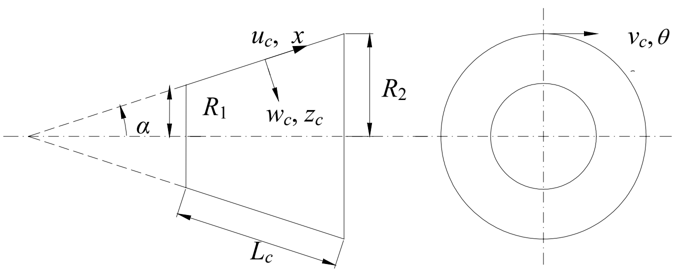

Figure 4. Coordinate system for a thin truncated conical shell.

External fluid loading on the conical shell was taken into account using a local cylindrical approximation which is described in what follows. The conical shell is divided in several narrow segments, as shown in Figure 5. The segments are narrow enough to be considered as locally cylindrical in order to account for the fluid loading; that is, the fluid loading on the conical strip is considered the same acting on an equivalent cylindrical shell with the same width and radius R_i. This approximation is only applicable to the calculation of the fluid loading acting on a shell segment. To solve for conical shell displacements, the equations of motion and corresponding general solutions for a conical shell were used. This method of accounting for the fluid loading acting on a conical shell using a local cylindrical approximation is shown to be reliable at low frequencies [19].

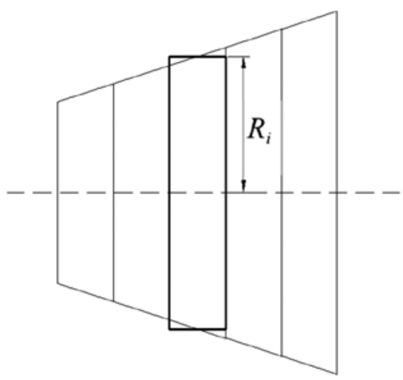

Figure 5. Local approximation of the conical shell.

Propeller shaft excitation

The propeller force is transmitted to the edge of the cylindrical section of the hull. The transmitted force can be modelled as an axisymmetric distributed load given by $F=F_o/2\pi a$ as shown in Figure 6. The distributed load excites only the n=0 breathing modes.

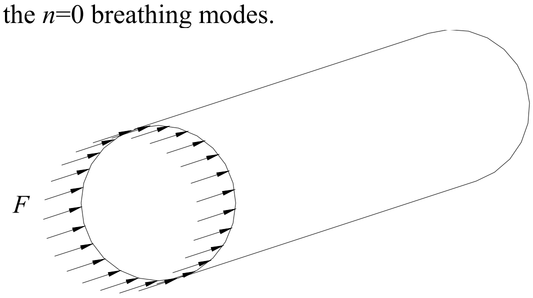

Figure 6. Distributed force excitation of the hull.

The dynamic response of the submarine for each value of the circumferential mode number n is expressed in terms of $A_{n,j}$ and $B_{n,j}$ (j=1,2 for each circular plate) and $W_{n.i}$ (i=1:8 for each section of the hull). The entire submarine is free-free. At the cylinder/plate junctions, continuity of displacements and equilibrium of forces/moments have to be satisfied. The whole structure consists of three cylindrical shell segments, six circular plates and two truncated conical shells. The boundary and continuity equations can be arranged in matrix form **BX**=**F**, where **X** is the vector of unknown coefficients and **F** is the vector containing the external fluctuating forces from the propeller. Once the unknown coefficients have been determined the radial displacement of the hull can be obtained.

3. FAR FIELD SOUND PRESSURE

After the radial displacement of the structure has been determined, the far field sound pressure P can be evaluated following the procedure presented by Skelton and James [21]. The submarine structure can be viewed as a slender body of revolution. The cylindrical coordinate systems are (r, θ_r, z_r) for the exterior body and (r_0, θ_0, z_0) on the surface of the structure, as shown in Figure 7.

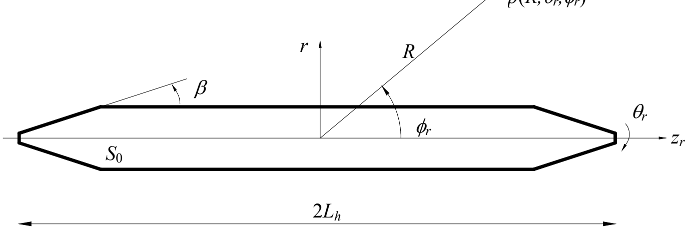

Figure 7. Coordinate system for the far field point.

The angle β is defined by $\tan\beta=\partial a_r(z_r)/\partial z_r$ where a_r is the radius of the structure at location z_r and $2L_h$ is the total length of the structure. The displacement normal to the surface, calculated solving the matrix **BX**=**F**, can be written as

$$W_N(r_0,\theta_0,z_0)=\sum_{n=0}^{\infty}W_N(r_0,z_0)\cos(n\theta_0) \tag{12}$$

Considering a local approximation for the pressure near the surface of the body, the sound pressure in the far field can be calculated and expressed in polar coordinates by

$$P(R,\phi_r,\theta_r)=\frac{\omega\rho_f c_f e^{jk_f R}}{2R}\sum_{n=0}^{\infty}-j^n X_n(k_f\cos\phi_r)\cos(n\theta_r) \tag{13}$$

where

$$X_n(k_f\cos\phi_r)=\int_{-L_h}^{L_h}\frac{I(\gamma a_r)W_n(a_r,z_0)a_r(z_0)}{\omega\rho_f c_f\cos\beta}e^{-jk_f\cos\phi_r z_0}dz_0 \tag{14}$$

$$I(\gamma a_r)=-k_f J_n(\gamma a_r)+\frac{H_n(k_f a_r\cos\beta)(\gamma\cos\beta J_n'(\gamma a_r)+j\alpha\sin\beta J_n(\gamma a_r))}{\cos^2\beta H_n'(k_f a_r\cos\beta)+j\sin^2\beta H_n(k_f a_r\cos\beta)} \tag{15}$$

k_f is the acoustic wavenumber and c_f is the speed of sound in the medium. The integral in Eq. (14) can be calculated by considering separately the contribution of each section of the submarine corresponding to the conical and cylindrical shells. In this analysis, the surface is considered continuous.

Figure 6 Distributed force excitation of the hull.

Scattering from the curvature discontinuity at the junction between the cylindrical and conical shells and between the cones and the external plates are neglected.

4. RESULTS

Numerical results are presented for a ring-stiffened steel cylinder of radius a=3.25m, hull plate thickness h=0.04m, length L=45m and with two evenly spaced bulkheads of thickness h_p=0.04m. The end plates at each end of the cylinder are also of thickness h_p=0.04m. The conical end enclosures are of dimensions h_c=0.014m, R_1=0.50m, R_2=3.25m, $\alpha=\pi/10$rad. The material properties of steel are density ρ=7800kgm^{-3}, Young's modulus E=21x10^{11}Nm^{-2} and Poisson's ratio υ=0.3. The stiffeners have a rectangular cross-sectional area of 0.08m x 0.15m and are evenly spaced by 0.5m. The cylinder was submerged in water (ρ_f =1000kgm^{-3}). The onboard equipment and ballast tanks are taken into account considering a distributed mass on the shell of m_{eq}=1500kgm^{-2}. Internal structural damping was included in the analysis using a structural loss factor of 0.02. The submarine was excited with an axial force of unity amplitude F_o=1N applied to one end of the finite cylindrical shell. Only the natural frequencies of the breathing modes defined by the n=0 circumferential mode were excited, resulting in axisymmetric motion of the hull. The structural results are presented in terms of the frequency response function of the axial and radial displacements at the ends of the cylindrical section. The acoustic results are presented in terms of the maximum sound pressure evaluated in the far field at θ_r =0 and R=1000m.

Structural response

Figures 8 and 9 present the frequency response functions (FRFs) of the axial and radial displacements at each end of the cylindrical shell corresponding to x=0 and L. In Figure 8, the main peaks occurring at 22.7, 45.4 and 67.9 Hz are the first three resonant frequencies of the submarine for the axisymmetric case (n=0 breathing modes). The small peaks occurring at approximately 9 and 36 Hz are due to the bulkheads. The bulkhead resonances are more evident in Figure 9 which shows the radial displacement at each end of the cylindrical shell. As the axisymmetric modes are mainly axial in nature, the radial responses at the bulkhead natural frequencies are comparable with the responses at the resonances of the cylindrical shell.

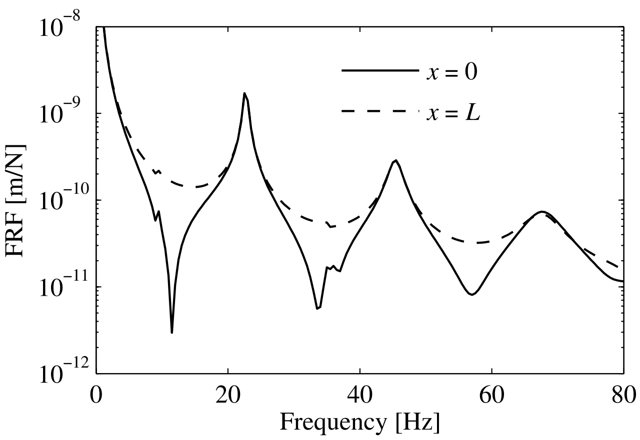

Figure 8. Frequency response of the axial displacement.

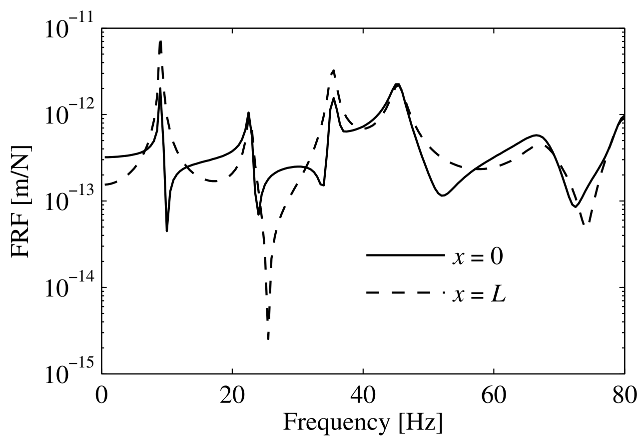

Figure 9. Frequency response of the radial displacement.

The corresponding deformation shapes which are a combination of axial and radial displacements are shown in Figures 10 to 12 for the first three axisymmetric modes, respectively. Different scales are used for the horizontal and vertical axes in order to magnify the radial response. At the first and third resonant frequencies of 22.7 and 67.9 Hz respectively, the ends of the hull are vibrating out of phase with each other. At the second resonant frequency (Figure 11), the ends of the hull are vibrating in phase. The accordion motion of the hull results in large deformation in the axial direction and only a small radial expansion of the central cylindrical hull. The conical shells behave almost rigidly except for a small deformation at the junctions between the cylinder and end plates. The localised effect of the bulkheads on the radial displacement is shown. The effect of the ring stiffeners is not observed as the stiffeners were modelled using orthotropic shell properties. In all figures of the deformation shapes for the first three axisymmetric modes, the contribution of the axial motion and thus the radiation from the end cones result in the maximum values of the radiated sound pressure.

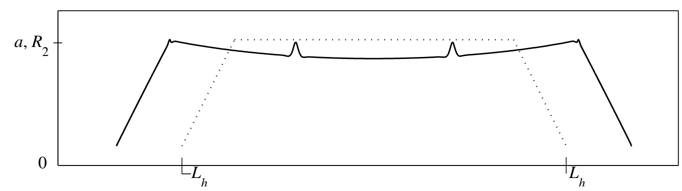

Figure 10. Deformation shape at the first n=0 natural frequency of 22.7 Hz.

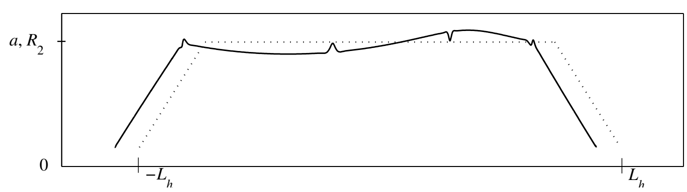

Figure 11. Deformation shape at the second n=0 natural frequency of 45.4 Hz.

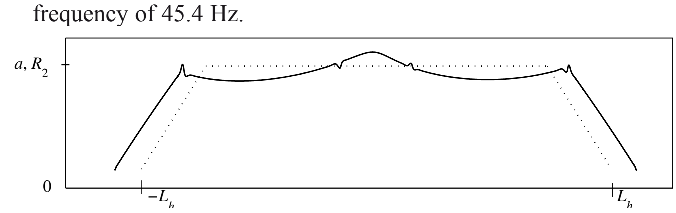

Figure 12. Deformation shape at the third n=0 natural frequency of 67.9 Hz.

Acoustic response

Figure 13 presents the maximum radiated sound pressure, which clearly shows the first three resonant frequencies of the submarine for the axisymmetric case (n=0 breathing modes). Small peaks due to the bulkheads are just visible. The radiation directivity patterns in terms of the angle ϕ_r are shown in Figures 14 to 16 for the first three axisymmetric modes of the submarine, respectively. The contribution from the cylindrical shell to the total radiated pressure is represented by the central lobes in the directivity patterns. The side lobes are due to the contribution from the end cones. As the frequency increases, the radiation directivity increases in complexity. For the first three resonances, there are one, two and three central lobes, respectively. In Figure 14, the directivity pattern shows that the contribution to the total sound pressure from the cones results in large lobes in the axial direction. A partial cancellation due to the pressure radiated by the cylindrical section occurs in the direction normal to the axis of the submarine. At the second natural frequency, the cylindrical section assumes a sinusoidal shape and its directivity pattern is bilobate. Similarly, at the third resonance, the radiated pressure from the central cylindrical shell is trilobite. As expected, the end cones determine the maximum sound pressure since the axisymmetric modes are mainly axial modes with little radial expansion.

5. CONCLUSIONS

An analytical model to study the low frequency structural and acoustic responses of a submerged vessel has been presented. Modelling of the submarine included several influencing factors corresponding to ring stiffeners, bulkheads and fluid-loading. The hull was closed by end plates and truncated conical shells. The truncated cones were solved using a power series solution whereas the hull was solved using a wave solution. The excitation from the propeller shaft results in an axisymmetric force distribution to the cylindrical hull which excites only the accordion modes of zeroth circumferential mode number. Results were presented in terms of frequency responses at each end of the cylindrical hull and of the maximum far field radiated sound pressure. Results were also presented for the deformation shapes and corresponding directivity patterns for the first three axisymmetric modes. Future work will involve extending the analytical model to include the effect of higher order circumferential modes, thus allowing the individual contributions from the higher order circumferential modes on the hull structural and acoustic responses to be observed. Furthermore, the development of an analytical model will allow the implementation of appropriate active control strategies to be investigated.

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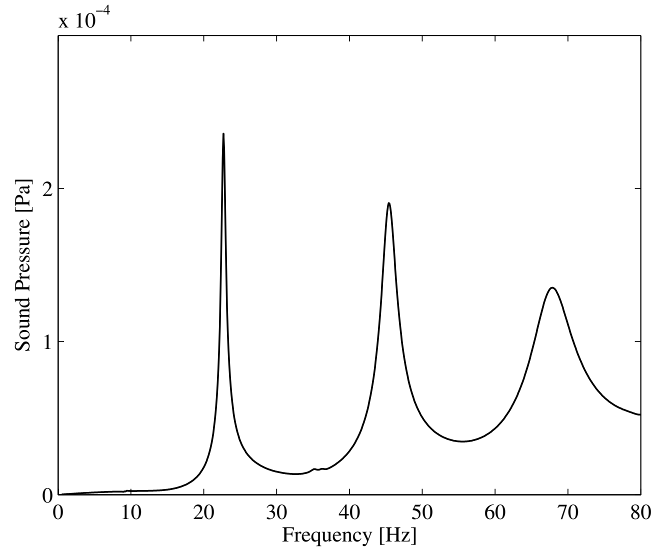

Figure 13. Maximum far field sound pressure, θ_r=0, R=1000 m.

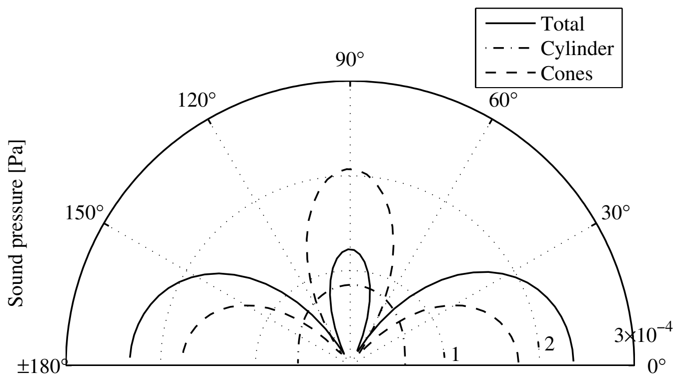

Figure 14. Directivity pattern at the first n=0 natural frequency of 22.7 Hz.

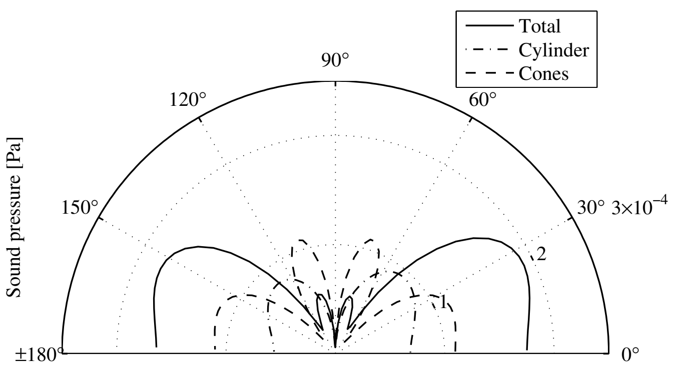

Figure 15. Directivity pattern at the second n=0 natural frequency of 45.4 Hz.

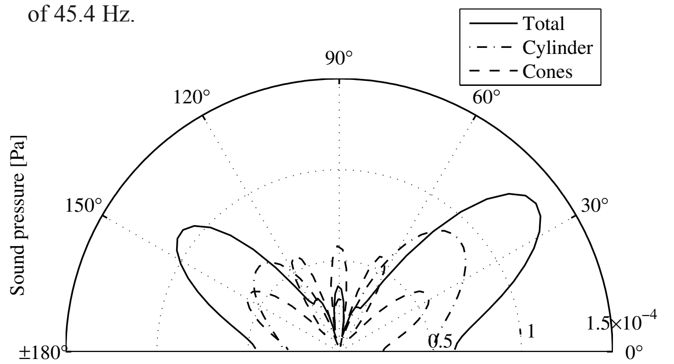

Figure 16. Directivity pattern at the third n=0 natural frequency of 67.9 Hz.

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APPENDIX: Elements of the Flügge differential operator

The elements of the matrix differential operator L_{ij} used in Eqs. (1) to (3) according to the Flügge theory and modified to take into account the internal ring stiffeners are given by [17]

$$L_{11} = \frac{\partial^2}{\partial x^2} + \frac{q_1(1+\beta^2)}{a^2}\frac{\partial^2}{\partial\theta^2} - \frac{\gamma}{c_L{}^2}\frac{\partial^2}{\partial t^2}, \quad L_{12} = \frac{q_2}{a}\frac{\partial^2}{\partial x\partial\theta},$$

$$L_{13} = \frac{\upsilon}{a}\frac{\partial}{\partial x} - \beta^2 a\frac{\partial^3}{\partial x^3} + \beta^2\frac{q_1}{a}\frac{\partial^3}{\partial x\partial\theta^2}$$

$$L_{21} = \frac{q_2}{a}\frac{\partial^2}{\partial x\partial\theta}, \quad L_{22} = d_1\frac{\partial^2}{\partial\theta^2} + d_2\frac{\partial^2}{\partial x^2} - \frac{\gamma}{c_L{}^2}\frac{\partial^2}{\partial t^2},$$

$$L_{23} = d_3\frac{\partial}{\partial\theta} + d_4\frac{\partial^3}{\partial\theta^3} - d_5\frac{\partial^3}{\partial x^2\partial\theta}$$

$$L_{31} = \frac{\upsilon}{a}\frac{\partial}{\partial x} - \beta^2 a\frac{\partial^3}{\partial x^3} + \frac{\beta^2}{a}q_1\frac{\partial^3}{\partial x\partial\theta^2},$$

$$L_{32} = d_3\frac{\partial}{\partial\theta} + d_4\frac{\partial^3}{\partial\theta^3} - d_5\frac{\partial^3}{\partial x^2\partial\theta}$$

$$L_{33} = d_6 + d_7\frac{\partial^2}{\partial\theta^2}\beta^2\left(d_8 + d_9\frac{\partial^2}{\partial\theta^2} + a^2\frac{\partial^4}{\partial x^4}\right.$$

$$\left. + d_{10}\frac{\partial^4}{\partial x^2\partial\theta^2} + d_{11}\frac{\partial^4}{\partial\theta^4}\right) + \frac{\gamma}{c_L{}^2}\frac{\partial^2}{\partial t^2}$$

where

$$\beta = \frac{h}{\sqrt{12}a}, \qquad q_1 = \frac{1-\upsilon}{2}, \qquad q_2 = \frac{1+\upsilon}{2},$$

$$\gamma = \left(1 + \frac{A}{bh} + \frac{m_{eq}}{\rho h}\right)$$

$$d_1 = \frac{1+\mu}{a^2}, \qquad d_2 = q_1\left(1+3\beta^2\right), \qquad d_3 = \frac{1+\mu+\chi+\beta^2\eta}{a^2}$$

$$d_4 = \frac{\chi+\beta^2\eta}{a^2}, \qquad d_5 = \beta^2\frac{3-\upsilon}{2}, \qquad d_6 = \frac{1+\mu+2\chi}{a^2},$$

$$d_7 = \frac{2\chi}{a^2} \quad d_8 = \frac{1+3\eta}{a^2}, \qquad d_9 = \frac{2+4\eta}{a^2}, \qquad d_{10} = 2+\eta_t,$$

$$d_{11} = \frac{1+\eta}{a^2}, \qquad \mu = \frac{(1-\upsilon^2)EA}{Ebh}$$

$$\chi = \frac{(1-\upsilon^2)EAz_e}{Ebha}, \qquad \eta = \frac{EI}{bD}, \qquad \eta_t = \frac{GJ}{bD},$$

$$D = \frac{Eh^3}{12(1-\upsilon^2)}.$$

β is the thickness parameter. The ring stiffeners have cross sectional area A, b is the stiffener spacing and z_e is the distance between the shell mid-surface and the centroid of a ring. G is the shear modulus, I is the area moment of inertia of the stiffener about its centroid and J is the polar moment of inertia of the cross sectional area. m_{eq} is the equivalent distributed mass on the cylindrical shell to take into account the onboard equipment and the ballast tanks.

THE ROBUSTNESS AND APPLICABILITY OF AUDIO SOURCE SEPARATION FROM SINGLE MIXTURES

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ABSTRACT: The separation of audio sources from their single mixture is a great challenge in signal processing research. Many single mixture source separation techniques have been proposed in the past 20 years but unfortunately the results are not pleasing enough for practical applications. In this tutorial-review paper, single-channel audio source separation techniques are divided into three broad categories: separation by auditory scene analysis (ASA), training based separation and blind source separation (BSS). Each of the categories is briefly described to contrast their methodological differences. This study focuses on the limitations and robustness under adverse acoustic environment of the seveal categories. We compare the success and usability of the different techniques in real world applications.

1. INTRODUCTION

The technical challenge of blind separation of audio sources is actively pursued in both engineering and applied mathematical disciplines. Single mixture (monaural) blind source separation addresses the most challenging case. It has many applications in signal processing including automatic speech recognition and music transcription. Monaural separation of acoustical sources refers to an algorithm that separates the components from a mixture of acoustical signals [1]. It is especially useful in circumstances where multiple sources are closely spaced and therefore where methods based on spatial localisation fail.

The single mixture situation often happens during taping of speakers' utterances in a public space with a single microphone. The problem is that the information of the audio sources (locations, the acoustics of the surrounding place, energy ratios, phase-delays, etc.) is merged in a single channel. All information related to the target source is mixed up with the information of the interfering sources. Researches on single mixture source separation are aiming on several directions. It is difficult to categorise the techniques explicitly to illustrate their comparative studies. A well established method is commonly known as auditory scene analysis (ASA) [2, 3, 4, 5]. Some techniques (i.e., training based method) use *a priori* knowledge about the sources of some specific types of mixtures [6, 7]. The statistical signal processing approach, such as independent component analysis (ICA) [8], is also the subject of increasing research. In this paper, we discuss three broad categories of single mixture audio source separation methods. We have the robustness and applicability of the different categories in a practical scenario.

2. CLASSIFICATION

Despite considerable research on single mixture audio source separation, the success has been limited. In the following sub-sections, three categories of research regarding single channel source separation are discussed: (i) computational auditory scene analysis (ii) training based separation, and (iii) separation by independent subspace analysis (ISA). Each category has its own success, applicability and failure.

2.1 Auditory Scene Analysis (ASA)

Auditory scene analysis (ASA) is the process by which the human auditory system organises sound into perceptually meaningful elements. . Computational ASA (CASA) is a machine learning system that aims to separate mixtures of sound sources in a way similar to that used by human listeners. It is closely related to audio source separation. CASA differs from the field of blind source separation in that, like the human auditory system, it uses no more than two microphone recordings of an acoustic environment. The block diagram of CASA system is shown in Figure 1.

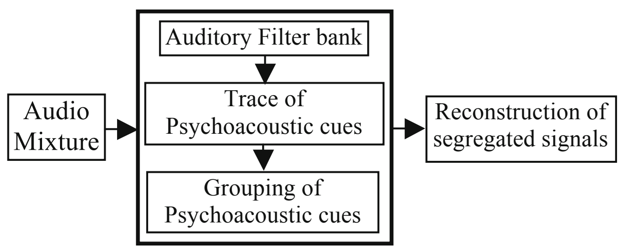

Figure 1: A block diagram of Computational Auditory Scene Analysis (CASA).

In traditional CASA, the goal is to extract multiple sound components from a mixture. The output sound can then be analysed independently to compute their features. The separated sounds should be similar to the input sound in some perceptual ways. Scheirer [2] proposed an ASA-based method of sound understanding without separation similar to the ability of the human listener. ASA understands a real environment using acoustic events. The human auditory system can easily solve some ASA problems in a multi-source audio environment. But, in solving the problem of ASA using acoustic signals received from the same environment, a unique solution cannot be derived without constraints on acoustic sources and the real environment. The sequential steps of the auditory segregation model are shown in Figure 1.

2.1.1 *Auditory model of mixed audio signal*

The audio mixture is first analysed into a time-frequency representation by an auditory filter-bank approximating the function of the cochlea. Different types of filter-bank, for example, constant-Q filter-banks [3] and gammatone filter-banks [4] have been suggested. Bregman [5] reported that, for ASA, the human auditory system uses four psychoacoustically heuristic regularities related to acoustic cues namely, (*i*) common onset and offset, (*ii*) gradualness of change, (*iii*) harmonicity, and (*iv*) changes in the acoustic event. Tracing and grouping of such cues in the time-frequency representation are the most important steps in source segregation using CASA.

2.1.2 *Auditory grouping*

The mixed audio signal is first decomposed into a collection of acoustic components. The auditory system appears to construct the subsets of analysed components using some organisational principles [4]. The organisation explicitly represents the form of groups of auditory primitives which can reasonably be assumed to belong together.

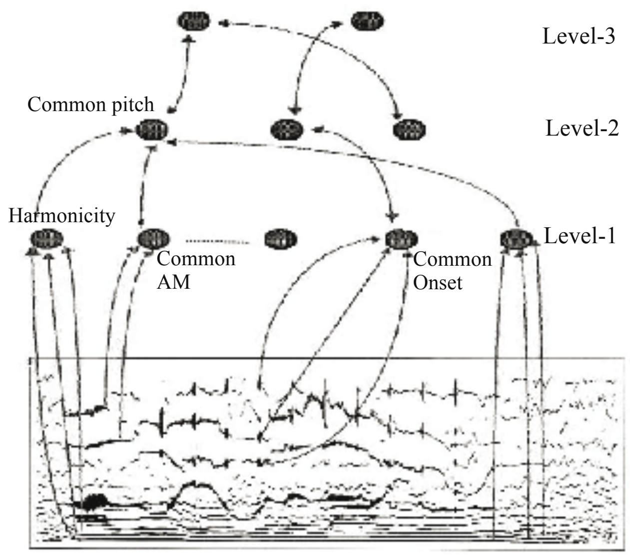

Figure 2: A hierarchical view of auditory scene analysis.

When those components are considered together, the grouping is performed from a complete and self-consistent explanation of the listener's acoustic environment. The hierarchical model of auditory grouping process is shown in Figure 2.

If the initial decomposition has resulted in a set, $C=\{c_1, c_2,\ldots\ldots\ldots,c_n\}$, of components, the grouping task might be expressed as one which demands that a collection $G=\{g_1, g_2, \ldots.., g_m\}$ of groups be discovered, such that,

$$\forall(g\in G)\cdot g\subseteq C \qquad (1)$$

This approach is to view grouping as a process, which builds a hierarchical model on the set C, as illustrated in Figure 2. The resulting representation is a graph in which lowest level (Level-1) nodes correspond to auditory primitives, whilst intermediate level (Level-2) nodes represent the groups of objects discovered at the preceding level (Level-1). The upper level (Level-3) would correspond to more complete explanations of each acoustic source – auditory streams.

The grouping process consists of more or less direct implementation of the cues known to us from psychoacoustics [3]. Cues such as harmonicity, common onset, common amplitude modulation (AM), and energy continuity [5] are used to group the acoustical elements. For each rule, the grouping method takes a single element as a seed. The grouping process returns zero or more groups to grow up from the seed. When the grouping is properly completed, the next step is to partition the time-frequency representation of the mixture into the number of sources. Ideally the number of groups with all the acoustic cues is equal to the number of sources forming the mixture. Most of the time, some clean-up or post-processing is required for proper grouping and segregation of the sources.

2.2 Training-Based Separation

Considering the complexity of the blind source separation, some researchers have proposed training based segregation of sources from a single mixture. Some use time domain methods [8, 9] and others time-frequency based algorithms [10]. Training based separation requires either strong assumptions about the nature of the sources, substantial *a priori* information, or a combination of both.

2.2.1 *Time domain method*

Most time domain techniques are based on splitting the whole signal space into several disjoint and orthogonal subspaces that suppress overlaps. The criteria employed by the earlier time domain methods mostly involve second order statistics (SOS). Those methods perform well with input signals well-suited to the AR (autoregressive) model. Moreover, the use of SOS restricts the separable cases to orthogonal subspaces [11]. The recent approach [8, 9] based on exploiting *a priori* sets of time domain basis functions learned by independent component analysis (ICA) uses higher-order statistics (HOS) resolving the problems with SOS. For better understanding, this paper presents the time domain separation method described in [8, 9].

To formulate the problem, the observed signal y^t is assumed as the summation of P independent source signals,

$$y^t = \lambda_1 x_1^t + \lambda_2 x_2^t + \ldots. + \lambda_P x_P^t \qquad (2)$$

where $t\in[1, T]$, x^t_i is the t^{th} sampled value of the i^{th} source signal, and λ_i is the gain of each source which is fixed over time. The goal is to recover all x^t_i given only a single sensor input y^t. To represent the generative model, continuous samples of length N with N<<T are chopped out of a source; the subsequent segment is denoted as an N-dimensional column vector x_i^t, expressed as

$$x_i^t = \sum_m^M a_{im} s_{im}^t = A_i s_i^t \quad (3),$$

where M is the number of basis functions (a_{im}) and s^t_{im} is the coefficients of the vector x^t_i. It is assumed that $M = N$ with A as a full rank, reversible matrix. The ICA learning algorithm is used to determine $W_i = A_i^{-1}$ such that $s^t_i = W_i x^t_i$. Figure 3 shows the generative model of time domain signal decomposition as the weighted sums of the basis functions. The algorithm first involves the ICA-based learning of time domain basis functions of the sources that are the subjects to be separated. This corresponds to the prior information necessary to separate successfully the signals [8]. Considering P=2 and hence, $\lambda_1+\lambda_2=1$, only λ_1 is estimated. The proposed method is tested with four different types of sounds: rock music, jazz, male and female speech with reasonable success rates.

(a)

(b)

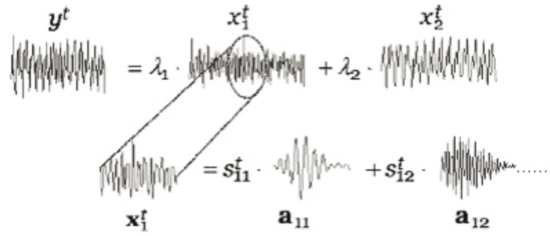

Figure 3: Generative model of the observed mixture and the source signals; (a) mixture as the weighted sum of two source signals, and (b)individual source generated by weighted (s^t_{im}) linear superposition of basis functions (a_{im}).

2.2.2 *Method in time-frequency domain*

To tackle the underdetermined problem, single mixture source separation is often implemented using short-time spectra, i.e. a time-frequency representation of the mixed signal. In such a representation, we may consider sound as comprising a collection of localized time/frequency components. The distribution of these basic sound elements on the time-frequency plane will effectively be the spectrogram of the analysed sound. Using this representation, we can employ a wealth of probabilistic analysis techniques directly on the spectral distributions without having to worry about enforcing non-negativity and also providing a clear way to incorporate these techniques in learning framework [11].

The basis decomposition with the time-frequency method is of the form $y_i = w_i.S$, where S is the input magnitude spectrogram in the form of matrix and w_i is a matrix containing the weight corresponding to the i^{th} source, and y_i is a magnitude spectrogram of the i^{th} source signal. If we wish to separate the i^{th} source component, we can then modulate the phase of the original mixture spectrogram with y_i and invert the frequency transform yielding the separated source. The method for computing the weight factors can be varied. As an example, the monaural source separation method by Roweis [10] is illustrated here. In [10], a filtering technique is presented to estimate time-varying masking filter that localise sound streams in a spectro-temporal region. The sources are supposedly disjoint in the spectrogram and the estimated mask exclusively divides the mixed streams completely. If $w_k(t)$ is a set of masking (weighting) functions, a source signal $y(t)$ can be recovered by modulating the corresponding sub-band signals $X_k(t)$ as [10]:

$$y(t) = \sum_{k=1}^{K} w_k(t) X_k(t) \quad (4),$$

where K is the number of sub-band signals. The masking method is performed on the original spectrogram as shown in Figure 4. The goal of the source separation depends on the construction of the masking signals $w_k(t)$, i.e. to group together regions of the spectrogram that belong to the same auditory sources.

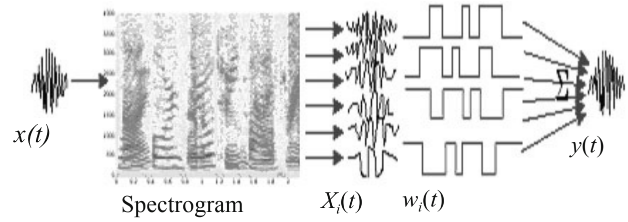

Figure 4: Masking approach of source separation

Roweis [10] uses simple factorial hidden Markov models (HMM) system which learns from the spectrogram of a single speaker to generate the masking function. The approach first trains speaker-dependent HMM on isolated data from single speakers. Then, to separate a new single recording which is a mixture of known speakers, these pre-trained models are combined into a factorial HMM (FHMM) architecture. The FHMM consists of two or more underlying Markov chains which evolve independently and the sources are separated simultaneously. The results of separating a simple two-speaker (male & female) mixture are presented in [10]. Training based source separation, being based on prior knowledge about the sources, is not able to adapt many robust situations which are common in real-world application such as robust speech recognition, signal de-noising etc.

2.3 Separation by ISA

Presently, several audio source demixing researchers [12, 13, 14, 15] proposed independent subspace analysis (ISA) method as the tool of separation. ISA aims to derive some independent basis vectors from the single mixture spectrogram (time-frequency plane). Two types of basis vectors, temporal basis and spectral basis, can be derived from the spectrogram. The more suitable one for source separation is selected based on the energy distribution in the spectrogram [13]. Applying ICA, the independent basis vectors are then grouped together to derive the subspaces corresponding to each source. Kullback-Laibler divergence-based clustering algorithm is introduced in [13] to group the independent basis vectors into the number of sources. The time-frequency representation can also be performed on a Hilbert spectrum [15], a newly developed method for analysing non-linear and non-stationary signals.

2.3.1 *Basic separation model using ISA*

The block diagram of the overall separation algorithm is shown in Figure 5. The source subspace decomposition operates on the audio mixture signal $s(t)$ composed of N

independent sources. The mixture signal is then projected onto the time-frequency plane $\boldsymbol{S}(n,k)$ using short time Fourier transform (STFT) [13] or a Hilbert spectrum [15]. One can easily separate magnitude $X(n,k)$ and phase $\phi(n,k)$ information from $S(n,k)$.

The overall magnitude spectrogram X can be represented as the superposition of N independent source spectrograms as:

$$X = \sum_{i=1}^{N} x_i \tag{5}$$

x_i is also uniquely represented as the outer product of an independent spectral basis vector F_i, and corresponding amplitude envelope A_i (temporal basis vector) as:

$$x_i = F_i A_i^T \tag{6}$$

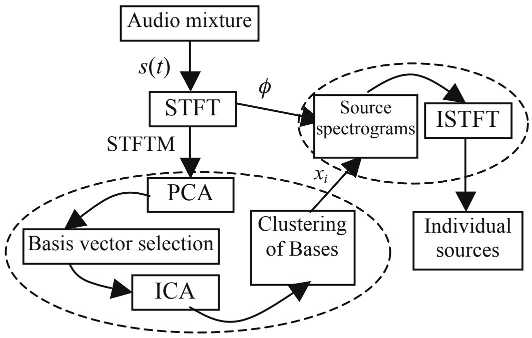

Figure 5: The block diagram of the separation algorithm using ISA.

Now the object is to derive N sets of F_i and A_i from X using the sequential application of principal component analysis (PCA), independent component analysis (ICA) and clustering method. Each set of basis vectors corresponds to features of the independent sources.

2.3.2 *Constructing independent subspaces*

Usually, the number of rows and columns of X is greater than the number of spectral/temporal basis vectors required for subspace decomposition. The dimension of the overall magnitude spectrogram X is first reduced by principal component analysis (PCA) [12, 14].

The basis vectors obtained by PCA are only uncorrelated but not statistically independent. To derive the independent basis vectors, a further procedure called ICA is be carried out. JadeICA algorithm [15] is used here to obtain the independent basis vectors (F or A based on selection in PCA). Once the spectral or temporal independent basis vectors have been obtained, the corresponding amplitude envelopes A or frequency basis F respectively can be obtained by projecting X on to the independent one (F or A). The basis vectors are then grouped (group F and A into F_i and A_i subsets respectively) into the number of sources (for two sources i=1, 2 i.e. two subsets of F and A). In [13], a Kullback-Laibler divergence (KLd) based k-means clustering algorithm has been proposed for the grouping process. After properly grouping F and A, the individual source subspaces (source spectrograms) are obtained by Eq. (6). The time domain source signal is constructed by simply appending the phase matrix $\phi(n,k)$ and applying the inverse STFT (ISTFT). The separation results of two sources from single mixture using ISA [13] are illustrated in Figure 6.

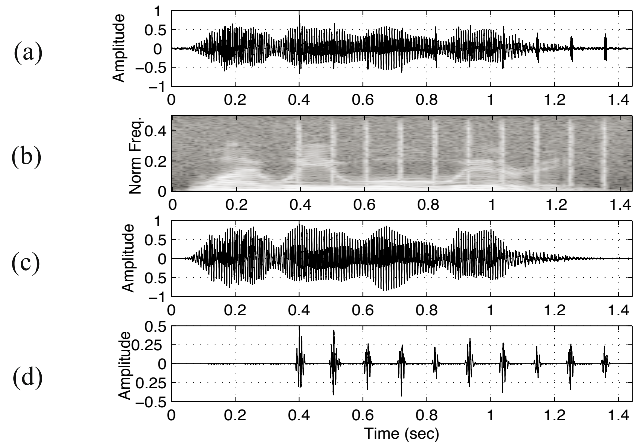

Figure 6: Separation by ISA [13]; (a) mixture signal of speech and bubble noise, (b) spectrogram of the mixed signal, (c) separated speech signal and (d) separated bubble noise.

We [13] have presented the simulation results to separate the sources from the mixture of two audio streams (speech and other sounds). Using this method, it is not possible to separate two similar sources such as two male speakers. In this case, the proposed model is likely to produce the same type basis vectors, indicating similar source features.

3. COMPARATIVE DISCUSSION

Single-mixture audio source separation techniques do not work well when the spectra of the component sources overlapp. None of existing methods of single mixture source separation is capable of separating two or more speech signals coming from moving male speakers recorded through a single microphone. It is difficult to compare the methods discussed above. Table 1 provides a comparison of the above-mentioned methods regarding their robustness and usability in practical applications.

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Table 1: A comparison of Single-Channel audio source separation methods

Separation Method	Robustness	Applicability
Auditory scene analysis	a. There are many ambiguous situations for sources with similar spectra. b. Performance also depends on the time-frequency representation of the mixture signal.	a. More suitable to segregate only one source from the mixture. b. Applicable for vocal extraction from music, speech segregation from noise etc.
Training based separation	a. Being training-based, it focuses on a specific region of source separation problem. b. Unable to separate sources with similar spectral characteristics. c. Implemented to date only for the mixture of two sources.	a. Requires a *priori* knowledge about the sources. b. Real world applications include robust speech recognition, signal de-noising of known signal-noise type.
Separation by ISA	a. Performs better when there are some differences spectra of the component sources. b. Performance depends on the time-frequency analysis and segmentation of the mixture signal.	a. Separation is performed without any prior knowledge about the sources. b. Suitable when the sources are independent and linearly mixed.

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HEARING PROTECTOR TESTING AND INDIVIDUAL VARIABILITY

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ABSTRACT: Consistency of test procedures is extremely important when certifying products for both safety purposes and Australian Standard requirements. The results presented in this study demonstrated that using the subject-fit methodology as specified in *Australian New Zealand Standard AS/NZS 1270: 2002, Acoustics – Hearing protectors*, hearing protector attenuation can be reliably measured to within 0.1 dB. A small learning effect was observed with a reduction in the standard deviation from 3.7 dB in the initial fit to 2.7 dB at the final presentation.

1. INTRODUCTION

The test procedures used to determine the acoustic attenuation are a major discussion point at international meetings of those involved with setting hearing protector test standards. This involves the use of experienced compared to inexperienced test subjects in conjunction with experimenter assisted-fit or to subject-fit test methods. New Zealand and Australia strongly adhere to the inexperienced subject or 'subject-fit' methodology [1] while the majority of researchers in North America and Europe hold to experienced test subject - experimenter assisted methodologies [2, 3]. For those North American ("*Method B – subject fit*", see [2]) and European researchers who do favour a subject-fit, a method has been agreed and published as ISO/TS 4869 – 5: 2006(E) [4]. However, the subject-fit methodology is only presented as an optional procedure and the vast majority of jurisdictions still prefer the use of the experimenter assisted-fit technique.

The main reason for the vigorous discussion is due to measurements demonstrating the wide difference in the attenuation that can be experienced between laboratory testing and testing in the field [5] and criticism of NRR data which significantly overestimate hearing protector performance in the workplace [6]. (Note: NRR is a single number hearing protector rating scheme used primarily in the USA.) This difference arises because, when using experienced test subjects, the maximum attenuation of the device can be found through the reduction or minimisation of human factors that may possibly be introduced by inexperienced users. The test method allows experimenters to assist with the fitting of the device thus maximising performance.

This contrasts to the inexperienced subject-fit method where the object is to determine attenuation that could most reasonably be expected to be found to apply for the majority of typical users. The requirement of the Australian/New Zealand Standard, paragraph 4.3.1.3 [1], for a test subject to be inexperienced is defined in the following way:

"Subjects may participate in measurements of the attenuation of up to twelve hearing protectors, with a maximum limit of five pairs of earplugs, after which they will be ineligible for further participation."

Further the subject-fit method only permits the test subject to utilise information normally supplied with the device by the manufacturers, suppliers or distributors with or on the packaging. The subject-fit method is sometimes incorrectly called the naïve subject fit method.

This dichotomy can be understood from the manufacturers' and distributors' point of view as they wish to advertise what their particular product can achieve with respect to other products on the market. Thus they tend to favour the experimenter assisted method as it almost always provides a higher attenuation value. On the other hand, those supporting the subject-fit perspective wish to emphasise realistically achievable outcomes for typical end users, primarily in the workplace.

The work described here examines the personal variability in hearing protector attenuation arising through variation in fit/re-fit for one particular ear muff using the inexperienced subject-fit methodology. This variation in ear muff fit represents the intrapersonal variation – the variation for one subject. Indications from the lack of literature indicate that this has not been measured for either the experimenter assisted fit or the subject-fit methodologies. Interpersonal variation, that variation between subjects for fitting the same protector, is the standard deviation obtained during the normal test procedure.

2. METHOD

The particular hearing protector selected for this study was a common brand of ear muff readily available on the New Zealand and Australian market. When originally tested in accordance with the applicable test standard [1], the SLC_{80}[1] was 30 dB and the *mi*SLC_{80} [7, 8] was also 30 dB. The device was again tested several months later under the requirements of the test standard [1] in conjunction with several other hearing protectors. This test involves subjects having their hearing threshold measured in a diffuse field with both occluded and un-occluded ears (i.e. wearing and not wearing the hearing protectors respectively). The difference between the occluded and un-occluded hearing threshold levels provided the attenuation information.

[1]SLC_{80} or Sound Level Conversion is the Australian single number rating figure for the attenuation (dB) of hearing protectors representing the attenuation that can be expected to be achieved by approximately 80% of users.

There were 20 normal hearing test subjects selected, as per the requirements of the standard, to participate in a fit followed by a re-fit attenuation test along with a mixture of several other devices. The test subjects were not informed that one of the devices under test was to undergo repeat testing so, unless they particularly recognised the device when presented the second time, they were undertaking a blind test. The time between test and retest was typically about forty minutes.

The order of presentation of the devices was counterbalanced as described in Appendix C of the standard [1] in order to minimise any possible learning effect. With this in mind, naturally, each time the device of interest was first presented this instance was taken as the 'test' condition while the second presentation was taken as the 'retest' condition.

The statistical analysis of the results was carried out using the commercial software packages Excel© and Statistica©.

3. RESULTS

A summary of the results are presented graphically in Figure 1 and numerically in Table 1. These show, for comparison, the overall test results for the test and retest treated as a single population, the results of the first test and the results of the retest.

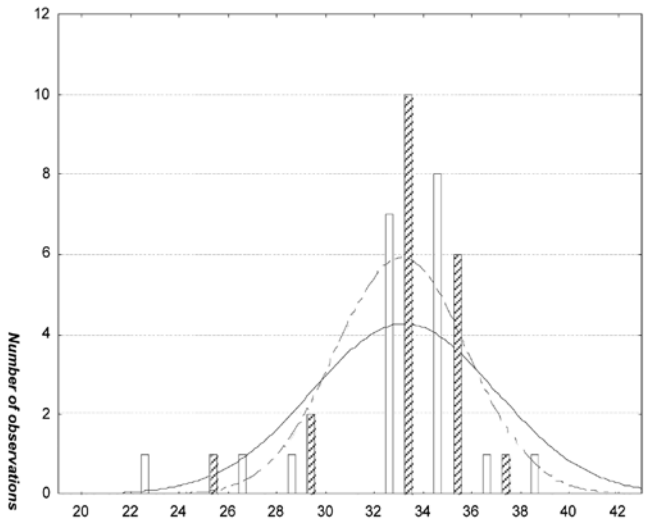

Figure 1. The histogram shows the distribution of attenuation results original test unshaded, retest shaded. The curves show normal distributions having the same mean and standard deviation, continuous for test and dashed for retest.

Parameter	*Overall (dB)*	*Test (dB)*	*Retest (dB)*	*Difference (dB)*
SLC_{80}	29.9	29.6	30.2	+ 0.6
Mean standard deviation	4.1	4.3	3.8	- 0.5
miSLC	33.1	33.1	33.0	- 0.1
i - standard deviation	3.2	3.7	2.7	- 1.0
$miSLC_{80}$	29.9	29.4	30.3	+ 0.9

Table 1. Differences in performance from test – retest results

The mean difference of the test retest attenuation (*mi*SLC) was - 0.1 dB with a standard deviation of 2 dB and the standard error reduced from 0.83 dB to 0.60 dB. A t-test for dependent samples indicated that there was no significant difference between the test and retest results ($p = 0.83$).

4. DISCUSSION

There was no statistically significant difference between the test and retest results. The difference in the mean attenuation (*mi*SLC) between test and retest was 0.1 dB. The standard deviation for the retest presentation was reduced to 2.7 dB from 3.7 dB in the original test presentation. Consequently the $miSLC_{80}$ increased from 29.4 dB to 30.3 dB as the $miSLC_{80}$ is the *mi*SLC minus the standard deviation.

The standard deviation of the test minus the retest difference in attenuation was calculated to be 2.0 dB. This represents the variation in ear muff fit arising due to personal factors or intrapersonal variations – variations from time-to-time when an individual uses the same protector. As mentioned in the introduction the interpersonal variation – variations arising from different individuals fitting the same hearing protector - is the standard deviation that results from normal hearing protector testing, 3.2 dB from the above results. These relative values are as would be expected, ie that the differences between people each fitting the same model of ear muff would be greater than a single individual refitting the same ear muff. More simply intrapersonal variation would be expected to be greater than interpersonal variation.

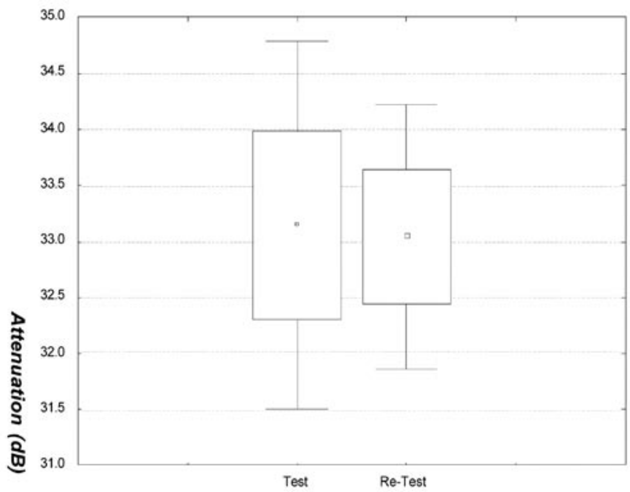

Figure 2. Test - retest results for comparison. The box shows the mean ± one standard deviation while the bars show the mean ± 1.96 standard deviations.

The decrease in standard deviation between test and retest, illustrated in Figure 2, implies the existence of a small learning effect gained from using several devices in sequence. This means that while the same mean attenuation can be expected to be achieved by users, the consistency of fit will normally improve with refit or practice, reflected by a reduction in the standard deviation.

This decrease in the standard deviation is important as it is reflected through the use of the single number performance figures SLC_{80} and *mi*SLC_{80} which use the mean attenuation minus one standard deviation figures included in their calculation. For example, with the above device the SLC_{80} increased from 29.6 dB on the initial test to 30.2 dB upon retest. Similarly the *mi*SLC_{80} increased from 29.4 dB to 30.4 dB reflecting the decrease in standard deviation.

5. CONCLUSION

The results of this work indicate that the consistency of test retest attenuation results for ear muffs is excellent and supports the current subject-fit testing procedures in use. There is a small learning effect indicated between test and retest presentations. The results also provided a value for the within-subject variation in device fit/refit with a standard deviation of 2 dB compared to the overall between-subject standard deviation of 3.2 dB.

6. REFERENCES

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ARE WE ASSESSING CHILD CARE NOISE FAIRLY?

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ABSTRACT: In recent years there has been a significant increase in the demand for child care, with many centres opening in 'normal' suburban streets, just a garden fence between the outdoor play area and the neighbour's garden. Some may feel that the sound of children playing is a happy sound; that childcare is part of life and should just be accepted. Others consider that child care can be a very profitable business and should be treated as any other commercial operation which has 'amenity' obligations to meet. Councils across NSW and the Land and Environment Court do not appear to have reached a clear decision on how to assess a child care centre.

1. INTRODUCTION

On 12 September 2007, the NSW Division of AAS held a technical meeting addressing noise issues in relation to childcare centres. Significant noise issues were discussed, but no clear consensus was reached that night. To follow up from the evening a questionnaire, based on the evening's questions and discussion was prepared and submitted to those who attended. It is noted that it was not the intention of the questionnaire to set down a clear policy guideline. Rather, its purpose was to record the opinions of those who attended, with the potential to assist in the future development of a policy on child care centre noise.

Approximately 45 people attended the evening and 26 questionnaires were returned. The majority of the responses were from consultants (20), with 2 responses from Council representatives and 3 responses from organisations other than Department of Environment and Climate Change (DECC). There was 1 anonymous response. DECC notified that they were not in a position to provide a response to the questionnaire, however they were considering the development of guidelines to assist Councils in developing criteria and assessing childcare centre noise. DECC indicated that the responses to the questionnaire would provide useful input should the guideline be developed.

Based on popular responses to the questionnaire, the following comments are made by the author in relation to the assessment of child care centre noise:

- Child care centres with 5-10 children or more should require noise impact assessment, not including home-based 'family day care';
- Outdoor play, mechanical plant and drop off/ pick up are the most significant noise issues that should be assessed. However, where relevant, indoor play, additional traffic on the existing road network and on-site traffic noise should also be assessed;
- A slim majority agreed that child care centres should be assessed in the same way as any other commercial premises (ie in accordance with the INP). However many suggested that outdoor noise be excluded from this or that a modified criterion should be applied;
- A minimum background noise level should apply when the background noise level is found to be low (eg 30 dB(A) when the background noise level is less than 30 dB(A), as per the NSW Industrial Noise Policy);
- Background + 10 dB, or 40 dB(A), whichever is higher, is an acceptable criterion for outdoor play noise. However, most comments suggested that duration should be attached to this criterion (1.5 to 3 hours). There was a slightly greater preference that this be determined on a site to site basis rather than applied as a blanket criterion applied to all centres;
- Where a receiver is affected by more than 1 identified noise source from a child care centre, and where background + 10 dB is adopted for outdoor play noise, background + 5 dB was the preferred criterion for other noise sources associated with the centre.
- Council (or Regional Organisation of Councils; or DECC) should provide a policy on child care centre noise, provided they are well informed. It was suggested that guidelines prepared by AAS or AAAC may be useful in achieving some conformity in child care centre noise policy across different Councils;
- There was no real consensus in relation to the correct assessment location, although the general preference was that assessment should not be 'at the boundary', rather at some other location within the boundary (eg free field; areas likely to be used for relaxing; at the building façade);
- The majority of respondents preferred that upper floors should always be considered for 2 storey houses overlooking an outdoor play area;
- No tonality adjustment is required;
- There is significant variation (7 to 11 dB) in the range of source sound power levels for children at play outdoors adopted by respondents when calculating noise impact from proposed centres;
- There was no clear response on the minimum background noise level where a child care centre is no longer feasible, although generally a background level of 30-40 dB(A) was considered the point where appropriate treatment becomes difficult in a residential area;
- The majority agreed that road, rail, aircraft and industrial noise impacts onto child care centres should be considered in a noise impact assessment.

The results of the questionnaire are available on the Society's website at http://www.acoustics.asn.au/journal/Gowen_AA_August08.pdf

LIFE-TIME LEISURE NOISE EXPOSURE – IS IT TIME TO LOOK AT THE BIGGER PICTURE?

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This *Acoustic Opinion* proposes a re-consideration of leisure noise exposure, not on a comparative basis from the standard hazard exposure perspective, but rather from a whole-of-life perspective.

1. INTRODUCTION

For the purposes of this discussion it can be accepted as a given that exposure to noise or sound, from what ever source, is a hazard to hearing health [1, 2]. For many years, the concentration of noise exposure activities has been directed primarily toward the workplace, most obviously by reason of the existence of occupational health and safety responsibilities through the consideration of the health and safety of workers exposed to noise. These OHS obligations fall mainly on those responsible for the workplace but employees also share a significant part of this responsibility.

Leisure noise, that noise that an individual mostly chooses to experience from activities that are not commonly part of their workplace, is not specifically regulated and is hence difficult for the individual to control. To date, noise exposure outside the workplace has been discussed mainly on a comparative basis looking at the relative effects of workplace noise sources in relation to hobby or home activities such as power tool use or shooting. Possibly more importantly leisure noise should be better considered both separately and in conjunction with workplace noise as a whole-of-life exposure in a similar manner as is now done with UV-radiation (sunlight).

2. A PARTICULAR EXAMPLE

Consider now a typical example of leisure noise exposure for a young, working adult. The scenario may run as follows with the associated average noise levels (L_{Aeq}): listening to their MP3 player while commuting to and from work for a total of two hours at 91 dB; five hours on a Friday or Saturday evening spent at the pub with friends listening to a rock band where the average levels sit in the order of 100 dB; and once a month a three hour concert where the level is 106 dB.

To conveniently analyse the total noise exposure for a one month period the most practical method is to use the workplace exposure criterion where an acceptable $L_{Aeq,8h}$ is recommended to be 85 dB with a 3 dB exchange rate. For convenience let us call this daily exposure value the 'allowable daily exposure' (ade). Thus an L_{Aeq} of 85 dB for eight hours is one ade; 88 dB for four hours is one ade; and 91 for five hours is 2.5 ade. Now summarise this young adults noise exposure over a one month period:

Noise source	*L_{Aeq} (dB)*	*Time (hr)*	*Equivalent (ade)*	*Days per month*	*Monthly exposure (ade)*
MP3 player	91	2	1	10	10
Evening at Pub	100	5	20	4	80
Rock concert	106	3	48	1	48
			Cumulative exposure		138

Over the period of one year the implication is that the cumulative exposure is 1656 ade (138 x 12) and for a ten year period in the order of 16,560 ade.

Now consider the premises on which the noise exposure standards are based [3]. These are based on the acceptability of a risk of hearing loss to a small percentage of the population after exposure to an equivalent, A – weighted, continuous noise level (L_{Aeq}) of 85 dB for eight hours per day ($L_{Aeq,8h}$) for a working life of eight hours per day, five days per week. This assumes that the other sixteen hours per day and further two days per week are spent in comparative quiet, usually less than around 75 dB(A). The usual number of days considered to be working days per year is taken to be around 220 after considering recreation and sick leave and a working life can be considered to be around 40 years. Hence a working lifetime could be considered to be 8,800 days. This sets the acceptable working life exposure to workplace noise at 8,800 ade.

Now compare the acceptable working life noise exposure to the leisure noise exposure presented above. Our leisured individual over a ten year period has sustained an exposure level currently considered to be equivalent to almost two acceptable working life exposures (16560: 8800 or 1.9: 1).

4. DISCUSSION

Given the above comparison of noise exposure levels and the fact that the current recommended exposure standards do not represent a level of zero risk but rather a level of acceptable risk – much like driving on suburban streets with a speed limit of 50 k.p.h. – should we be more serious about the acknowledgement of leisure noise and its affects on society and the individual?

Appendix G from AS/NZS 1269.4 [4] presents a summary of the relative prevalence of expected hearing loss across the community from long term exposure to noise distilled from the more detailed ISO 1999 [3]. Estimating the degree of hearing loss from noise exposure is at best a very difficult process through a multiplicity of considerations and uncertainties in major part due to human factors and variations. Ethical considerations do not offer the opportunity to carry out direct exposure risk experiments on people. However, we are aware these risks exist and that avoidance and exposure minimisation are the best defence.

Exposure to loud noise during leisure is no longer limited to traditional unpleasant or unwanted noise sources such as shooting, power tools and trail bikes. Now, damaging noise can more frequently arise from wanted sound sources such as MP3 players, portable high-powered entertainment amplifiers and modern car stereo systems. Rapidly developing technology has facilitated this evolution and it certainly does not look like slowing down in the near future.

Consequently in a future society where individual and community health is of supreme importance perhaps we will firstly need to provide more consideration to the maintenance of hearing health and secondly develop noise exposure standards that can allow for a reasonable exposure to leisure noise.

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[3] ISO 1999 *Acoustics – Determination of occupational noise exposure and estimation of noise-induced hearing impairment*, International Organisation for Standardisation, Geneva

[4] Australian/New Zealand Standard AS/NZS 1269.4: 2005 Occupational noise management, Part 4: Auditory assessment, Standards Australia, Sydney, 2005

Sustaining Members

The following are Sustaining Members of the Australian Acoustical Society. Full contact details are available from http://www.acoustics.asn.au/sql/sustaining.php

3M AUSTRALIA
www.3m.com

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www.acran.com.au

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NSW DEPT OF ENVIRONMENT & CLIMATE CHANGE
www.environment.nsw.gov.au

PEACE ENGINEERING
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News

RJ Hooker Bursary Announced

A new Queensland Division award was announced at the technical meeting held on 30 July, 2008. The new award, to be known as the RJ Hooker Bursary, in honour of the late Bob Hooker FAAS, was announced to the members by Queensland Division, Vice Chairman Matthew Terlich.

The new bursary extends the existing Queensland Awards program to encompass research conducted in an industrial context in the course of a "professional placement". The bursary will be awarded for a proposed 4th year undergraduate or 1st year postgraduate acoustical research project. To be eligible, the applicant will need to work full time or part-time in industry, with the industrial experience and resulting project report counted towards their overall academic assessment.

A bursary of $1500 in cash will be awarded to the successful applicant.

Submissions for the inaugural RJ Hooker Bursary close: 5.00 pm, Friday, 24 October 2008. Application requirements have been posted at http://www.acoustics.asn.au/general/awards-index.shtml

Noise legislation summary

An IINCE Technical Study Group (TSG3) has been working for some years on the production of a technical report SURVEY OF LEGISLATION, REGULATIONS, AND GUIDELINES FOR CONTROL OF COMMUNITY NOISE. This document is intended to provide a basis for comparison between the approaches to community noise in different countries. Warren Renew from Qld. has been the AAS representative on this international committee. The current version is available for viewing from the AAS website at www.acoustics.asn.au. The voting on the document will be during the IINCE General Assembly meeting to be held in Shanghai on October 26, 2008. Any comments or corrections for this document, or recommendations relating to the Australian vote, should be forwarded to GeneralSecretary@acoustics.asn.au by September 26, 2008 so that Council can brief its representative at this General Assembly.

MSC.Software celebrates 25 years

MSC.Software, previously known as Compumod, is celebrating a quarter of a century of providing consulting services to the Australian engineering market. In that time, their team of engineers has completed over 1,000 projects ranging from the analysis of individual components to assisting in the design of major infrastructure projects and new vehicle designs. Their services in simulation and analysis (consulting) of engineering designs include acoustics and vibration. www.mscsoftware.com.au/services

ACT Draft Noise Policy

The ACT Government Environment Protection Authority has released for public comment the draft Noise Environment Protection Policy (EPP). The Noise EPP was first released in 1998 and this latest draft is a major revision and updating. The Noise EPP is aimed to assist understanding of the ACT Environment Protection Act and Regulation and be consistent with the two EPPs on specific types of noise i.e. Motor Sports Noise and on Outdoor Concert Noise. This draft is available for public comment until 29 September 2008 and is available from the 'Whats New' link at www.tams.act.gov.au/

Hearing safety device wins design award

Hearing technology company Sensear Pty Ltd has won the Medical & Scientific category of the prestigious 2008 Australian International

Design Awards. The company has developed the world's first electronic ear plug for safety which minimises dangerous industrial noise, but allows face to face, mobile phone and two-way radio communication. The Australian International Design Awards, a division of Standards Australia, attracted entries from Australia and overseas. There were 61 finalists. Sensear's innovative product was also recognised as one of the five best in the competition. Sensear's electronic ear plug also won the competition's Powerhouse Museum Design Award. This award, introduced by the Powerhouse Museum in 2007, is given to a product that has potential to make a significant improvement to the quality of health, wellbeing or the environment. It recognises the important role for design in harnessing the challenges of science and technology to make a positive impact on our lives.

Sensear's electronic ear plug is claimed as the world's first communication enabled electronic earplug effective in high noise environments. The SP1 and SP1x (Bluetooth®) earplugs provide easy to use, maximum comfort hearing protection that allows clear communication beyond 85dB(A) via face to face, two-way and mobile phone. The control unit, resembling an MP3 player, can be worn around the neck, or in a pocket.

More information from Sensear Pty Ltd.
Tel: + 61 8 6488 8120
or www.sensear.com

New Managing Director for Pyrotek

Steve Ray has been appointed managing director of Pyrotek, replacing Harvey Chalker, who has moved to Pyrotek Inc, USA. Steve will be based in Sydney and responsible for operations throughout Australia, New Zealand and Indonesia. His plans for the company include boosting customer service, further expansion internationally, development of new products, and consolidating policies to ensure compliance to environmental standards. Originally from England, Steve comes to his new position from a six year posting as managing director of Pyrotek's Sierre plant, Switzerland.

NAL testing facilities

National Acoustics Laboratory (NAL) has terminated the services of its acoustic testing facilities as the Managing Director Anthea Green has stated that 'the demand for services...has declined significantly over the last six months". NAL is currently exploring a range of options including seeking 'expressions of interest from organisations that may be in a position to deliver testing services in collaboration with NAL using the existing infrastructure'. Anyone interested can contact Steve Grundy on 02 9412 6800.

Editors note - The excellent facilities at NAL have offered a range of services including NATA certified testing of building materials and hearing protectors. For the latter it is the only independent facility offering this type of testing in Australia. It is disappointing to see this major independent testing facility required to seek a commercial arrangement or face closure.

Robot clarinet player wins international competition

An Australian robot clarinet player has won first prize at an international competition for robots that play unmodified musical instruments. The annual competition is organised through ARTEMIS (Advanced Research & Technology for EMbedded Intelligence and Systems) – see www.artemisia-association.org/artemis_orchestra

The Australian entry performed 'The Flight of the Bumblebee' and 'Bolero' in the final, beating a Dutch guitar-picking robot and a Finnish piano–playing machine.

John Judge, a senior research engineer at NICTA led the development of the clarinet player. The project team included UNSW computer science and engineering student, Mark Sheahan, who accompanied Judge and the robot to Athens for the competition. Other team members were senior research engineer Peter Chubb from NICTA, Kim Son Dang and Dr Jay Katupitiya from UNSW's School of Mechanical and Manufacturing Engineering, and Jean Geoffroy, Paul Santus, Assoc Prof John Smith and Prof Joe Wolfe from UNSW's School of Physics.

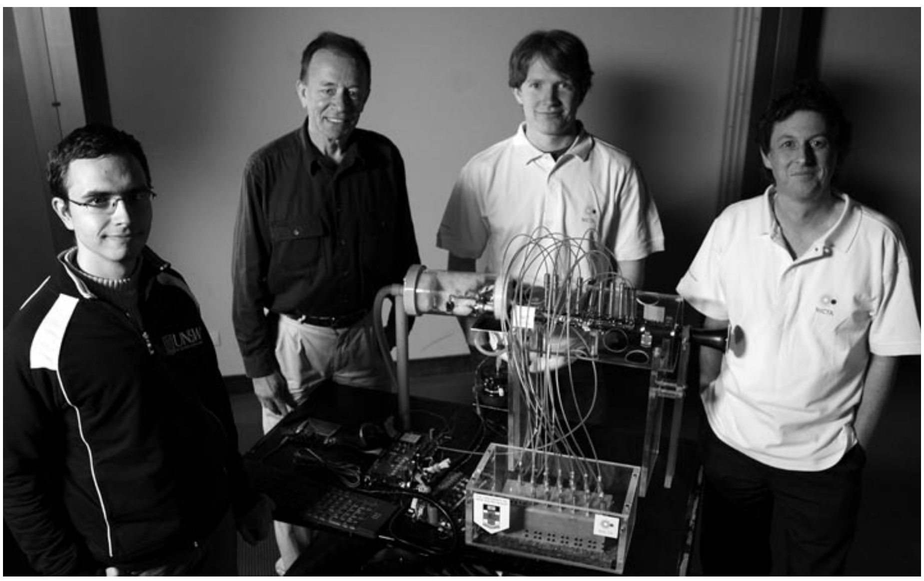
Dr Judge describes the robot as "an embedded computer system connected via specially constructed electronics to actuators that control the keys and mouthpiece of the clarinet".

Researchers at the UNSW's Music Acoustics Lab will use the robot clarinet to understand better the gestures of human players. "It was a big rush to get a robot to play in time for the competition" says Wolfe "and we didn't have time to include a lot of what we know from research on human players. This robot was a beginner with fast fingers. Next year's model will be a much better musician: we'll teach it, and it will teach us about the details of musicianship, too."

A movie and sound files are available on www.phys.unsw.edu.au/music/

Launch of CadnaA Noise Prediction Software

RTA Technology have been appointed distributors of CadnaA in Australia and NZ. CadnaA is designed to handle all major international noise calculation algorithms and



Robo–clarinet and some of its creators: Jean Geoffrey, Joe Wolfe, Mark Sheahan, John Judge (left to right). Photo – Dan Gaffney.

noise mapping requirements. It features one click calculation and presentation quality results. For further information and a quote, please contact

Phillip Mitchell,
02 9281 2222

pmitchell@rtagroup.com.au,

NSW Draft Construction Guidelines

NSW Department of Environment and Climate Change has released the consultation draft of the Construction Noise Guideline. NSW communities are being asked to comment on new guidelines designed to help lessen the impact of noisy building sites on neighbours. Construction noise accounts for almost six per cent of noise complaints to the Environment Line and 10 per cent of calls to local councils. The building industry and local councils have asked for clearer and more detailed advice on how to deal with noise complaints and how to work in a way that avoids them the first place.

This guideline has been developed to focus on applying a range of work practices most suited to minimise construction noise impact, rather than focussing on achieving numeric noise levels. The almost 60 page document has 8 main sections including one on qualitative assessment as well as the anticipated one on quantitative assessment. This draft is out for public comment and anyone with any experience in the topic of controlling noise from construction sites is encouraged to provide comment to the Department.

The proposed guidelines cover matters including:

◊ community notification,

◊ assessing noise levels,

◊ operating plant quietly and efficiently,

◊ handling complaints.

The draft Construction Noise Guideline can be found on the DECC website at http://www.environment.nsw.gov.au/noise/constructnoise.htm or by calling 131 555.

Submissions can be made until Friday 19 September, 2008.

Changes to Queensland Divisional Awards

The Category II bursary, a “book prize” of $150, which is awarded to the most outstanding student in the acoustical component of a relevant undergraduate or 1st year postgraduate degree subject, has been recently extended to include ME3511 *Dynamics and Acoustics* at James Cook University. In 2007 the Category II bursary was extended to include AUDL7800 *Acoustics and Psychoacoustics* at University of Queensland.

The winners of the Category II bursaries for 2007 were Nur Aiza Zaidin (MECH3250 *Engineering Acoustics* at UQ), Lucy Cupitt (MMB413 Industrial Noise and Vibrations at QUT) and Mitchell Davies (AUDL7800 Acoustics and Psychoacoustics at UQ). Nur Aiza and Mitchell’s awards were announced at the 2007 Queensland AGM, while Lucy’s award was made at our April 2008 technical meeting.

Submissions for the existing Acoustic Bursary award close: 5.00 pm, Friday 29 August, 2008. Application details available at http://www.acoustics.asn.au/general/awards-index.shtml

Fantech celebrate 35 years

This year Fantech celebrates 35 years since its birth in 1973 when a Scotsman and a Welshman met up for a quiet drink after a busy week at work. Originally named ‘Air and Noise Equipment Pty Ltd’ by Jack Pirie and Glen Harris, Fantech has now grown up to be a major supplier of ventilation and acoustics products throughout Australia and New Zealand.

See www.fantech,com.au

Soundproofing proven green

The Soundguard range of soundproofing products from Pyrotek has been shown to involve no ozone depleting substances (ODS) or volatile organic compounds (VOC) in their composition or manufacture. This was confirmed recently by evaluations made against the US EPA List of Ozone Depleting Substances (Class 1 and Class 2) and definitions stated under the Australia National Pollutant Inventory, The Council of the European Union, Council Directive 1999/13/EC or the USA EPA regulation 40 CFR 51.100(s). Soundguard products should thus also meet the expectations of ABGR (Australian Building Greenhouse Rating) and GBCA (Green Building Council of Australia) Green Star Rating Scheme EMI-9 (Insulant ODP). See www.soundguard.com.au

New Products

ARL introduce new Vibration Logger

Acoustic Research Laboratories Pty Ltd (ARL) is pleased to announce the addition of a new vibration logger to our hire fleet. The Vibra is a low power ground vibration logger that stores tri-axial measurements of velocity, acceleration and frequency. Powered by three D sized alkaline batteries and enclosed in a pelican case for security reasons, this versatile unit will meet the ground vibration measurement requirements of most users. For further information, contact

Ken Williams:

02 9484 0800.

http://www.acousticresearch.com.au/

Brüel & Kjær introduce new generation of PULSE hardware

Brüel & Kjær presents LAN-XI, their next generation of data acquisition hardware for sound and vibration measurement. It can accommodate from two to more than one thousand channels, with the advantages of detachable front panels and simplified cabling. Extended dynamic range (Dyn–x) and frequency response equalisation (REq–x) are available to improve performance. Brüel & Kjær are offering trade up opportunities to existing PULSE owners.

See http://www.bksv.com.au.

ARL introduce new Sound/ Vibration Measurement System

The RION Multi-Channel Sound/Vibration Measurement System is designed for flexibility, combining units for applications such as acoustic measurements, wide range vibration level measurement or simultaneous monitoring of noise and vibration levels.

Each unit has its own display showing settings, measurement values, operation and transfer of data. An optional Battery Pack Unit is available. For more information, contact

Acoustic Research Laboratories:

02 9484 0800 .

http://www.acousticresearch.com.au/

Meeting Reports

Planning and Noise

On Friday 1 February approximately 30 members attended the first NSW technical session for 2008 which was a breakfast talk given by David Kitto entitled Major Project assessment in NSW - A Department of Planning perspective. It was held at a new venue, the Vibe Hotel at Ruschcutters Bay, where pastries, fruit and a hot breakfast was served. The venue also offers a bar and finger food so in the future we may share talks between NAL and the Vibe. (We will make sure everyone understands the parking arrangements.)

This was one of the most informative talks given in recent years and made me realise that the committee should strike a balance between talks by our acoustic peers and talks by "others". Of course to maintain the quality, this needs the continual suggestions by members of suitable presenters.

While the early morning start may have reduced total numbers compared to the normal evening sessions, everyone who responded showed up. For our evening sessions, there can be quite a high proportion of no shows as the day's work commitments often make it difficult to get away. The society funds the catering at each talk so it is important we do not waste society funds by over catering.

David has been reviewing major projects (mostly mines and quarries) for more years than he cares to remember and over this time has a good understanding of the noise and vibration aspects. His talk focused on the differences between the relatively new part 3A planning process, which has avoided for many projects the requirement to follow a Part 4 or Part 5 process. He also talked about the Independent Hearing and Assessment Panel (IHAP).

The most valuable part of the talk was his personal opinion about the general quality of acoustic assessment and the difficult issues that seem to appear in every project. This included, background noise, low frequency noise, cumulative noise impacts, acquisition criteria, "feasible and reasonable", blasting and the increased need for real time noise monitoring. I am sure that for those who attended, the way they deal with these issues in their next major project will be well appreciated by the DoP and presumably by their clients.

Neil Gross

Expert Evidence and Acoustics

The second AAS Victoria Division technical meeting for 2008 was held on March 4 in the SKM theatrette, Armadale with 21 registered participants. It was a workshop on *Expert Evidence and Acoustics* led by Hugh Selby, a teacher in the Law Faculty at ANU. *Inter alia*, he trains experienced lawyers, police, and law and high school students to become expert witnesses. The main topics covered by this workshop were:

[a] being a comfortable, competent expert witness in a court or tribunal,

[b] preparing a report which teaches and persuades, and

[c] understanding what makes an acoustical report good.

Concerning **court procedure**, Hugh Selby's advice covered the main aspects.

First, expert witnesses need to appear both comfortable and competent in their presentations, and answers to questions. This begins with reading the initial oath or affirmation *slowly* – to gain control over anxiety. Also, witnesses need to be consistent – always either swear *or* affirm; otherwise, they may appear open to compromise. Inconsistency here raises credibility issues, which could adversely tip a 50/50 balance. Expert witnesses are advised to dress appropriately and comfortably. If wearing a tie is not normal, wearing one provides opportunity for nervously fidgeting with it. T-shirts need to be regarded as inappropriate; wearing one could provoke the judge into wondering about a person's eccentricities.

Secondly, expert witnesses have an obligation to the court to explain their professional expertise. *Curricula vitae* need to be customised for the present circumstances. Everything else, including previous court experience, is irrelevant. Decision makers have to be able to trust an expert witness. In the event of an opponent issuing a report critical of a witness' original report, witnesses are advised to write, not merely speak to their lawyers, to establish an appropriate 'paper trail'.

Thirdly, it is a fact of present litigation procedures that they involve, not truth, but winners and losers. In court, a person being questioned needs to look *towards*, but not necessarily *at* the judge, and not at the questioner. This has implications particularly in cross examination, such that witnesses are less likely to be disconcerted or intimidated by a hostile barrister. This is a matter of appropriate and helpful body language.

Fourthly, there are useful ways of "buying time". Sipping from a glass of water provides a momentary pause [even drinking lots of water to get a loo break!]. A useful pause in proceedings can also be gained by asking for a quiet room for repeating calculations. And expert witnesses need never hesitate in asking the judge for permission to refer to a report or notes.

On the matter of **costs**, a client is responsible for the consultant's fee. Expert witnesses [as consultants] are advised to ask for part payment before they complete their investigatory work, or ask for the client's payment into a solicitor's fund or account, but never to make receiving their fee contingent upon the outcome of the court case. They need to ensure that their client is fully aware of what the tests involve, in terms of costs, resources and time. The lawyer's letter commissioning the expert witness' investigations is important; lawyers sometimes need advice on this. Further, *sub poenas* are sometimes issued to protect an unwilling witness. People under *sub poena* are liable to be paid. The procedure includes a prior statement of costs to the legal firm and, in court, a judge's determination of reasonable costs.

On **other aspects** of court procedure, Hugh Selby commented on the court's use of expert reports.

First, a printed report needs an ample margin for the insertion of the lawyer's notes of explanation. These marginal notes are required in the copy given to the judge. So that the Commonwealth Law Reports' [CLR] unique identifier can be used for referring to any part of a report, its paragraphs need to be successively numbered using whole numbers [i.e., without commas, hyphens or full stops]. This identifier provides the [year], CLR report no. and [paragraph no.]: eg, [2000] 200CLR1 at [300]. If a client's report is used in court proceedings, it needs to given under an affidavit. If a report has to be reformatted, both versions are to be included under the affidavit. Since some types of law differ from state to state, the submitting of reports to a court must comply with the appropriate state law.

Secondly, some aspects of using a client's expert report attract Client Legal Privilege. There is a duty of confidentiality in a lawyer/

client discussion. But a 3-way consultation has no privilege if the third person is an expert such as an accountant or engineer, etc. The confidential briefing of an expert witness by a client's lawyers to provide an expert opinion on the matter of the forthcoming court case ordinarily attracts client legal privilege, but not to proposed illegal action. Notes and drafts used in preparing a report do not attract privilege.

Thirdly, expert witnesses are teachers with just one chance to explain their evidence and report to an uninformed audience, and so need to be clear and as simple as possible without trivializing the complex.

Fourthly, a lawyer and expert witness form a team. Most answers in examination and cross examination are a simple yes or no. To answer, "yes, but I can explain," signals the expert's lawyer that further detail needs to be presented in subsequent examination. A cross examiner works to show this evidence in a bad light. Advice to witnesses is never to be nasty in cross examination until the benefits of being nice are exhausted! In a court, only a judge can instruct.

Fifthly, concerning reports, reversals of opinion or conclusion become a final conclusion, with the earlier opinions constituting a stage in reaching the final conclusion. A statement such as "the earlier conclusion seemed right at the time, but more recent work has shown it to be contradicted by the later evidence," confirms that the earlier evidence no longer has weight.

Sixthly, it is considered highly advisable to keep reports and associated documentation for at least six years, as they are the record of work done, and hence the basis of payment for it.

The final section of the workshop was concerned with the more detailed aspects of **writing expert reports**. As an example for the discussion, a poorly written sample report containing 42 inconsistencies and errors was studied in some detail. This study also revealed a further error in a precise technical term [traffic flow] being incorrectly named [traffic density]. It also showed that expert witnesses who write reports containing such errors and inconsistencies readily leave themselves wide open to ridicule on cross examination, and so lose all credibility as to their assumed expertise.

A more general point in writing reports was that expert witnesses must always recognize the weakest point in their argument before others do. In asking the questions "how is this vulnerability to be treated?" and "need such a weakness be disclosed?" the advice was that the weaker points are better disclosed, and inserted in the middle of the report surrounded by the stronger points.

This report of the workshop has highlighted the various matters raised by Hugh Selby in his presentation. He also issued a set of Course Notes which treated these and related matters in rather greater detail. The points raised here have been included to show that it was a most informative and interesting workshop, and that those who registered and attended derived good value for money.

At the conclusion, Victoria Division chairman Norm Broner thanked Hugh Selby, a sentiment with which all present enthusiastically concurred. *Louis Fouvy*

Effects of hearing impairment

This NSW Technical Meeting was held on June 11, 2008 Dr.Virginia Best presented an informative and interesting presentation entitled: *"Effects of hearing impairment on selective and divided listening in speech mixtures"*

Listeners with sensorineural hearing loss have great difficulty understanding speech in attentionally demanding listening environments. This presentation gave an overview of two psychophysical studies conducted at Boston University that aimed to explore the sources of this difficulty. Critical aspects of the experimental approach were (a) the use of realistic sound stimuli and (b) the comparison of performance in listeners with hearing loss to those with normal hearing.

The first study addressed whether hearing loss influences a listener's ability to make use of top-down attention. Listeners were presented with a speech mixture and their task was to report back a target sequence that was embedded amongst Interferers. In different conditions, simple visual cues indicated when and/or where the target would occur. The visual cues provided no information about target content, but enhanced target intelligibility by enabling listeners to focus their attention to the appropriate location and/or point in time. Listeners with hearing loss received a benefit from both kinds of visual cue, but the magnitude of the spatial-cue benefit was significantly smaller than in listeners with normal hearing. Reduced utility of selective attention for resolving competition between simultaneous sounds may impact the ability of listeners with hearing loss to understand a sound of interest (such as a friend's voice at a noisy cocktail party).

The second study examined the impact of hearing loss on divided listening. Listeners were presented with two spoken messages (one to each ear) and were required to respond to just one message ('selective task') or to both ('divided task'). Listeners with hearing loss showed a small deficit in the selective task relative to listeners with normal hearing, and a large deficit in the divided task primarily due to poor recall of the second message. Their pattern of performance was similar to that of the normal-hearing group listening at lower signal-to-noise ratios. The impact of hearing loss and noise on divided listening may be partly explained by disruptions to a temporary sensory trace that is used to deal with simultaneous inputs. The results have implications for communicating in dynamic listening situations (such as a conversation between several different people).

Dr Best completed her PhD in Sydney before moving to the USA for four years to work at Boston University's Hearing Research Centre. She recently returned home to take up a Research Fellowship at the University of Sydney. *Donald Woolford MAAS*

Dr Virgina Best

ICBEN2008 – Noise as a Public Health Problem

The 9th International Congress of the International Commission on Biological Effects of Noise was held in Connecticut, USA from 21 - 25 July, 2008, and was attended by around 200 of the top people involved in research and policy development in the area of noise effects. As usual, attendees were given in-depth reviews of current and recent research, discussion papers on issues relevant to policy development, and recent developments in community education, amongst much else. Some highlights included:

- Ageing is a more significant factor in the hearing loss of older people than noise exposure, but noise exposure is controllable
- The Dangerous Decibels program, which aims to educate children about the dangers of excessive noise exposure. Check out Jolene, a "visually intriguing sound level measuring system", at www.dangerousdecibels.org
- Links between occupational noise levels and risk of fatal accidents
- HYENA - a four-year environment and health study which has found links between hypertension and environmental noise exposure
- Recent studies of the disturbance caused by aircraft noise have shown levels of community annoyance that are consistently higher than the recent (1998) dose-response curves. There was speculation that this may be due to the fact that aircraft are quieter, so that more aircraft fly-overs are necessary to achieve the same Lden
- If an airport night-time curfew can not be applied to the entire night, a short curfew at the end of the night will do more to improve sleep quality than one imposed at the start
- Informal discussion regarding difficulties at the World Health Organisation, particularly with regard to preparing (and releasing) the proposed Night Noise Guidelines
- Most fish's ears are velocity sensors (accelerometers) rather than pressure sensors
- The twelve-course banquet (of course).

The ICBEN Congress has been held every five years, but a decision was made by the ICBEN executive to hold congresses every three years from now on. The next congress will be in London, England, in 2011. The CBEN website is at www.icben.org. *Neil Huybregts*

Acoustics 08

The Palais de Congres, just on the edge of central Paris was the venue for Acoustics 08, from 29 June to 4 July. This event was a combination of the 155th meeting of the Acoustical Society of America, 5th Forum Acusticum of the EAA. 9th Congres Francais d'acousticque of the SFA as well as 7th Euronoise and 9th European conference on Underwater Acoustics. With the combination of all these events it was anticipated that it would be large, but the success was quite overwhelming for the organisers. With over 3,000 papers the program was a challenge, but the committee resolved this by arranging up to 25 parallel sessions and starting early and continuing till quite late. Of course there was a good break in the middle of the day to enjoy some French cuisine. The total number of registrations exceeded 5,000; this is including day and accompanying registrations. The technical exhibition comprised over 60 booths. The entertainment at the opening was 'live virtual and visual music' composed and presented with the 'meta instrument'. This is a large backpack worn by the performer with 54 controls on fingers, arms, body etc to use in the production and control of sound.

Such a large conference surely has many pluses but also some minuses. Overall, the technical committee did a wonderful job allocating the papers to the sessions. Those interested in one main topic stream did not have to move far from their room. Those seeking to dip into different topic streams were rather more challenged. Although all papers, except the plenary, were 20 mins, the sessions started and stopped at different times. With so many parallel sessions, and the program book listing them alphabetically for each day, it was not easy to work through to find the papers of interest in the traditional way. It was also interesting to note the limitations of the computer based displays designed to assist finding the paper and the room. I also encountered problems using it from a lack of familiarity with the layout of the French AZERTY keyboard. A nice feature, however, was the possibility to search the programme on the web, and to construct and to print one's own schedule.

After some confusion on the first day, we soon become used to the layout of the rooms. The audio visual aids worked well in all rooms as did the self-loading of the presentations. As is often the case in conference centres, the acoustics in most of the rooms was poor, so we had the sad spectacle, repeated many times, of groups of fewer than a hundred people being forced to rely on microphones to be heard! Ironic when the people involved were acousticians.

The technical committees of each section offered a prize to the best student presentation. An Australian PhD student, Jer Ming Chen, won the award in Music Acoustics for a paper entitled "How to play the first bar of *Rhapsody in Blue*".

I am sure that all came away from the experience with some new insights into their areas of interest in acoustics. And it was particularly interesting to note that over 800 were still around till 1940 on Friday evening for the closing party. There was a good contingent of Australian acousticians – many obviously balancing the participation in the conference with the draw of the highlights of Paris just a metro trip away. *Marion Burgess*

Marion extols the virtues of participating in an Australian Conference to potential delegates at the ICA2010 booth at Acoustics 08 in Paris.

This is the tenth in a series of regular items in the lead up to ICA in Sydney in August 2010.

The planning for ICA 2010 has moved another step forward following the report to the ICA Board Meeting in June in Paris. The board was complimentary about the progress to date and only had some minor questions, which were easily answered.

The organising committee is concerned about financial matters and in particular the impact of the weakening of the US$ against the Aust $ this year and consequent effect of increasing the costs for those traveling from US. The increasing costs of airline fuel and air fares also has the potential for an impact on overall attendance. However, our goal continues to be to provide an outstanding congress in acoustics in Sydney.

The time of Acoustics 08 in Paris was an opportunity for the organisers of two associated symposia, one on musical acoustics and the other on room acoustics, to meet with colleagues and to discuss how best to organize these events in conjunction with the main ICA. New Zealand will soon be developing plans for the associated meeting on sustainability. Recently Singapore has expressed an interest in organising a symposium on nonlinear acoustics. Laura Allison, from Bassett's Sydney office has now joined the committee in the role of liaison officer for these associated meetings.

Acoustics 08 in Paris was an excellent opportunity to promote ICA2010 and we are grateful for the provision of a complimentary booth well located not far from a coffee station. The little koalas continue to be a draw to the stand and provide the opportunity to encourage travel to Sydney in 2010. We also participated in the closing party with samples of Australian wine plus tasting of Vegemite! Even though there was plenty of French wine the Australian wine was extremely popular and our supply (purchased from local supermarkets!) soon was depleted.

More information on the conference will soon be added to the web page: **www.ica2010sydney.org**

Marion Burgess, Chair ICA 2010

Future Meetings

AIPC2008

The 18th National Conference of the Australian Institute of Physics will be held from 30 Nov to 5 Dec 2008 in Adelaide. This is an important multidisciplinary conference and offers a friendly platform for exchanging new ideas and results.

The conference venue is within easy walking distance of the Central Business District and the environs of Adelaide offer a selection of Australian experiences, including beaches, winery tours and wildlife parks and sanctuaries.

The AIPC2008 topic areas include Acoustics, Music and Ultrasonics, Astronomy, Atomic & Molecular Physics, Synchrotron Studies, Biomedical Physics, Complex Systems, Computational and Mathematical Physics Condensed Matter, Materials and Surface Physics Education Environmental Physics Geophysics History for Physics Meteorology, Climate Change and Oceanography Nuclear and Particle Physics Optics, Photonics and Lasers Plasma Science Quantum Information, Concepts and Coherence Group Relativity and Gravitation Renewable Energy Solar Terrestrial and Space Physics Women in Physics Quantum Information, Concepts and Coherence Group.

For the first time the section Acoustics and Music has been extended to Ultrasonics. The first Keynote Speaker will be Prof Neville Fletcher whose background ranges from musical and linear acoustics to condensed matter physics.

For more information see
http://www.aipc2008.com/

ICSV16

The Sixteenth International Congress on Sound and Vibration (ICSV16), will be held in Krakow, Poland, 5-9 July, 2009, in cooperation with the International Union of Theoretical and Applied Mechanics (IUTAM), the American Society of Mechanical Engineers International (ASME International), and the Institution of Mechanical Engineers (IMechE).

Theoretical and experimental research papers in the fields of acoustics, noise and vibration are invited for presentation. Companies are invited to take part in the ICSV16 Exhibition and sponsoring.

Krakow has traditionally been one of the leading centres of Polish scientific, cultural and artistic life. The intellectual potential of Krakow is created by 22 universities, nearly 20,000 academic lecturers and 190,000 students. As the former capital of Poland with a history encompassing over a thousand years, the city remains the spiritual heart of Poland. It is a major attraction for local and international tourists and Krakow's historic centre is a UNESCO World Heritage Site.

Deadline for proposals for structured sessions and workshops: 1 November, 2008.

Deadline for submission of abstracts:
1 December, 2008.

WIND TURBINE NOISE 2009

The third conference on Wind Turbine Noise will be held at the Hotel Hvide Hus, Aalborg, Denmark from 17 – 19 June, 2009.

Wind Turbine Noise 2005, the first in this series of international conferences, took place in Berlin in 2005 and was a great success, bringing together 130 delegates from 22 countries. The second WTN conference took place in Lyon, France in 2007 with more than 150 delegates from 24 countries representing manufacturers, developers, researchers in noise and vibration, environmentalists, pressure groups and consultants.

The third conference in the series will once again provide a venue for all those with an interest in wind turbine noise, and its effects on people, to meet together and also meet with those who design wind turbine installations, both in industry and in the planning process.

Offers of papers for this conference are invited and prospective authors should send a 200-word abstract by 28 February, 2009 to organiser@windturbinenoise2009.org

NOVEM 2009

Noise and Vibration: Emerging Methods' will be held at Keble College, Oxford, 5-8 April 2009. The third in the NOVEM series, the conference will bring together researchers working in the areas of noise and vibration. Information is available at http://www.isvr.soton.ac.uk/novem2009/index.htm.

FASTS

Risk-Aware Research Workshop

Following discussion with colleagues here at UNSW@ADFA and having expressed an interest to attend the workshop, I was pleased to be registered as the AAS representative at the Policy Workshop supported by FASTS and focused on the emerging issue of "*Supporting risk-aware research*" from 09.00 to 17.00 on 11 July at the Members Dining Room of the Old Parliament House, Canberra.

For me, the notion of research embodies an element of risk (we are, after all, exploring the unknown to some extent or another) so it was surprising to encounter such a high-powered group (some 60+ attendants from throughout the country with representatives from almost all national science organizations), devoting so much time and energy to this issue.

In the event, after a day which included some 15 presentations (all to a consistently high standard) from academia, FASTS, Research Councils, CSIRO, the Australian Centre for Innovation and the commercial and industrial sectors, along with numerous discussion/question/exchange sessions, I have to agree that, yes, this is an important issue with ramifications for funding, opportunities and career developments, as well as the overall concepts of efficiencies and value for research money. Embodied in several presentations was the notion that prosecution of a system which did not actually generate the odd research failure probably meant we were being over-cautious in our outlook.

It is impossible to present even a flavour of the diverse aspects of Risk-Aware Research covered at the Workshop in a brief report such as this; rather I will refer and encourage interested persons to consult the details available online at http://repp.anu.edu.au/ripp/risk/. There they will find not just details of the workshop programme, activities and speakers, but many of the presentations which are already available for downloading (with the prospect of most, if not all presentations being posted on the website).

The key players and organisers are actively preparing a Workshop Report in the hope, I think, that it will be considered within the ambit of the wide ranging review of Australia's national innovation system announced by Senator Kim Carr the Minister for Innovation, Industry, Science and Research. Time is short with a Green Paper notionally due to be produced by the review panel by the end of July 2008.

An important topic, which formed part of the opening and closing addresses by FASTS President Ken Baldwin, was to explore the merits of a 'taxonomy' of risk in research. I shall conclude this report with the draft list introduced by Ken: Transformative Risk; Capacity Risk; Failure Risk; Precedence Risk; Regulatory Risk. A further suggestion - Collaborative Risk - proposed by Stewart Campbell during questions and developed by Gabrielle Bammer (ANU) in her presentation, was also included in the closing remarks.

Overall I found this to be a very interesting workshop which incorporated a great deal of high quality information and insight to the operation of, not just risk-aware research, but research in Australia as a whole. As a closing remark, I encourage researchers to keep a weather eye on their website http://repp.anu.edu.au/ripp/risk/, both to explore the workshop presentations as they are added, and to digest the final report when it becomes available.

Stewart Campbell,
Emeritus Professor,
UNSW@ADFA

Standards Australia

Standards Australia has spent some time investigating its operations. In part this was an outcome of the 2006 Productivity Commission which identified areas where the work conducted by Standards Australia had been marginalised by inefficient processes. The new business model for Standards Australia aims to "focus and invest resources where they can add the maximum amount of net benefit to the Australian community."

The CEO, John Tucker, states "Under our new model, stakeholders and the relevant 'communities of interest' will be responsible for identifying and articulating their issues that require solutions. These stakeholders can choose to work with Standards Australia through an enhanced range of pathways, products and services or may elect to pursue other options to resolve issues. At the core of our new model is the concept of Net Benefit – the idea that the outcomes of each and every Standards project must outweigh the costs and impacts of implementation and are of benefit to the community at large. Where an Australian Standard is sought, or where we seek input, alignment or adoption of an international ISO or IEC Standard, the Net Benefit arising from the development and implementation of the Standard must first be established."

This new model of operation should be in operation by October 2008 – for more details see www.standards.org.au/

Obituary

PETER DAVIES

4 October 1922 – 14 February 2008

Professor P. O. A. L. Davies was born in Sydney and educated at Canberra Grammar School and Sydney University where he graduated in 1947 with first class honours in Mechanical and Chemical Engineering. His education was interrupted by service in the RAAF from 1941 to 1945. In 1948 he traveled to Cambridge University for his PhD research on hydrodynamics. On return to Australia he held the appointment of Lecturer, then Senior Lecturer, in Fluid Mechanics at Adelaide University from 1950 to 1956.

Peter returned to the UK in 1956 as a Senior Research Fellow in Aeronautics at Southampton University. In 1963 he was a founding member of the Institute of Sound and Vibration Research (ISVR), which became Peter's permanent professional home, even after his retirement in 1988. His research interests in a distinguished career included turbulent shear flows, free turbulence, sound propagation in discontinuous flow ducts, sound generation by coupled flow acoustic effects and source identification.

Peter remained a keen musician throughout his life, playing bassoon and contrabassoon in many local chamber groups and orchestras.

Adapted from Acoustics Bulletin

ACOUSTIC ENGINEERS

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Norman Disney & Young is a leading multi-discipline consulting engineering firm that delivers quality engineering service solutions within Australia, New Zealand, the United Kingdom and Asia.

NDY Sound is seeking Acoustic Engineers at a variety of levels in our established practices in Sydney, Melbourne, Perth, Canberra, Adelaide and Auckland, and is looking for staff to assist in establishing and growing NDY Sound within Norman Disney & Young's office in Brisbane.

Norman Disney & Young is one of Australia's largest Building Services Consultancies, with a considerable presence in New Zealand and the UK. The firm is commonly owned across all regions which promotes investment and sharing of our people, processes and intellectual property.

The company has an enviable record of professionalism and innovation which allows NDY to consistently deliver a range of highly specialised services to our clients.

NDY Sound is now established in Australia, UK and New Zealand and has successfully completed high profile projects such as:

- ❑ The Australian Film Television and Radio School (AFTRS), Sydney
- ❑ Macquarie Bank Fitout, Sydney
- ❑ The University of Sydney Acoustic Laboratory

Our expanding recognition in the market place provides significant opportunities for talented staff who are willing and able to contribute to that ongoing success.

We are currently seeking the following staff:

- ❑ Managers: Acoustic consultants with proven abilities to market Acoustic Consulting Services, manage a team of acoustic engineers and provide competent advice to our clients.
- ❑ Senior Acoustic Consultants: Acoustic Consultants who have established track records and a minimum of five years experience.
- ❑ Acoustic Consultants: Acoustic Consultants who have established track records and a minimum of three years experience.

Successful applicants will need to demonstrate the following:

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An engineering degree together with experience as an Acoustic Consultant and/or post graduate education in Acoustics. Alternative appropriate qualifications will be considered.

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Positions are available for specialists in the following fields:

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James Henshaw – Director / Manager NSW
Email: j.henshaw@ndy.com
or Olivier Gaussen – Manager / NDY Sound NSW
Email: o.gaussen@ndy.com

NDY Sound
Norman Disney & Young
Level 1 / 60 Miller Street
North Sydney NSW 2060

www.ndy.com

NORMAN DISNEY & YOUNG

Diary

2008

22 – 26 September, Brisbane
INTERSPEECH 2008 - 10th International Conference on Spoken Language Processing (ICSLP).
www.interspeech2008.org

21 – 23 October, Tokyo
The 13th International Conference on Low Frequency Noise and Vibration
www.lowfrequency2008.org

26 – 29 October, Shanghai
INTER–NOISE 2008
www.internoise2008.org

10 – 14 November, Miami
156th Meeting of the Acoustical Society of America
http://asa.aip.org/meetings.html

24 – 26 November, Geelong
Australian Acoustics Society National Conference
'Acoustics and Sustainability'
http://www.acoustics.asn.au/conference-link.shtml

2009

4 – 6 January, Cairo
Advanced Materials for Application in Acoustics and Vibration (AMAAV)
www.amaav.org

5 – 8 April, Oxford
NOVEM 2009, Noise and Vibration: Emerging Methods
http://www.isvr.soton.ac.uk/novem2009/index.htm.

18 – 22 May, Portland
157th Meeting of the Acoustical Society of America
http://asa.aip.org/meetings.html

17 – 19 June, Aalborg
3rd International Conference on Wind Turbine Noise
http://www.windturbinenoise2009.org

5 – 9 July, Krakow
ICSV16: 16th International Congress on Sound and Vibration.
http://www.icsv16.org

23 – 28 August, Ottawa
INTER–NOISE 2009
http://www.internoise2009.com

6 – 10 September, Brighton
Interspeech 2009
http://www.interspeech2009.org

2010

13 – 16 June, Lisbon
INTER–NOISE 2010
http://www.internoise2010.org

23 – 27 August, Sydney
ICA2010
http://www.ica2010sydney.org

26 – 30 September, Makuhari
Interspeech 2010 - ICSLP.
http://www.interspeech2010.org

2011

27 June – 1 July, Aalborg
Forum Acusticum 2011
http://www.fa2011.org

Meeting dates can change so please ensure you check the www pages. Meeting Calendars are available on http://www.icacommission.org/calendar.html

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Thomas Cockings (NSW)
Salvatore Demasi (NSW)
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* Payment of annual subscription
* Proceedings of annual conferences

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