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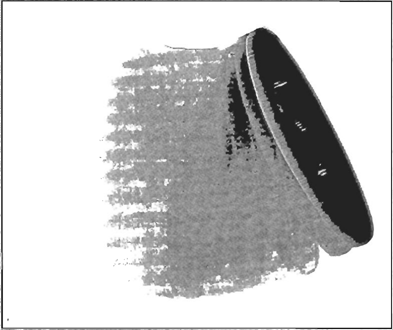

- Blue Whale Calls
- Aboriginal Musical Instruments
- Ring of Bell Plates
- Performance of Hearing Protectors
- Top Ten Issues in Acoustics

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CONTENTS

Cover illustration: Image of bullroarer— see paper by Fletcher.

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From the President

With this issue of the journal is enclosed a 'Member Survey' which is also available on the Society web page, www.acoustics.asn.au. Please fill it in and send it to the General Secretary. It is important for planning the priorities for the society.

WESPAC8 was most successful due to the outstanding efforts of Charles Don and his committee. The Australian Acoustical Society sponsored this international conference at which over 200 papers were presented, covering a very wide range of topics. For the titles of papers presented, to see what you missed if you didn't go, and the details on how to purchase the CD of the proceedings follow the links on the Society web page.

Membership has remained stagnant for the last decade. We gain a few and loose a few each year. The average member age is increasing. There are many new faces practising acoustics, but they are not all members. Do you utilise your membership fully? Do you actively meet with your colleagues? Is there someone working with you who would benefit from membership?

Last year Charles Don stated "Each Division is powered by a group of individuals who continuously strive to introduce innovative technical meetings and stimulating conferences, as well as providing a social environment for its members. But a strong Society needs more than the dedicated few. Every member should try, at least occasionally, to take some role in Society activities. Encourage associates to join the Society, attend at least one or two meetings each year, contribute papers or news items to conferences or Acoustics Australia, and even volunteer to join Divisional Committees. Your involvement can help keep our Society from fading away due to lack of interest." This quote remains true.

To further streamline the membership process there is now a $25 application fee and annual fees are due on acceptance, except for students who are granted one years membership free. Full fee paying Non-members attending the Annual Conference will be given one year membership at subscriber level.

For further details I urge you to read the summaries of Top Ten Issues in Acoustics and Strategic Planning for the Society included in this issue of the journal or download the full documents from the society webpage (you can find the location from the Site Contents page). Please provide feedback to any committee member, State Division or Federal Council (all their contact details are also on the www).

Ken Mikl

PS Fill in the Survey.

OBSERVATIONS AND EXPLANATION OF LOW FREQUENCY CLICKS IN BLUE WHALE CALLS

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This paper is based on the 2002 PRESIDENT'S PRIZE paper. This prize, established in 1990 by the Australian Acoustical Society, is awarded to the best technical paper presented at the Australian Acoustical Society Conference.

ABSTRACT: A brief study has been conducted on the low frequency "clicks" and tones observed in calls recorded in recent years from Blue Whale aggregations at locations off the Rottnest trench. As has been suggested previously, it is concluded that the 20 Hz clicks most likely are the self-excitation of the bubble resonance of the gas within the lungs by the whale. This is probable, as the click waveform has the appearance of the decay of a resonance, and as there are no other conceivable mechanisms which might give rise to a resonance within a whale body at 20 Hz. This is explained with recourse to bubble physics, which are extended to include a treatment of both spherical and elongated bubbles, and to considerations of the effects of various depths at which a whale might call. The amplitude of the bubble oscillations required to generate the observed signal levels is shown to be surprisingly large, and appears to be close to the theoretical maximum for a resonant bubble driven by any means.

1 INTRODUCTION

Recordings of calls from Blue Whales (*Balaenoptera musculus*) are known to include low frequency components which may be tonal or impulsive "clicks"[1-5]. The signals are noteworthy for the high levels achieved (up to 190 dB re (1 μPa)^2 @ 1 m) at a low frequency range (centred about 20 Hz[1-5]). These features have been observed in Blue Whale calls recorded in recent years at locations off the Perth Canyon[5]. These observations are of interest to the Royal Australian Navy (RAN) as, firstly, causes of ocean ambient noise need be understood in relation to interference to the operation of passive sonar systems, and, secondly, it is desirable for RAN vessels to be aware of the proximity of Blue Whales and other marine mammals so that suitable separation distances may be achieved. This paper reports a brief study of low frequency 'clicks' observed in Blue Whale calls and investigates the mechanism by which these signals are generated. It has been suggested previously[2], that an air-filled resonator is likely to be the source and it is concluded here that the 20 Hz clicks most likely are the self-excitation of the ensemble gas bubble within the lungs by the whale. This is explained with recourse to bubble physics, which are extended to include a treatment of both spherical and elongated bubbles, and to considerations of the effects of various depths at which a whale might call. As is shown, the amplitude of the bubble oscillations required to generate the observed signal levels is surprisingly large.

1.1 MARITIME FAUNA INTEREST

At present, there is an increasing interest within the Australian Defence Force (ADF), and within defence forces internationally, in the welfare of the maritime environment. In particular, it is a desire of the ADF that it has the capability to conduct its maritime operations and maintain its related equipment in an environmentally responsible manner both within Australian waters and worldwide. The Environmental Protection and Biodiversity Conservation (EPBC) Act 1999 came into effect on 16 July 2000. This Act places requirements on the Department of Defence in regard to actions which are likely to have a significant impact on the environment anywhere in the world. For this reason, the Directorate of Environmental Stewardship has a requirement that relevant phenomena are investigated and essential principles are established. In the area of Defence maritime operations, relevant issues include the radiation of acoustic energy, particularly in regard to sensor and communication systems, and all relevant issues affecting the knowledge of the seasonal and diurnal distribution of marine fauna, and the susceptibility of marine fauna. Maritime Operations Division (MOD) is providing support to the ADF by providing scientific guidance and advice in these areas.

With reference to RAN activity within the West Australian Exercise Area (WAXA), the presence of Blue whales and Pygmy Blue whales (*Balaenoptera musculus brevicauda*) is of strong interest as the species are listed as "endangered" under the EPBC. MOD is providing scientific support to the Blue whale study funded by the Defence Materiel Organisation[6].

2 OBSERVATIONS OF BLUE WHALE CLICKS

A considerable body of knowledge exists concerning Blue Whale vocalisations. For example, Thode et al[4] report tonals at harmonically-related frequencies of 16 Hz (Source Level (*SL*) up to about 175 dB line level re (1 μPa)^2 at 1 m), 32 Hz (*SL* up to about 168 dB line level), 50 Hz (*SL* up to about 170 dB line level) and 67 Hz (*SL* up to about 160 dB line level). Thode et al suggest that an air-bubble type resonator within the animal may be the cause of the observed sounds, but suggest that the observed variation of frequency with depth of the animal (frequency proportional to depth squared) does not closely match the expectation for a bubble which is allowed to collapse with depth (frequency linearly proportional to depth).

Aburto et al[3] report tonals at 17 Hz with *SL* in the range 195 dB line level re (1 μPa)^2. Like Thode et al, Aburto et al report that the 17 Hz tonals are accompanied by higher harmonics of lower amplitude. Aburto et al report whale depth as nominally 30 m.

McCauley et al[5] have observed signals similar to those reported by Aburto et al and Thode et al, as shown in Figure 1. These show a tonal of extended duration at about 20 Hz, with higher harmonics at lower amplitude. McCauley et al have also observed "click" waveforms which consist of the decay of a tonal at about 20 Hz. An example of three consecutive 'clicks' from three different sources, is shown in Figure 2. The frequency spectra of these 'clicks' are shown on Figure 3. As the decay has a duration of about 0.75 seconds, and as the frequency is about 20 Hz, the quality factor Q for the oscillation is about 15.

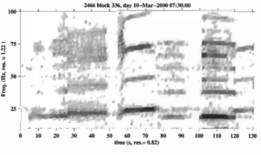

Figure 1: Spectrogram of Blue Whale call observed in the Perth Canyon. The 'call' is made up of three units, the first over 5–48 s, the second over 55–77 s and the third over 100–120 s. Distant calling whales are present in the background.

All of the observations reported above are consistent with the existence of a fundamental bubble resonance existing within the whale and with this resonance being intentionally excited by the animal to create a strong signal. The time series shown in Figure 2 are indicative of resonant decay of an oscillator, and the spectrogram shown in Figure 1 is indicative of non-linear radiation at a fundamental and harmonics. It is suggested that the harmonics of the base tone near 20 Hz result from the bubble resonance being driven to high amplitude levels.

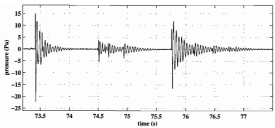

Figure 2: Time series of Blue Whale 'clicks' observed in the Perth Canyon. Using a variant of a method described by Cato (1998) for utilising multipath signals, the first 'click' was estimated to come from an animal at 2160 m horizontal range from the receiver and 260 m depth and the third signal from an animal at 805 m range and 200 m depth.

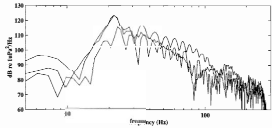

Figure 3: Power spectra of the three 'clicks' shown in Figure 2.

A bubble resonance is the most likely explanation for these observations as there are no other conceivable mechanisms which might give rise to a resonance within a whale body at about 20 Hz. At this frequency the wavelength is 75 m. With an average Blue Whale body length of about 25 m, and diameter no greater than about 5 m, a distributed impedance resonant device is unlikely and a lumped element device almost certainly is the cause. The latter may be formed by a summation of the air within the lungs of the whale, acting as a compliance, and the surrounding body tissue and/or water in the ocean as an inertance.

3 BUBBLE PHYSICS

A gas bubble contained underwater will have a single mode of resonance at a frequency for which the inertance of the effective surrounding mass (of whale tissue and water) is matched to the compliance of the gas within the bubble. For spherical bubbles in water, the frequency of resonance f_r of the air bubble is given by

$$f_r = \frac{1}{2\pi r_s}\sqrt{\frac{3\gamma P}{\rho_w}}. \qquad (1)$$

where r_s radius of gas bubble, m

γ ratio of specific heats for gas in bubble (γ = 1.4 for air)

P hydrostatic pressure, Pa

ρ_w density of water/body tissue surrounding the bubble, kg m^{-3}

This is the same as the equation in Urick, page 251[7], equations (7.55) and (10.14) of Kinsler et al[8], and corresponds with the expression given by Sims[9]. Based on equation (1), combinations of resonant frequency, bubble radius and operating depth are shown in Table 1.

Table 1: Diameter of a spherical air-filled bubble for resonance frequency and operating depth (shading indicates source at shallow depth, depth in wavelengths, λ)

Operating depth d (m)	resonance frequency f_r (Hz) 10	20	50	100	200	500
1	0.678 m 0.0067λ	0.338 m 0.013λ	0.136 m 0.033λ	0.068 m 0.067λ	0.034 m 0.133λ	0.0136 m
2	0.708 m 0.013λ	0.354 m 0.027λ	0.142 m 0.067λ	0.070 m 0.133λ	0.036 m	0.0142 m
5	0.792 m 0.033λ	0.396 m 0.067λ	0.158 m 0.167λ	0.078 m	0.040 m	0.0158 m
10	0.914 m 0.067λ	0.456 m 0.133λ	0.182 m	0.092 m	0.046 m	0.0182 m
18	1.080 m 0.120λ	0.540 m	0.216 m	0.108 m	0.054 m	0.022 m
30	1.292 m 0.20λ	0.646 m	0.258 m	0.1292 m	0.064 m	0.026 m
50	1.582 m	0.790 m	0.316 m	0.158 m	0.078 m	0.032 m
80	1.938 m	0.968 m	0.388 m	0.194 m	0.096 m	0.038 m
120	2.328 m	1.164 m	0.466 m	0.232 m	0.116 m	0.046 m

The shading in Table 1 identifies bubbles which are located at a depth less than ¼λ. This is significant as the resistive part of the radiation impedance, for a constant volume velocity source, has a depth dependence, and hence the maximum possible radiated sound power will also be depth dependent (eg. Section 4.1.4 of Brekhovskikh and Lysanov[10]). The radiation of sound from a small source of constant volume velocity, at shallow depth, d, may be considered as from a dipole composed of two small sources each of the same strength. Here[10], the acoustic pressure release at the ocean surface gives rise to a reflection which may be considered to come from an anti-phased image source. The ratio, x, of the sound power radiated into the water by the dipole source, to the sound power radiated by a source at infinite depth may be shown to be (eg. equation 4.1.24 of Brekhovskikh and Lysanov[10])

$$x = 1 - \frac{\sin(2k\,d)}{2k\,d} \approx \frac{8\pi^2}{3}\left(\frac{d}{\lambda}\right)^2 \quad \text{for sources very close to the surface.} \qquad (2)$$

where k is the acoustic wavenumber (radian frequency/speed of sound in seawater, in m^{-1}).

For non-spherical bubbles, different but similar expressions for resonance frequency will apply. For example, the frequency of resonance f_r for a cylindrical air bubble of radius r_c m and long length, contained within water/tissue was derived by the lead author as

$$f_r = \frac{1}{2\pi\, r_c}\sqrt{\frac{2\gamma\, P}{\rho_w\left(-\ln[k r_c]\right)}} \approx \frac{1}{2\pi\, r_c}\sqrt{\frac{2\gamma\, P}{5\rho_w}}. \qquad (3)$$

This was obtained by, first, deriving the radiation impedance of a cylinder from cylindrical radiation functions and, then, finding the frequency at which the inductive impedance component, per unit length of cylinder, cancelled the capacitive impedance component of the gas in the cylinder. Equation (3) is similar to a generalised expression derived by Zhang[11].

At a given depth, it may be surmised that an animal may exhibit some control over the shape of the ensemble bubble, and thus vary the resonance frequency. For example, it is conceivable that an ellipsoidal bubble might be formed – the expression for a cylindrical bubble then representing an extreme case of elongation. If such an elongation occurs for a given mass of gas, the cylindrical radius r_c must of necessity be much less than the radius of the sphere r_s. In the limit of a very long cylinder being formed there will then be an increase in the resonance frequency of the bubble.

3.1 DEPTH DEPENDENCE

The data shown in Table 1 do not relate to a bubble formed by a single breath taken at the ocean surface. We may arrive at an expression for the variation of resonance frequency f_r with depth d for a given mass of air m taken at the surface by substituting for spherical bubble radius r_s in equation (1) and for cylindrical bubble radius r_c in equation (3) using the perfect gas relation $PV = mRT$[12]. If we then assume that a given air mass will be compressed isothermally (rather than adiabatically) as a whale varies its depth (as the air within cavities such as the lungs is in contact with body tissue which itself will not vary greatly in temperature), we may arrive at expressions for resonance frequency at depth f_r in terms of resonance frequency at the surface f_{rs}. For a spherical bubble we have

$$f_r / f_{rs} = \left[P_a + \rho_w\, g\, d / P_a\right]^{\frac{5}{6}} \approx \left[1.0 + d/10\right]^{\frac{5}{6}}. \qquad (4)$$

For a cylindrical bubble,

$$f_r / f_{rs} = P_a + \rho_w\, g\, d / P_a \approx 1.0 + d/10. \qquad (5)$$

where P_a is atmospheric pressure (Pa) and g is acceleration due to gravity (m s^{-2}). Equation (4) has been used to generate the data in Table 2.

Table 2: Variation of resonance frequency for spherical air-filled bubble of fixed mass lowered in depth, with isothermal compression (shading indicates source at shallow depth)

Operating depth d (m)	resonance frequency near surface f_{rs} (Hz) 5	10	20	50	100	200
1	5.4 Hz	10.8 Hz	22 Hz	54 Hz	108 Hz	216 Hz
2	5.8 Hz	11.6 Hz	23 Hz	58 Hz	116 Hz	232 Hz
5	7.0 Hz	14.0 Hz	28 Hz	70 Hz	140 Hz	280 Hz
10	8.9 Hz	17.8 Hz	36 Hz	89 Hz	178 Hz	356 Hz
18	11.8 Hz	23.5 Hz	47 Hz	117 Hz	235 Hz	470 Hz
30	15.9 Hz	31.7 Hz	63 Hz	158 Hz	317 Hz	634 Hz
50	22 Hz	44.5 Hz	89 Hz	222 Hz	445 Hz	890 Hz
80	31 Hz	62.4 Hz	125 Hz	312 Hz	624 Hz	1248 Hz
120	42 Hz	85 Hz	170 Hz	425 Hz	850 Hz	1700 Hz

From Table 2, it is clear that quite a variation in resonance frequency is expected across the range of depth values at which whales were reported to be present whilst vocalising at about 20 Hz. In particular, a rise in resonance frequency of a factor of about 1.8 is expected in going from 10m depth to 30m depth.

3.2 BEHAVIOUR OF BUBBLE AT RESONANCE

A universal measure of the performance of a resonant system is the quality factor, Q, (e.g. section 1.10 of Kinsler et al[8]). This is a measure of the damping in the system. Q defines the sharpness of a resonance in relation to the frequency of excitation. It may be shown that it is the same as the amplification provided by the resonator (Kinsler et al show this for the case of a Helmholtz resonator). Further, the greater the amplification, the narrower the frequency band over which the resonance is encountered. The quality factor may be defined as[8]

$$Q = \frac{\omega_r}{\omega_2 - \omega_1} = \frac{f_r}{\Delta f} = \tfrac{1}{2}\,\omega_r \tau = 1/\eta_a \qquad (6)$$

where Q quality factor
ω_r resonant frequency, radians s^{-1}
ω_2, ω_1 frequencies above and below ω_r, respectively, for which radiated power is half the value at resonance (that is, - 3 dB), radians s^{-1}
Δf 3 dB bandwidth, Hz
τ relaxation time, s
η_a acoustic radiation loss factor (for example, equation (7.17) in Bies and Hansen[13])

In equation (6), the relaxation time τ is the time for oscillations to decay in amplitude by $1/e$, following the cessation of excitation. The relaxation time τ, in seconds, then follows as

$$\tau = 2Q/\omega_r = Q/(\pi\, f_r) \qquad (7)$$

The oscillations decay exponentially with time. There are about Q/π oscillations of the decaying resonator within time τ. Thus, there are Q oscillations within time $\pi\tau$, after which the amplitude of oscillation has decayed by the factor $1/e^{\pi} \cong 0.043$. So, a rule-of-thumb approximation is that there are Q oscillations, lasting $\pi\tau$ or Q/f seconds, in the decay of the tonal pulse. The waveforms shown for the 20 Hz "clicks" in Figure 2 then indicate a value of Q of about 15.

The appropriateness of this measured value Q of 15 (same as 23 dB amplification) may be seen from the data shown in Table 3. These data show the amplification achieved in the case with no damping caused by the bubble housing. For an ideal spherical bubble, the damping or quality factor $Q = c_w\sqrt{\rho_w/(3\gamma P)}$, where $\gamma \cong 1.4$ is the ratio of specific heats for the gas within the bubble, c_w is the speed of sound in the water. The values of Q shown in Table 3 are slightly less than this, as they have been prepared by taking into account extra damping caused by heat transfer at bubble walls, as discussed by Devin[14]. Note that no account has been taken here of the reduction in radiative damping for sources at shallow depths.

The values shown in Table 3 indicate a variation in amplification with, mainly, depth with the amplification ranging from 36 dB near the surface, to 26 dB at 120 m depth. Significant damping is to be expected due to body tissue and internal lung tissue, so the lower observed value for Q of 15 (23 dB) is reasonable.

Table 3: System amplification factor Q for spherical air-filled bubble of indicated resonance frequency and deployment depth (shading indicates source at shallow depth)

operating depth d (m)	resonance frequency f_r (Hz) 10	20	50	100	200	500
1	64 (36 dB)	62 (36 dB)	58 (35 dB)	55 (35 dB)	50 (34 dB)	43 (33 dB)
2	62 (36 dB)	60 (36 dB)	56 (35 dB)	53 (34 dB)	49 (34 dB)	42 (32 dB)
5	56 (35 dB)	54 (35 dB)	51 (34 dB)	48 (34 dB)	45 (33 dB)	39 (32 dB)
10	49 (34 dB)	48 (34 dB)	46 (33 dB)	43 (33 dB)	40 (32 dB)	35 (31 dB)
18	42 (32 dB)	41 (32 dB)	39 (32 dB)	37 (31 dB)	35 (31 dB)	32 (31 dB)
30	35 (31 dB)	35 (31 dB)	33 (30 dB)	32 (30 dB)	30 (30 dB)	28 (29 dB)
50	29 (29 dB)	29 (29 dB)	28 (29 dB)	27 (29 dB)	26 (28 dB)	24 (27 dB)
80	25 (28 dB)	25 (28 dB)	24 (28 dB)	24 (27 dB)	23 (27 dB)	21 (27 dB)
120	20 (26 dB)	20 (26 dB)	19 (26 dB)	19 (26 dB)	18 (25 dB)	17 (25 dB)

3.3 FEASIBLE SOURCE LEVELS OF 20 HZ TONE

The maximum source level (SL) which an animal may achieve by exciting the resonance of its body and lung ensemble gas may be estimated by considering the physical limits to oscillation.

A practical limit is reached when the amplitude of oscillation is so large that the acoustic pressure p' and condensation s' of the air, the latter being the fractional density change, cease to be linearly related by the adiabatic bulk modulus (see, for example, chapter 5 of Kinsler et al[8]). That is, density changes caused by the acoustic oscillations must be small in relation to the mean density of air, that is, s' must be small. In practice, large amplitudes of condensation will give rise to non-harmonic gas oscillations and additional damping (reduced amplification Q). The limit may be assumed to be a condensation Δs, numerically equal to the maximum relative density change. A practical limit may be assumed $\Delta s \cong 0.2$ (a peak level, not rms.)

The maximum possible source levels, as dB re (1 µPa)^2 (line) for resonant frequencies and bubble diameters given in Table 1, are shown in Table 4. Note that the SL for shallow sources as shown in Table 4 has been reduced in accordance with a sound power reduction as given by equation (2). For non-shallow sources, the mean-square SL values were calculated based on the following expression for peak radiated pressure level, p, at 1 m:

$$p = \gamma \Delta s\, r_s \rho_w g\,(d + 10) \text{ Pa at 1 m} \qquad (8)$$

This expression is effectively the same as equation (4.47) of Ross[15].

The source levels indicated in Table 4 are the maximum possible, acoustically, let alone physiologically. Note that some definitions of SL may ascribe higher values to sources at shallow depth, as transmission modelling which accounts for Lloyd mirror, and is based on such values, will result in the same radiated power. It is remarkable indeed that a source level of 195 dB has been reported by Aburto et al for animals at about 30 m depth. Based on the 2nd column within Table 4 this is only about 10 dB less than the estimated maximum. As such, the corresponding condensation Δs ~ 0.06, corresponding pressure amplitude within the bubble and in the

Table 4: Maximum possible *SL* for driven spherical air-filled bubble of indicated resonance frequency and deployment depth (shading indicates source at shallow depth)

operating depth d (m)	resonance frequency f_r (Hz) 10	20	50	100	200	500
1	168 dB	168 dB	168 dB	168 dB	168 dB	163 dB
2	175 dB	175 dB	175 dB	175 dB	173 dB	165 dB
5	185 dB	185 dB	185 dB	181 dB	176 dB	167 dB
10	195 dB	195 dB	191 dB	185 dB	179 dB	171 dB
18	205 dB	204 dB	196 dB	190 dB	184 dB	176 dB
30	214 dB	208 dB	200 dB	194 dB	188 dB	180 dB
50	220 dB	213 dB	206 dB	200 dB	193 dB	186 dB
80	225 dB	219 dB	211 dB	205 dB	199 dB	191 dB
120	229 dB	224 dB	216 dB	210 dB	204 dB	196 dB

surrounding tissue within the whale is $|p'| = \gamma \Delta s P \approx 34$ kPa, that is 210 dB.

3.4 INSONIFICATION OF BUBBLE BY WHALE

The observations of clicks indicates a sudden displacement of a resonant system and subsequent decay. However, for tonals of duration 5 – 10 seconds or so, it is feasible that a whale may provide a continual excitation and allow the quality factor to build the signal to maximum level. As such, there will be a finite time required for the bubble to respond fully – a build-up time. This "resonance build-up time" T_b follows from equation (7) as

$$T_b = Q/f_r \qquad (9)$$

where T_b is time for CW response of bubble to build up to 96% of steady state amplitude, following commencement excitation, in seconds. Values of pulse build-up time are shown in Table 5 for different values of Q and resonance frequency. For the observed $Q \approx 15$, 0.75 seconds build up time is required at 20 Hz.

Table 5: Resonance build-up time, T_b, seconds

quality factor, Q	resonance frequency f_r, Hz 5	10	20	50	100
3	0.6 s	0.3 s	0.15 s	0.06 s	0.03 s
5	1.0 s	0.5 s	0.25 s	0.10 s	0.05 s
10	2.0 s	1.0 s	0.5 s	0.2 s	0.1 s
15	3.0 s	1.5 s	0.75 s	0.30 s	0.15 s
20	4.0 s	2.0 s	1.0 s	0.4 s	0.20 s

It is conceivable that a whale might excite its lung air bubble using a frequency sweep (frequency modulation (FM)). This FM sweep must be at rate, in Hz/s, which is sufficiently slow to permit the bubble to reach maximum amplitude of oscillation. In particular, the frequency must not sweep more than about the 3 dB bandwidth within the build-up time T_b.

The 3 dB bandwidth is given by $\Delta f = f_r/Q$. The time for the resonance to build up is Q/f_r. Thus, the tone must sweep more slowly than a rate of about $(f_r/Q)^2$ Hz/s. These rates are shown in Table 6 for combinations of Q and resonance frequency in Table 5. For example, at 20 Hz, with $Q = 15$, an animal must sweep more slowly than 1.8 Hz/s.

Table 6: Maximum sweep rate for FM insonification of target, $(f_r/Q)^2$ Hz/s

quality factor, Q	resonance frequency f_r, Hz 5	10	20	50	100
3	2.8 Hz/s	11 Hz/s	44 Hz/s	280 Hz/s	1100 Hz/s
5	1.0 Hz/s	4 Hz/s	16 Hz/s	100 Hz/s	400 Hz/s
10	0.25 Hz/s	1.0 Hz/s	4 Hz/s	25 Hz/s	100 Hz/s
15	0.11 Hz/s	0.44 Hz/s	1.8 Hz/s	11 Hz/s	44 Hz/s
20	0.06 Hz/s	0.25 Hz/s	1.0 Hz/s	6.2 Hz/s	25 Hz/s

4 AIR CAVITIES WITHIN WHALES

The largest air cavity in a whale is the lung, and although no dimensions appear to be available for a blue whale, Slijper[16] reports that the lungs of a 23 m long fin whale have maximum capacity of 2000 litres, equivalent to 1 m^3 per lung. Fin whales are similar to blue whales in morphology and the size of this specimen is similar to the range reported for pygmy blue whales[17] of 21-22 m. It seems reasonable, therefore, to use the dimensions of a fin whale lung as representative of that of a pygmy blue whale. A spherical air cavity of 1 m^3 diameter would have a radius of 0.62 m. Slijper's diagram of the fin whale lung, however, shows it to be closer to a tapered cylindrical in shape than to a sphere, a representative diameter being roughly $^1/_4$ of the length of the cylinder. Such a cylinder of volume 1 m^3 would have a radius of 0.34 m. The resonant frequencies for these dimensions for various depths can be calculated from equations (1) and (3). For the sphere of 1 m^3, the resonant frequency is 7.4 Hz at 10 m depth and 10.5 Hz at 30 m depth. For the cylinder it is 5 Hz at 10 m depth and 7.0 Hz at 30 m. These simple calculations give estimates that are of the right order of magnitude for the lowest frequencies of sounds observed from blue and fin whales. A more realistic model would need to take account of effects of the internal tissues of the lung. In addition, the reduction in volume of the lung can be expected to be more than calculated by equations (4) and (5) as the increased pressure would cause some of the air to be dissolved in tissues and fluids of the body, giving higher resonant frequencies than calculated above.

5 CONCLUSIONS

By examining some data recordings of Blue Whale vocalisations, the postulation of a bubble resonance phenomenon being exploited by animals to produce low frequency clicks and tones has been revisited. By examining the relevant physics of underwater resonant bubbles, many aspects of the generation of the observed signals have been examined. It is concluded that a resonance of the ensemble of gas within a whale's lungs and the surrounding body tissue and seawater is, in fact, the most probable cause of the very high amplitude, very low frequency sounds which have been observed. Estimated resonant frequencies and amplitudes are of the right order of magnitude. It does appear that Blue Whales may produce a sound of such intensity that it is within about 10 dB of a postulated maximum for a resonant bubble excited by any means. It would also appear that the process of driving a low frequency fundamental near 20 Hz generates significant, but lesser, sound intensity at harmonics of the fundamental.

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AUSTRALIAN ABORIGINAL MUSICAL INSTRUMENTS: THE DIDJERIDU, THE BULLROARER AND THE GUMLEAF*

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ABSTRACT: The Australian Aboriginal people developed three musical instruments – the didjeridu, the bullroarer, and the gum-leaf. Most well known is the didjeridu, a simple wooden tube blown with the lips like a trumpet, which gains its sonic flexibility from controllable resonances of the player's vocal tract. The bull-roarer is a simple wooden slat whirled in a circle on the end of a cord so that it rotates about its axis and produces a pulsating low-pitched roar. The gum-leaf, as the name suggests, is a tree leaf, held against the lips and blown so as to act as a vibrating valve with "blown-open" configuration. Originally intended to imitate bird-calls, the gum-leaf can also be used to play tunes.

1. INTRODUCTION

The Australian Aboriginal people have lived in this country, probably for more than 40,000 years, with almost no contact with the outside world. During that time they developed sophisticated tools such as the woomera spear-thrower and the returning boomerang. They also developed three musical instruments – the didjeridu, usually spelt "didgeridoo" in the non-academic literature and actually called a yidaki or yiraki in the Aboriginal language of the region where it originated, the bull-roarer, and the gumleaf. The didjeridu is a simple wooden tube blown with the lips like a trumpet, which gains its sonic flexibility from controllable resonances of the player's vocal tract. The bull-roarer, called by other names in Aboriginal languages, is a simple wooden slat whirled in a circle on the end of a cord so that it rotates about its axis and produces a pulsating low-pitched roar. The gum-leaf, as the name suggests, is a leaf from a Eucalypt tree, held against the lips and blown so as to act as a vibrating valve with "blown-open" configuration, denoted by (+,–). The sounding pitch is controlled by vocal tract resonances and is typically about an octave above the female singing voice. Originally intended to imitate bird-calls, the gum-leaf can also be used to play tunes. This paper will briefly describe each of these instruments.

2. THE DIDJERIDU

The didjeridu originated in Arnhem Land on the northern coastline of central Australia, and has some similarity to bamboo trumpets and even bronze horns developed in other cultures, though it pre-dates most of these by many millennia. The characteristic feature is that the didjeridu, which is a slightly flaring wooden tube about 1.5 metres in length, is simply hollowed out by natural termites ("white ants") from the trunk of one of the small trees of the region. After cutting down, the instrument is cleaned out with a stick, the outside refined by scraping and then painted with traditional designs, and the blowing end smoothed by adding a rim of beeswax.

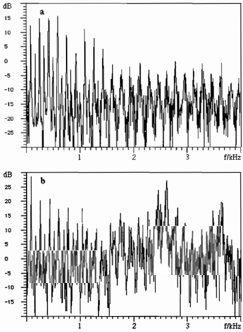

Figure 1. Spectra of didjeridu sound. (a) an uninflected drone, and (b) a drone with two prominent formant bands. (From [4])

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The predominant sound of the didjeridu is a low-pitched drone with frequency around 70Hz, but depending significantly upon the length of the instrument and the flare of its bore. The second mode of the tube, with frequency a little less than 1.5 times that of the fundamental (because of the tube flare) is used sparingly as an accent to the sound, and the main variation comes from production of pronounced formant bands, the frequencies of which can be adjusted by the player over a range from about 1kHz to 3kHz, as shown in Fig. 1. In traditional use, the didjeridu, with clap-sticks for emphasis, accompanies songs or illustrates traditional stories about ancestors and animals [1]. Recently, however, its use has spread into the popular music domain and has had world-wide influence [2].

The acoustics of the didjeridu tube is simple. Because of the irregular shape and general slight flare, the upper resonances (impedance maxima) are not well aligned with odd harmonics of the fundamental, and the main determinant of quality is the smoothness of the walls, on a sub-millimetre scale, and the absence of cavities. The diameter of the blowing end, typically about 30mm, must also be a convenient match to the lips of the player.

The real acoustic interest comes from the techniques by which unusual sounds are made [3]. The prime technique is one involving adjustment of the impedance maxima of the vocal tract, as judged from the vibrating lip valve, since this impedance is effectively in series with the comparable impedance of the didjeridu tube itself. The player achieves this adjustment by raising the tongue to narrow the airway near the lips and further adjusting the spacing between the rear of the tongue and the hard palate [4]. Some further results of research on this subject are presented in a recent paper by Wolfe *et. al.* [5]. The main reason that these techniques are so effective in the didjeridu, compared with other lip-driven instruments, is that the diameter of the instrument bore near the lips is quite similar to that of the upper vocal tract, and there is no intervening mouthpiece cup to isolate one from the other.

The other impressive contribution to didjeridu sound comes from a technique in which vocalisation occurs simultaneously with normal lip-generated drone. There are then two pressure-operated valves, the vocal folds and the lips, acting in series upon the air flow. Because the operation of each valve is nonlinear, since the air flow is essentially governed by a Bernoulli equation, this generates multiple sum and difference frequencies $nf_1 \pm mf_2$ in the sound output [3]. If the player sings a note a musical tenth above the drone, so that $f_2 = (5/2) f_1$, then in particular the sub-octave $f_1/2$ is generated, giving a deep "growl". In addition, the player may insert many other transient sounds to mimic the cries of dingoes or birds, with marked dramatic effect.

3. THE BULLROARER

Since there are no bull-like animals in Australia, this is a misnomer for the Aboriginal instrument, but the actual word used is "secret-sacred" and not shared with non-Aboriginal people. The instrument itself consists of a simple wooden slat, 30 to 40cm in length and 5 to 7cm wide that is whirled around in a circle on the end of a length of cord. The slat rotates under the influence of aerodynamic forces and generates a pulsating sound with a frequency typically around 80Hz. This sound is an important feature of Aboriginal initiation ceremonies.

The instrument itself is by no means unique to Australia, and similar sound generators have been used by populations as diverse as those of ancient Egypt and the Inuit of Northern Canada. An Australian instrument is shown in Fig. 2.

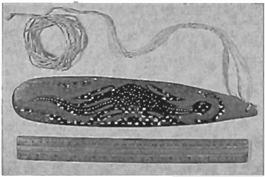

Figure 2. An Australian bullroarer. Note the decorations, which show the totemic symbol of the tribe of the maker. (From [6])

The aerodynamics of sound generation in the bullroarer has been described in detail elsewhere [6], and only an outline will be given here. Since the quasi-static aerodynamic forces and torques on the slat balance out over a single period of its revolution, the aerodynamic torque driving its rotation depends upon the rate of rotation itself. There is one rotation-inducing torque term that is linear in slat rotation speed, and also a drag term proportional to the square of the rotation speed. These lead to a threshold rotation rate that must be exceeded to begin the process, and then to an upper limit to the rotation rate. The steady angular rotation rate f of a rectangular slat of width W swung through the air on a string of length L with rotation frequency F can be shown to be approximately

$$f \approx 1.6\, LF/W - 5,$$

where f and F are in rotations per second. Each rotation of the slat creates an oscillating flow dipole and, from considerations of symmetry, the dipole oscillation frequency, and thus the radiated sound frequency, is $2f$. The radiated acoustic power P is approximately

$$P \approx 3\,(\rho/c^3)\,H^2 V^6$$

where H is the length of the slat, ρ is the density of air, c is the speed of sound in air, and $V=2\pi LF$ is the speed of the slat through the air. From these two equations we see that wide slats produce sound of lower frequency but that the radiated power is independent of slat width. Sound frequency is, however, proportional to airspeed and thus to arm rotation rate, and the radiated power is a strong function of this arm rate. For typical conditions, the radiated power is a few milliwatts for an arm rotation rate of 120 r.p.m., which is about as fast as can normally be achieved. Sound radiation is nearly omnidirectional.

Because the output power is a strong function of airspeed V, and the arm rotation is normally faster on the down-sweep than on the up, the sound pulsates with a frequency typically between 1 and 2Hz. There is an additional slower pulsation with a period of several seconds that derives from the fact that the slat rotation gradually twists the cord, providing a contrary torque which eventually stops the rotation and re-launches it in the opposite sense.

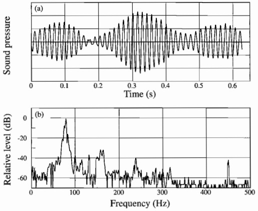

Figure 3. (a) The pressure waveform of sound from a bullroarer, showing typical pulsations. (b) Frequency analysis of this sound, showing low harmonic development. (From [6])

Analysis of the sound, as in Fig. 3, shows little harmonic development, the second-harmonic peak being about –30dB relative to the fundamental. The peaks are, however, somewhat broadened because of the variable rotational speed of a human arm.

4. THE GUMLEAF

The gumleaf is altogether more primitive as a musical instrument, since it consists simply of a leaf, the shape of which is illustrated in Fig. 4(a), from one of the various species of Eucalypt trees growing throughout Australia, held against the lips using the fingers of both hands. It does, however, have a long tradition and culture [7].

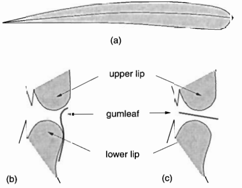

Figure 4. (a) The shape of a typical gumleaf from a Eucalypt tree. (b) In normal playing, the leaf is held firmly against the lower lip and rested lightly against the upper lip, and it is the upper edge of the leaf that vibrates. (c) A variant way of holding the leaf that results in a raucous quasi-chaotic sound.

In the normal playing configuration, shown in Fig.4(b), the leaf is held tightly against the lower lip and, in a bent shape, lightly against the upper lip [8]. It is stretched rather tightly between the two hands. When air pressure is applied through the mouth, it tends to lift the top of the leaf away from upper lip and allow air to escape, so in this sense the valve can be described as an "outward-swinging door", which is given the symbol (+,–), indicating the effect on the flow of applying pressure from the supply side (+) and from the exhaust side (–). Its configuration is thus similar to that of the valve constituted by the lips of a brass-instrument player, although these are sometimes (+,+) as in a sliding door, and the opposite of the reed of a clarinet, which is (–,+), as in an inward-swinging door. The acoustic behaviour of valves of each of these types has been examined elsewhere [9,10], and this treatment provides the basis for the present discussion.

Although it takes a good deal of trial and error for a beginner to even produce a sound from a gumleaf held as indicated in Fig. 4(b) above, a skilled player can control the pitch with good accuracy over a range of more than an octave and play simple tunes with ease, the pitch range being typically from about 500 to 1000Hz. Interest therefore centres on exactly how this is done.

Theory [9] and experiment [10] agree that for a valve with configuration (+,–) to oscillate, the sum of the up-stream and down-stream acoustic impedances must have a negative imaginary component. Since the downstream impedance is essentially zero in this case, this implies that the mouth and vocal tract must present a compliant (capacitive) impedance at the lips. When this condition is satisfied, the valve will oscillate provided the applied air pressure exceeds a certain threshold and the losses are not too great. The actual oscillation frequency is necessarily higher than the mechanical resonance frequency of the elastically braced leaf, and is further determined by the magnitude of the impedance presented by the mouth to the leaf. If the imaginary part of this impedance is negative and large, corresponding to a small enclosed air volume in the mouth and a narrow passage to the lower vocal tract, then the oscillation frequency of the valve will be much higher than its natural frequency. In many ways, then, the technique for varying the mouth and vocal tract when playing the gumleaf is similar to that used in whistling.

As the gumleaf valve opens and closes, so the pressure in the mouth falls and rises, with a phase advance of about $\pi/2$ relative to the lip opening. Because the airflow through the valve is in turn proportional to its opening area and to the square root of the driving pressure, this nonlinear relationship generates harmonics of the fundamental frequency, and the sound is rich in upper partials and has an incisive quality.

There is one other way of playing the gumleaf that is also worthy of mention. The configuration used is shown in Fig. 4(c), with the leaf simply lying parallel to the slot between the lips. As a variant, the leaf is sometimes held vertically between the sides of two opposed thumbs, which are pressed against the lips to create essentially the same configuration. The aerodynamic behaviour is now very different, and laboratory investigations suggest that the leaf, which is essentially flat, moves backwards and forwards in the slot and, at the same time, twists about its longitudinal axis. This motion repeatedly narrows and widens the flow channel at a frequency equal to twice the mechanical oscillation frequency of the leaf and so has a similar effect on the air flow and thus on the emitted sound. In a larger-scale laboratory experiment the motion could be made simple and regular, but in most playing situations the leaf makes irregular contact with the lips or the thumbs and this upsets the motion. The resulting sound, while having a predominant pitch, is rough and quasi-chaotic. It is useful for special effects, such as imitating the cry of the native sulphur-crested cockatoo [11], but has no obvious musical value.

5. CLAPSTICKS

As in most cultures, the Aborigines also used percussive instruments in their ceremonies. Often these were simply two boomerangs clashed together, but they also made special shaped sticks for this purpose. Because the wood used is a fine-grained hardwood, the clapsticks are physically long-lasting and produce a sharp and well defined sound.

In their usual form, these sticks are about 200mm in length and 20mm in diameter and are shaped to a long point at each end. One stick is held in each hand and they are struck together at about the mid-point of each. The pointed ends ensure that the fundamental transverse vibration has a high frequency, so that the percussive effect stands out well above the drone of the didjeridu.

6. CONCLUSION

Ethnomusicology is a very interesting field, and it is made even more interesting when allied with a study of the acoustics of the musical instruments that were developed by the society under study. The musical instruments of the Australian Aboriginal people have come into world prominence because of the popularity of the didjeridu, both as a tourist item and as a musical instrument. It is only recently that we have begun to have an appreciation of the acoustical subtleties associated with performance on this and other ancient instruments.

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WHY DO BELL PLATES RING?

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Abstract: Bell plates are polygonal plates which, when held in the hand and struck with a beater, produce an initial transient followed by a sustained, pure tone. The presence of the sustained tone depends sensitively on the shape. This paper addresses the question: why does a particular shape ring so well, while slightly different shapes do not? We show that, in the standard ringing shape, the nodal lines of one of the lowest modes of vibration fuse in the handle to produce a region that exerts neither vibrational force nor torque on the hand, and therefore does not transfer vibrational energy to the hand.

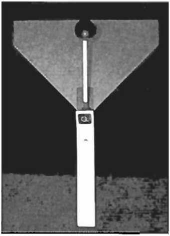
1. INTRODUCTION

Bell plates are new musical instruments that are played in much the same way as handbells, but are much cheaper. They are also lighter and so easier to hold when played with two in each hand, a style in which the axes of the bells or plates in the same hand are at right angles, so that they can be shaken independently or together by rotation about an appropriate axis. They have a pleasant, slightly bell-like sound and are becoming popular as an alternative to hand bells as a group musical activity in schools. A bell plate consists of a flat metal polygonal plate with a handle attached (Fig. 1). When struck in the middle with a hard rubber beater, it produces a very short, bell-like transient followed by a long, pure tone. Monsma [1], Rupil [2] and Hogg et al [3] have studied the sounds produced. Monsma measured relations between size and pitch.

The performance of the bell plate depends strongly on its shape. In general, even modest changes in the proportions produce a plate that, to put it colloquially, 'goes clunk' when struck, i.e. it produces a short, non-harmonic transient and no sustained tone. However, there is a family of possible ringing shapes: as b:a increases, c:b must be decreased. We have posted sets of photographs and sound files [5] on the web to demonstrate the dependence of the sound on the shape, as well as other features. Two sonagrams are shown in Fig. 2. Note that both plates have a strong initial transient but that, while the plate with the standard shape has a strong, sustained pure tone throughout the two second period displayed, the analogous resonance of the plate of altered shape decays strongly over the first 0.2 second.

It is difficult to describe the feeling of pleasant surprise and wonder that this produces when one first experiments with such plates. Why is it that this plate rings so beautifully while another just goes 'clunk'? The purpose of this paper is to answer that question.

Metals have low intrinsic elastic losses, so one would expect metal plates of almost any shape to ring if struck without the influence of gravity and therefore without supports. In contrast, holding the plate in the hand provides a mechanism whereby mechanical energy from the plate vibrations is rapidly lost in the hand holding it. It is helpful at



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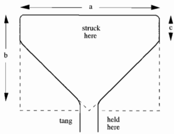

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Fig. 1. (i) A photograph of a commercial instrument (Belleplates, Ashford, UK) that plays the note G4. (ii) The standard geometry of a typical bell plate. The dimensions a:b are typically in the ratio 1.5 to 1.6 while the ratio a:c is approximately 6 or 7 (table of shapes given in [2]). The size and shape of the tang is not important for the musical sound and is therefore chosen for the convenience of the player—a constant 20.2 mm width and 45 mm length. In commercial instruments, all corners are rounded, but this is not important to the sound. For playing, a hand strap and the mounting for a clapper are attached to the tang. Other pitches can readily be made: for thin plates, the resonant frequencies are approximately proportional to the thickness and inversely proportional to the square root of linear dimension [4].

this stage to consider a simpler example. A glockenspiel bar is usually mounted on two supports that are positioned below the bar at nodes of the lowest mode of vibration (See Fig. 3). When the bar is thus supported and when struck somewhere near the middle, it rings audibly for many seconds. The nodes do not move, so no oscillatory force is exerted on the supports. If one holds it at a point that is not a node of one of the low modes, it makes a short transient sound, but there is no sustained ring. Another way of describing this is to say that the deformation shown in Fig. 3(ii) displaces the centre of mass, requiring oscillating forces at the supports, while that in Fig. 3(i) does not.

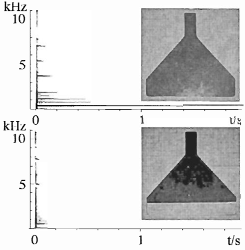

Fig. 2. Sonagrams (amplitude in a logarithmic grey scale vs time and frequency) for a standard shaped bell plate (top) and for the same plate after a 25 mm strip was guillotined from the long edge. The insets show photographs of the plates. Both were struck with a soft rubber mallet. These are among the sound files on the web [5].

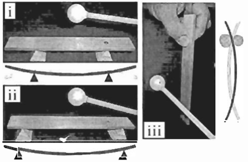

Fig. 3. How must one hold a glockenspiel bar so that it rings? The supports must be at the nodes of a low frequency mode: (i) rings at the fundamental and (ii) does not. Further, the supports must allow rotation at the node: (i) rings well and (iii) rings poorly.

Supporting the bar at a node is a necessary condition, but there is a further condition: the supports must have very small size along the direction in the bar at right angles to a nodal line. The supports of a glockenspiel or xylophone are narrow in the direction along the bar. They therefore allow local rotational motion of the bar, so no torques are exerted on the support. In contrast, human fingers have larger width so, even if one holds the bar 'at' a node (Fig. 3(iii)), one's fingers impede the rotation about the node and so the oscillatory torques extract vibrational energy. To return to bell plates, obviously the tang of the bell plate must be a node, but what is it about this node that allows it to be held in the hand without damping the ringing mode? In this study, the shapes of the nodes of plates of various geometries were studied by the Chladni method to answer this question.

2. MATERIALS AND METHODS

Two sets of plates with a range of geometries were cut from aluminium sheet. One set had thickness 1.5 mm and the others were 1.0 mm thick. The latter gave lower frequencies and larger amplitude that made them easier to study with Chladni patterns. The thinner plates were sprayed with a thin coat of black paint on one side. (The thicker plates have higher frequency and are used for the sound files in our web site [5].) For Chladni patterns, the plates were excited electromechanically. They were supported on three or four posts, each topped by a dome-shaped pad of sponge rubber, whose position could be varied. The masses of the plates ranged from 50 to 100 g. Two small rare earth magnets (total mass 1.3 g) were placed near the striking point on opposite sides, so that they held themselves in place without the need for glue. An air-cored coil was placed coaxially with the magnets and driven by a sinusoidal current of variable frequency. Fine sand was sprinkled on the plate and the frequency of the coil was varied until the desired mode was excited. A microphone was positioned several millimetres above the plate and, in some experiments, scanned at 5 x 10 mm grid points across the surface of the plate to measure the relative amplitude of the vibration. When the frequency was adjusted to obtain maximum amplitude, the posts were moved to coincide with the nodes and the coil was retuned. The frequency was readjusted, if necessary, and this process was iterated until the post positions exactly coincided with the nodes. The distribution of the sand was then photographed.

3. RESULTS AND DISCUSSION

Before we discuss the results, we remind the reader of the lowest mode of vibration of a simple rectangular plate, which is sketched in Fig. 4. This is called the (2,0) mode, the numbers enumerating the nodes in the two perpendicular directions. In this mode, the nodes are slightly curved lines across the plate, roughly parallel to the short sides. In a Chladni pattern, particles accumulate at the nodal lines, where there is no motion. Note that nodal lines separate regions that are 180° out of phase.

A bell plate may be considered as a rectangle with two corners removed and a tang added. What happens to the nodal lines when we remove two corners? Fig. 4 shows the Chladni patterns of three steps in the 'evolution' from a rectangular plate to a bell plate. On the long side from which the corners have been removed, the nodal lines are, not surprisingly, closer together. In the bell plate shape, these two nodes meet near the edge of the rectangular part of the plate and form an extended node in the tang. Figure 5(v) shows the nodal lines on a shape qualitatively similar to a bell plate, but wider (higher *a:b* and *a:c* ratios, in the nomenclature of Fig. 1.). In this case, the two nodal lines meet and fuse inside the rectangular area, so that the tang is no longer a node. When held at the tang, this plate will not produce a sustained ring: it is a 'clunk plate'.

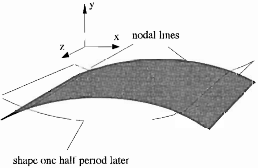

Fig. 4. A sketch of the lowest mode of a rectangular plate, and coordinate axes to which we refer later.

A horizontal section at mid-height through the plates shown in Fig. 5 (i-v) would give a shape $y(x)$ much like that of the glockenspiel bar in Fig. 2. The central region of the plate is in antiphase to the right and left hand edges, and so at the two nodal lines the plate displacement y is zero, but its slope dy/dx has opposite sign at the two nodes (Figs 3,4).

What happens when two nodal lines join, as they do in Fig. 5(iv)? When the two lines join, the displacement y is zero, but the slope dy/dx is zero too! This is important when one holds a plate. Consider what happens when one supports a plate with the fingers at a single nodal line (Fig. 3(iii)): although the average displacement across the support is zero, there is local rotation and therefore loss of energy via the torques. When two nodal lines join (Figs 5(iv) and (v)), there is no rotation, and no torque in the z direction is applied to the support. At such a position, one can hold the plate with a support of small, finite width and extract negligible energy from vibration, to a first order approximation in the width of the support. This recommends it as a good place for the handle, as bell plate makers have found empirically. Note that, in Fig. 5(iv), the region where sand has accumulated extends part way along the tang but not all the way to the end. The electromechanical excitation does produce vibration at the end of the tang so an extended handle must remove some vibrational energy here[1]. Because the end of the tang is narrow, however, and its motion small, the force that accelerates it in this circumstance is small. A similar force applied to a handle and hand would therefore lose relatively little energy. Holding the plate by the plate end of the tang and by the part where it joins the body makes no noticeable difference to the decay time.

In addition to the mode shown in Fig. 5(iv), the bell plate has several other modes, which do not produce a node in the tang. One of these, the (0,2) mode, is shown in Fig. 5(vi).

[1] This observation may be of interest to the manufacturer of the plate: a small increase in the decay time of the fundamental ring tone might be obtained by fixing the tang to the handle only along part of its length.

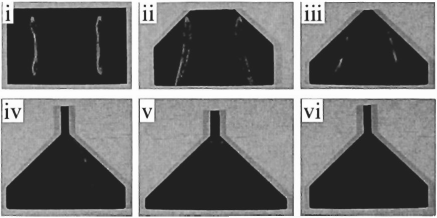

Fig. 5. Chladni patterns showing the 'evolution' of the bell plate shape. (i) The (2,0) a rectangular plate. (ii) The corresponding mode following the removal of material from two corners. (iii) The shape of a bell plate, but without the tang. (iv) The ringing mode on a bell plate. (v) A shape with a higher a:b ratio. It does not ring. (vi) The (0,2) mode for the bell plate in (iv). In each photograph, the small circular object is the magnet used to drive the plate.

These modes do not have a sustained ring, although those that do not have a node at the position at which it is struck presumably all contribute to the strike transient. In the plates we measured, the pitch of the (0,2) mode is approximately one tone lower than that of the ringing mode. One bell plate was made with a hole drilled at the intersection of nodal lines of these two modes. Suspended on a thread passed through this hole, the plate may be struck to produce both notes simultaneously. (It is also possible to produce the two notes by holding the plate at this point with thumb and forefinger, but with this support the ring time is much reduced. Examples are given in sound files [5].)

Finite element analyses of the bell plate were conducted using Strand 7. These gave shapes similar to those indicated by the Chladni patterns and microphone scans, and frequencies that differed by a few percent. These are described in detail by Lavan [6].

4. CONCLUSION

One of the lowest modes of a bell plate, the ringing mode, has nodal lines that curve and fuse at the region where the tang and handle are attached. Vibration in this mode exerts no force and no torque upon the hand holding it, and so this mode has a sustained ring. Other modes do not have such a node and contribute only to the initial strike transient. The nodal line fusion is a function of the specific geometry, so plates with only slightly different geometry may not ring at all.

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AN EXPLANATION FOR THE APPARENT POOR PERFORMANCE OF SOME HEARING PROTECTORS

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Abstract: Hearing protectors do not always perform as well as manufacturers and distributors would wish. Sometimes the attenuation ratings fall well below what was expected. On close examination of the test data it can sometimes be seen that the results are spread over a very wide range thus producing a lower than anticipated mean value and a large standard deviation. In Australia and New Zealand the rating of a hearing protector depends on the value of the mean attenuation minus one standard deviation at seven octave band centre frequencies of one-third octave wide filtered pink noise. A low mean and large standard deviation can reduce the hearing protector rating significantly. Recent work indicates that present methods of analysing data may not always be satisfactory. Perhaps bimodal or other analysis techniques are more appropriate.

1. INTRODUCTION

It sometimes happens that when hearing protectors are tested in accordance with the requirements of combined *Australian/New Zealand Standard AS/NZS 1270:2002 Acoustics – Hearing protectors* [1] and its precursors, that in the view of the manufacturer/distributor/supplier, unexpected results are obtained.

Sometimes the test results conclude with an unexpected high attenuation. Though this is not the usual case. The most common difficulty for laboratories is when an unexpected low attenuation results from the testing of a device when the manufacturer was expecting to achieve a high attenuation. Frequently this will be a 'new' or innovative device on which great hopes and expectations were placed for competitive entry into a new market segment. The company who requested (and paid for) the testing wants an explanation from the testing laboratory as to why the device has not performed up to their expectations.

This "low attenuation" performance is not limited to any particular device type or style. It occurs across the board with ear plugs, ear muffs, canal caps, helmet mounted muffs, corded and uncorded plugs. The precise reason for this 'underperformance' is currently unclear.

2. BACKGROUND

In a recent paper Murphy and Franks [2] have suggested that the modelling of hearing protector attenuation test results through the accepted procedure of using a normal distribution and applying the associated statistics may be flawed. The reason for the low attenuation was not addressed but rather they suggested that the traditional method of 'processing' the experimental results may be inappropriate.

Murphy and Franks analysed the ANSI [3] and ISO [4] test results from several sets of ear plugs and one set of earmuffs using statistics for a normal Gaussian distribution and for a bimodal distribution. They found that in many cases bimodal data fit was much more appropriate than a normal distribution. Their conclusion was that "*standards could be based on empirical quantiles which do not assume any particular attenuation distribution*" (p 2115) rather than specific assumptions and that perhaps a bimodal fit would be most appropriate.

In Australia and New Zealand acoustic testing of hearing protectors is carried out using a "subject fit" methodology. This is where the test subject is allowed to fit the hearing protector using the instructions supplied by the manufacturer but the tester is not allowed to interfere in this fitting process. To assist the test subject to produce the maximum attenuation 'fitting noise' the subject is supplied with an instruction from the tester "*so that you can adjust the protectors for good noise reduction*" [1, p. 26].

The argument has been made [5] that without the experimenter (tester) being able to be directly involved in the hearing protector fitting the results that are obtained may be sub-maximal. Conversely others argue that the subject fit method more realistically approaches what can be expected in the workplace when individuals are provided hearing protectors as part of an occupational noise management program. At the present time in Australia and New Zealand the second argument holds sway. The subject fit procedure is gaining credence internationally with discussions underway for an International Standard [4] utilising a subject fit protocol very similar to that of AS/NZS 1270.

3. THEORY

Currently the suggestion of Murphy and Franks [2] to use a bimodal model appears to fit the available data. Very simply, this model assumes that the measured test data arises from two separate and distinct causes that are indistinguishable during the course of testing.

The two sets of data are able to be described by normal Gaussian distributions, N_1 and N_2, respectively. Thus the overall distribution of test data can be described using a distribution function that is simply a linear combination of the two normal distributions. This combined distribution function N_{1+2} can be written as,

$$N_{1+2} = k\,N_1 + (1\text{-}k)\,N_2.$$

The distribution functions N_1 and N_2 can be found using cluster analysis and k is a proportionality constant, directly related to the number of sample points from each cluster, ranging between 0 and 1. The more the two distributions overlap, ie the closer the two means and more similar the standard deviations, the more the combined distribution resembles a single normal distribution.

4. ANALYSIS OF SPECIFIC DATA

When a hearing protector is acoustically tested, attenuation is determined for each of seven test signals. These test signals consist of one-third octave bands of noise, filtered from a pink noise source and centered on octave band center frequencies. The seven attenuations along with their respective standard deviations are combined as described in AS/NZS1270, Appendix A, to give the SLC_{80} rating and subsequent Class of the hearing protector.

The data on which the statistical analysis is carried out is the attenuation at each one-third octave band. Thus it is here that the test of bimodality is applied. Several examples of octave band data have been chosen from tests recently carried out at the National Acoustic Laboratories.

For commercial-in-confidence reasons the particular devices that were under test have not been specified. Also it should be noted that a hearing protector that performs poorly in one particular test band does not necessarily perform poorly over all test bands. However, poor performance in one test band can markedly affect the overall rating of a device.

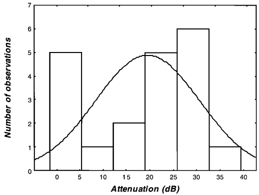

Figure 1: Attenuation results (dB) at 125 Hz for ear plug A, with superimposed normal distribution.

Consider the test results from ear plug A. The attenuation of this particular device in the 125 Hz band for each test subject was given in Table 1.

If this data is treated as being normally distributed it has a mean of 19.5 dB and a standard deviation of 11.1 dB. This distribution of data is illustrated in Figure 1. As can be seen from the superimposed normal Gaussian curve the distribution of the data is far from normal showing two distinct peaks.

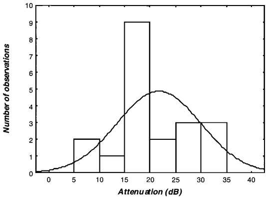

Figure 2: Attenuation results (dB) at 125 Hz for ear plug B, with superimposed normal distribution.

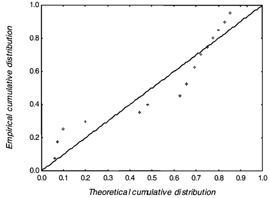

Figure 3: Probability – Probability plot for the attenuation of earplug A at 125 H

However, if the data is regarded as being distributed in a bimodal manner the result is two independent, normal distributions, N_1 and N_2, with means and standard deviations of 4.2, ±3.1 dB and 26.1, ±4.7 dB respectively, and $k = 0.30$. For this ear plug a mean attenuation of 4.2 dB would be regarded as a 'poor fit' while 26.1 dB would be seen as an 'acceptable' value. For these results it is clearly demonstrated that the results from the 'poor fit' subjects draw down the results of the 'acceptable fit' subjects.

Table 1: Individual attenuation in dB obtained by 20 test subjects for ear plug A at 125 Hz.

No	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
dB	24	5	10	27	28	36	24	18	25	25	19	30	2	29	26	23	2	3	3	31

Table 2: Individual attenuation in dB, 20 test subjects, for ear plug B at 125 Hz.

No	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
dB	18	24	10	19	35	16	19	7	16	19	30	25	30	18	13	35	17	35	26	20

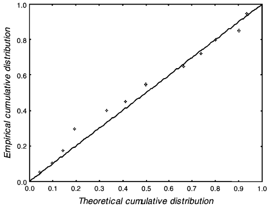

Figure 4: Probability – Probability plot for the attenuation of earplug B at 125 Hz

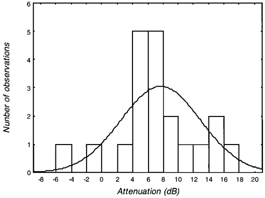

Figure 5: Attenuation results (dB) at 125 Hz for helmet mounted ear muff, with superimposed normal distribution

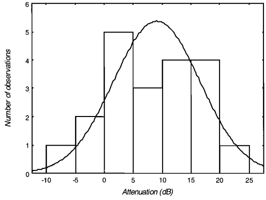

Figure 6: Attenuation results (dB) at 250 Hz for helmet mounted ear muff, with superimposed normal distribution

In the particular example cited above there are approximately six test results that could be interpreted as being due to 'poor fit'. It would be tempting to put forward an argument that under the guidance of some declared criteria test subjects with a "low" and "high" attenuation results be respectively divided into two groups and the data processed separately. However, it must be remembered that attenuation is tested at seven one-third octave bands and subjects that record a low attenuation in one particular one-third octave band do not necessarily record low attenuation results in other one-third octave bands.

Compare the above results for ear plug A with those for ear plug B tested at 125 Hz in Table 2. Here the mean attenuation is 21.9 dB with a standard deviation of 8.1 dB. The distribution of the data is illustrated in Figure 2 with the accompanying expected normal curve. It can be seen that this distribution is much better approximated by a normal Gaussian curve. Hence normal statistics can adequately describe the characteristics of this device.

The tendency to normal distribution is better described through the use of a *probability – probability* plot where, by definition, a normal Gaussian distribution is defined by a straight line. This is shown in Figures 3 and 4 for earplugs A and B respectively where ear plug B conforms to the straight line fit of a normal distribution as compared to ear plug A.

Consider now difficulties exhibited with the same hearing protector (a helmet mounted ear muff) at adjacent test frequencies from the same test population. The protector has not been removed or in anyway adjusted between these two test frequencies and the resulting attenuation is an average of three measured thresholds out of five, the first two being discarded as they are considered to be practice runs at the particular one-third octave band.

Figures 5 and 6 show the distribution of attenuation test data for the helmet mounted ear muff at the two adjacent test frequencies of 125 Hz and 250 Hz and their respective suggested 'normal' distribution curves. The actual distribution of the data indicates that there is a great deal of difference in both the spread and the concentration of the results. The degree of kurtosis exhibited by both curves is very different with the kurtosis of Figure 5 being 0.27 and Figure 6 –0.90.

5. DISCUSSION

As can be seen from the above analysis of a limited number of test results the assumption that hearing protector test data is normally distributed may lead to conclusions that do not accurately represent the true performance of the hearing protector in question. Although analysis was only demonstrated on a limited number of data sets the general principle of different possible distributions is clearly illustrated.

As proposed by Murphy and Franks [2] the use of a bimodal distribution describes many data sets that are not well described by normal statistics. However, the question arises "are there only two factors governing the attenuation test data – normal and bimodal?" With relatively limited data points from standard test procedures some further "attenuation" factors could be overlooked. Situations could exist where not only are there 'poor fits' and 'acceptable fits' but there may also be some intermediate results arising from other various causes. Thus there may be a variety of distributions involved.

Possibly what statistics to apply will not be known until what is causing the attenuation that is being measured is more fully understood. 'Poor' fit could be caused by behavioural or educational difficulties such as individuals not following the fitting instructions; unclear fitting instructions; or intentional poor fitting for whatever reason. However, the poor fit could also be caused by physical constraints such as poor design or some anatomical feature of the head, ear or ear canal that has yet to be fully considered.

Further investigation into the causes of significant steps in the attenuation of some hearing protectors needs to be carried out.

7. ACKNOWLEDGEMENTS

I would like to acknowledge the assistance of Geoff Colin-Thome at NAL for his assistance in gathering the test data and Richard Fraccaro from StatSoft Pacific for his assistance in analysing the bimodal data.

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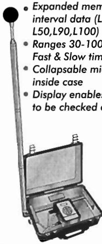

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TOP TEN ISSUES FOR ACOUSTICS IN AUSTRALIA

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1.0 INTRODUCTION

There is a real concern among the members of the Australian Acoustical Society (AAS) about the lack of support at all levels of government for research and education in acoustics in Australia. This issue has been raised in the President's editorial in the journal (Acoustics Australia, 30(2) p47 2002). While there is general agreement that there is a problem, there has been no clear plan of actions that can be taken by the Society to redress the damage that has already been done and to forge an expanding role for acoustics in Australia in the future.

The aim of this project, supported by an educational grant from the AAS, was to identify the "Top Ten" issues of concern to the acoustics community and the directions that could be pursued to redress the problems identified. The responsibilities for actions lie with the AAS Management and the individual members of the AAS. Assistance can be sought via the Federation of Australian Scientific and Technological Societies (FASTS) which is a lobby group with strong links into all levels of government.

The draft of the full report with suggested actions was available for discussion at the Future Directions Workshop held in late May 2003. Decisions on the actions to be implemented were made at that workshop and were included in the report. The full report is available from the AAS web page, www.acoustics.asn.au. This paper summarises the background and lists the actions which the Society will be implementing.

2. 0 BACKGROUND

Acoustics covers a very wide range and the membership of the AAS is certainly diverse. The areas of interest for the members of the AAS cover all aspects of sound and vibration. Members of the society can be self employed or work for the private or the public sector. The education background of the members includes engineering, science, electronics, architecture, building, psychology, physiology, music, etc.

The AAS comprises over 400 members within Divisions in five states. Management of the AAS is at the state level with Divisional Committees and at the federal level with Council. The only person in receipt of payment for participation in the society management is the General Secretary. The activities of the Society include state meetings, national annual conference, participation in international activities and production of a journal. A number of grades of membership are available. The Society maintains a web page www.acoustics.asn.au.

The AAS is a member of a number of other organisations including FASTS, which represents and lobbies government on behalf of some 60,000 scientists and technologists from over 50 member societies in Australia. FASTS produces a Top Ten list of issues annually and this concept formed the basis of the current study to identify the Top Ten issues for Acoustics in Australia

3.0 SUMMARY OF RESPONSES

It was decided to use an open-ended survey targeted at a representative focus group to formulate the first top ten issues listing. The survey simply asked each of 13 representatives for their top ten issues in acoustics. Some responded with their own comments while some consulted with their colleagues. Not all provided ten issues and most did not wish to rank-order their issues. As anticipated many of the responses were biased towards the area of particular interest to the respondent. However there were some issues that, although stated in different ways, were common to many responses. All the respondents provided at least three issues, most provided close to ten and some provided more than ten. Some also included comments by way of guidance for actions that could be taken. The following attempts to categorise the responses with a view to identifying the top ten and thence the action plans.

Public face for acoustics

A 'public face' for acoustics in Australia is required. An effective presence would be ready to actively participate whenever there were opportunities to counter the concerns about the future of acoustics, the lack of educational opportunities, the promulgation of misleading information, the reduction in expertise in publicly funded organisations and agencies etc. It could also be pro-active to highlight the achievements of Australian acousticians and the opportunities for successful and satisfying careers in acoustics.

Future of Acoustics

Many expressed concerns about the future of acoustics in Australia in particular because of the reduction of Government funding to research organisations, to universities and to state and federal agencies.

Staff reductions mean that research organisations and government agencies are not employing and training the young people to be able to maintain, let alone increase, the high reputation that has been achieved by Australian acousticians across a wide range of fields. This means the expertise will only be in those areas which are able to attract considerable funding from the private sector.

The requirement to generate funding has led to the closing and sale of government, and hence independent, acoustic test facilities. The CSIRO acoustic facilities in Sydney are to be demolished. The test facilities at CSIRO in Melbourne will only be supported as long as there is an income stream from commercial testing. The sale of the National Acoustic Laboratory includes a lease-back arrangement but this will lead to greater pressure for cost recovery and could lead to the demolition of the facilities. These are outstanding facilities which include the largest and quietest anechoic chamber in Australia and the reverberations rooms with the highest between-room flanking attenuation.

With no reliable and continuing source of external funding for public interest research in acoustics there is an increasing reliance on overseas findings which may not be directly applicable. For example in the environmental noise area there is a need for research which can be fed into the policy development process for important community concerns such as sleep disturbance, low frequency noise, transport noise etc. There is a need for collaborative research where the acoustics input is just one part of the team.

Education

At the tertiary level there is a lack of recognition of the discipline of acoustics and in particular noise and vibration. Funding bodies, like ARC and DEST, do not have a category code for this area. Encouragement in the form of awards for outstanding student research projects and the publicity of achievements is a possible way to increase the profile of acoustics in the academic environment as well as in the community.

Promotion of the opportunities for a career in acoustics is required at the secondary and tertiary level. An up-to-date brochure highlighting the career opportunities is required.

There are many opportunities for employment in the private sector and there is a lack of graduates with some knowledge of acoustics for these positions. A variety of flexible courses are desperately needed. These include tertiary courses in acoustics providing comprehensive education at both the professional and technical level, acoustics subjects as part of other relevant courses, and intensive short courses to provide improved knowledge and skills for those entering the profession as well as refreshers for more experienced acousticians.

At the public level there is a need to provide better information on many aspects of acoustics so that public discussion on the topic is well informed and exaggerated claims are countered. Emotional issues such as the effects of noise on people, animals and sea life often appear in the media and there must be readily available means to ensure that replies from knowledgeable researchers are provided.

Information provided to the public on issues such as environmental noise is confusing due to the range of indices used for assessment. Guidance should be provided to the public to assist them to understand and interpret such information.

Professional issues

The AAS has a code of ethics and the implications of this code should be discussed and reinforced amongst the membership.

The AAS has strict guidelines for full membership but this is not the same as accreditation or certification that the member has a level of competency in a particular area. State and Federal agencies require some means to be sure that consultants have the required competencies.

There is inadequate policing of performance claims on products and some technical data is presented but not based on Australian or internationally accepted standards. Legislative requirements for specifications on noise and vibration are not uniformly complied with.

The opportunities for careers in acoustics should be promoted and the profile of the profession increased.

Professional indemnity insurance is an increasing issue for any acoustician doing consulting work. The availability of insurance, in particular for those undertaking a small number of consultancies, is a problem. The extent of liability is also an issue of concern for those who may be part of a larger team such as in building or road construction. Acoustics is bundled with other higher risk groups and so the premiums are unnecessarily high.

The adversarial role that is required of expert witnesses under the current legal system lowers the status of the profession.

Codes and standards in Acoustics

The delay in the proposed changes to the Building Code of Australia reflects poorly on acoustics in Australia. Most working in the area agree that the current standard is inadequate and agree with the proposed changes. Until the Code has been changed the inadequate performance meets the criteria.

The variation in environmental noise regulations and codes across all states adds to the confusion in the community and the various agencies need strong encouragement to come to agreement.

There is an urgent need for calibration and traceability of sonar systems and of ultrasound instruments used in medicine. The former is of great financial import due to the amount of business in Australia in this area and the latter because of the great potential for damage.

The applicability of International Codes and in particular EU directives needs to be examined. The acceptance of such guides may save duplication of research but this should only follow careful consideration of the local conditions.

There needs to be support for codes aimed at minimising the damage on humans from vibration, both hand arm, from use of tools and on the whole body.

Acoustical Society

The Society needs to consider all possibilities to increase membership. The target group should be the youth who should be encouraged to join and also to participate in all aspects of the society including the committees.

The Society needs to provide more professional support for members. This can include providing a good communication network, maintaining an adequate database, developing efficient methods to support members encountering difficulties etc. A survey is required to assess the needs and expectations of the current membership.

The methods of communicating with the membership should be examined and updated. The format of the state technical meetings, the national conferences and the journal of the Society all need to be examined to ascertain relevance and effectiveness.

While there is a range of subject areas in acoustics, the high numbers in the noise related topics means that less attention is paid to those areas with smaller numbers. The establishment of specialist subgroups could assist to counter this.

4.0 'TOP TEN' ISSUES

The assessment of the responses led to a listing of the Top Ten issues with suggested options for actions by the AAS. This draft was discussed at the Future Directions Workshop, and agreement on actions was obtained and endorsed at the following Council meeting. The listing and the actions are shown in Table 1.

Table 1 Actions on Top Ten Issues for Acoustics in 2003

	Issues	Agreed Actions
1	Public face for Acoustics	An Occasional Paper be prepared highlighting the problems and possible solutions facing acoustics in Australia and so deal with many of the top ten issues. This paper to be used to lobby government and to be launched with support of FASTS. Paper to be prepared by Burgess to be used during the Meet the Politicians Day organised by FASTS in October 2003. A member survey be undertaken with results compiled by end of 2003. The current President, Ken Mikl, be identified as the primary media contact for the AAS. Procedure for promoting this to the media and preparing media policy document to be discussed with FASTS.
2	Educate the youth on acoustics	Subcommittee convened by Byron Martin to prepare list of courses on acoustics in Australia and the list to be placed on the web. Three senior academics be encouraged to prepare a submission for the creation of a Research Field Discipline and Subject Code (RFCD) for Noise and Vibration.
3	Improve the education of those in acoustics	It was agreed that short courses on all aspects of acoustics should be encouraged but no specific actions from AAS at this time.
4	Retain and expand publicly funded acoustic facilities	The draft letter tabled at the workshop should be used as a basis for lobbying government. Ken Mikl and Neil Gross to liaise with FASTS on the best way to proceed. These issues would feature in the Occasional Paper described above
5	Retain acoustic expertise in publicly funded organisations and agencies	
6	Retain reputation of profession	A formal process of accreditation was considered beyond the scope of the AAS at this time. A "self regulated" listing to be implemented based on members selecting their areas of competency and relying on them abiding by the Code of Ethics. The listing to be updated annually and available from the web.
7	Grow the AAS	Member survey to include request for details of potential members. President's editorial in Acoustics Australia to urge members to encourage others to join the AAS.
8	Involve all members	Survey to ascertain needs of members and AAS to act upon responses. AAS to work in cooperation with other relevant organisations. As a first step AAS to agree to arrange 2 sessions at the Aust Institute of Physics Congress in Canberra in 2005. Burgess to liaise with AIP.
9	Professional support – legal, insurance etc	The Australian Association of Acoustical Consultants (AAAC) has some capabilities to provide assistance. AAAC be urged to promote itself in Acoustics Australia.
10	Encourage research	No specific actions – to be referred to in the Occasional Paper.

5.0 CONCLUSION

A study has been undertaken to identify the top ten issues of concern to the acoustics community in Australia at this time. Based on the responses from key stakeholders within the acoustic fraternity a consolidated list of key issues has been developed. Directions for actions to redress the problems identified and that utilise the resources available to the AAS were used as the basis for discussions at the Future Directions Workshop held by the AAS. Selected actions were agreed to at that workshop and the Council committed to implementation.

ACKNOWLEDGEMENT

This study was undertaken via an education grant from the AAS. The various respondents contacted during the preparation of this report are thanked for their input to the study.

Request for comments

Comments on the issues and the actions outlined in this paper are welcomed. AcousticsAustralia@acoustics.asn.au

Interview

FERGUS FRICKE

Interviewed by Howard Pollard

Preamble: After a distinguished career at the University of Sydney, Professor Fergus Fricke has decided it is time to retire from his position as Director of the Acoustics Laboratory. He has an impressive list of publications and has twice been awarded prizes for the best paper presented at a conference (Australian Acoustical Society and the International Conference on Automatic Control).

He has served on many national and international bodies concerned with acoustics including Standards Australia, NSW committee of AAS, ISO and InterNoise. He has been active as a consultant in relation to concert halls and auditoria and is currently acoustics adviser to the Sydney Opera House Trust. We hope that Ferg will have an active and satisfying retirement.

HP: Where did you start your formal education?

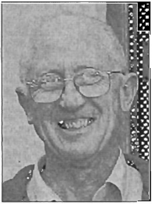
FF: I grew up in the eastern suburbs of Melbourne (Burwood). My early education was on the football field opposite where I lived, and nearby Gardiner's Creek, orchards, plant nurseries and market gardens.

My formal education was at Ashburton Primary School, Box Hill Technical School (my older brother went to Box Hill High School so I couldn't go there), specializing in sport, for four years. After that I went to Swinburne Technical College (now Swinburne University) and did a four year Diploma of Mechanical Engineering specializing in basketball and finally completed a BE at the University of Melbourne as a "blocko" (Graduates from Technical Colleges who showed some aptitude for academic studies were given a "block exemption" from the first two years of an engineering degree.).

Were you happy with the prospect of being an engineer?

After six weeks of work as an engineer at the Department of Civil Aviation I decided that an engineer's life was not a happy one and I enrolled in a research degree at Monash University studying pressure fluctuations in separated flows, skiing, bush walking, squash, sailing and acting whilst being a tutor at Deakin Hall and later while being a Senior Teaching Fellow.

My third job was as a Post Doctoral Fellow at the Institute of Sound and Vibration Research at the University of Southampton, working with Peter (P.O.A.L.) Davies on flow induced vibrations in nuclear reactor cores. This was much more like what I thought being an engineer was about. I also played squash with Peter until it was apparent that I would either have to give it up or learn how to resuscitate someone who had just had a heart attack (Peter subsequently survived a heart attack on the squash court but not in my presence). I chose the former and concentrated on sailing, in the Solent and across the Channel to France, and holidays driving a London, 48 HP, red, double-decker bus to the Soviet Union.



Fergus Fricke

Did you need a special license to drive the double-decker bus?

The friend who owned the bus asked me to come down to the lorry park by Southampton docks, one Saturday afternoon, for a trial drive to check out whether I was competent to drive it. That was the first time I had ever driven a vehicle as heavy as a bus and the first time I had driven a vehicle with a "crash box", though my first car (a $10 Morris 10) had very worn synchromesh so double-declutching was a concept I knew a little about. I drove once around the lorry park and Les asked me to back the bus in beside my Riley, which I did. He said that anyone stupid enough to do that manoeuvre on his first drive was fit to drive the bus to Leningrad. I suppose that was probably the start of my growing belief that there are lots of things that can be done in ignorance which can't be done with knowledge. I have made good use of that concept in my academic career.

What happened to the bus after you reached the Soviet Union? Did you drive it home?

Yes, part way. My wife and I left the bus at Helsinki on the way home and hitch-hiked back to Southampton through Finland, Sweden, Norway and Denmark for three weeks, sleeping in parks and youth hostels, when we could find them. Another ignorant person took over the bus driving from me and they got as far as the Netherlands before the crankshaft broke. My fellow travellers on the bus kindly blamed the replacement driver for that catastrophe but I have always had my suspicions that it was a fatigue failure. Again this had relevance to my subsequent views on life: don't drive yourself, or anyone else, too hard for too long and preferably hop off before failure occurs.

What was next on your agenda?

My fourth job was at Sheffield University where, as a lecturer, I undertook research in Building Aerodynamics and Acoustics and concentrated on family matters (both my children were born in Sheffield), squash, "tramping" in the Peak District, restoring a house, learning to play lawn bowls on a "humped" green (a peculiarly north of England game which made playing on a flat green look like a Sunday afternoon picnic) and canal boating.

After that lot I went to the Herrick Laboratory at Purdue University in the USA for six months on my way back to take up a position at Sydney University undertaking teaching and research in acoustics and more recently as a Head of Department and Acting Dean.

How did you react to teaching university students?

My acoustics teaching and research at Sydney University has been fairly varied. I have tried to teach undergraduate architecture students about acoustics with remarkably little success. It seems the greatest impression I left students with was the quality of my shirts and the fact that I didn't iron them. I was a little more successful in teaching undergraduate engineering, music and physics students and postgraduate coursework students. This teaching resulted in a number of excellent students deciding to undertake research degrees with me.

In 1995 I established an "Audio" postgraduate coursework program in the Department of Architectural and Design Science, in co-operation with Physics, Electrical Engineering and Music, despite opposition from many staff who thought that audio and acoustics had nothing to do with architecture. The program has been a great success thanks to Ian Dash, the first coordinator, and Densil Cabrera who took over from Ian.

And what about research?

My greatest success as a researcher, I suspect, was to interest people like Rob Bullen, Andrew Madry, Qunli Wu, John Wendoloski, Chris Field, Densil Cabrera and Joseph Nannariello in undertaking PhDs and letting them have their head. I am grateful that none of my 25 PhD students has yet emulated me and supervised 25 PhD students. I figure that if they had all followed my example the world would be totally populated by acousticians in under 250 years, if the world's population stayed the same and a few other assumptions held. A frightening thought!

My fields of interest range from empirical to theoretical studies in areas such as room acoustics, sound propagation, aerodynamic noise, noise control, duct acoustics, perception of sound, musical acoustics and the application of numerical methods, such as neural network analysis, to acoustic issues.

You presumably took study leave on a number of occasions.

My first study leave was taken at the UK Atomic Energy Authority at Windscale (now known as Sellafield) applying power fluidics techniques to control flows in reactor cores. The second was at the University of Canterbury, NZ to study sound propagation through forests. Then, at the National Acoustic Laboratories, Sydney I spent time working on other aspects of outdoor sound propagation, while at Cornell University I tried to understand more about Facilities Management (after I had set up a postgraduate program in FM at Sydney University!). At the University of Pennsylvania I saw whether I could live in the USA again (I couldn't) and at the University of Auckland, I worked on the application of neural network analysis to concert hall acoustic design.

After such a varied career, what are your plans for retirement?

My plans for retirement are fairly open as I believe that fortune and fate favour tall and relaxed people. I will be continuing my community and environmental activities, music playing, consulting work, writing and the supervision of my remaining research students to completion (I may have to have an extended lifespan in a couple of cases!).

I do have some ideas for acoustics research that I would like to work on and I also have ongoing work as acoustic adviser to the Sydney Opera House Trust and other consulting work. I hold a patent with Chris Field for a ventilation silencer (which is currently being commercialised) and so in my dreams I will have a full-time job deciding how I am going to give away or spend the royalty payments. Besides that Gill and I will be spending time in Italy and seeing more of Australia.

SOLVING THE MYSTERY OF THE CAT'S PURR USING THE WORLD'S SMALLEST ACCELEROMETER*

Elizabeth von Muggenthaler and Bill Wright
Fauna Communications Research Institute, USA.

Ever since the Egyptians started worshipping the cat, philosophers, scientists and cat lovers worldwide have wondered why cats purr. Fauna Communications and ENDEVCO initiated a novel research study that recorded the purrs of five species of cats – cheetah, puma, serval, ocelot and the domestic cat. This research has contributed valuable information that may solve the mystery behind the cat's purr.

It is commonly believed that cats purr when content. However, cats also purr when they are severely injured, frightened or giving birth. So if cats were purring solely out of happiness they would not purr when injured, especially as the generation of the purr requires energy, and an injured animal will generally not expend precious energy needed for healing on an activity not directly connected with their survival.

Since the purr has lasted through hundreds of generations of cats, there must be a survival mechanism behind its continued existence. Suggesting that the purr evolved to function solely as a vocalisation of self-contentment goes directly against the basic tenets of evolutionary psychology and natural selection. Could the purr in any way link to the fact that vibrational stimulation not only relieves suffering in 82% of persons suffering from acute and chronic pain but also generates new tissue growth, augments wound tissue strength, improves local circulation and oxygenation, reduces swelling and/or inhibits bacterial growth?

SURVIVAL OF THE FITTEST

Throughout history, the cat has been the most worshipped and the most persecuted domestic animal. Perhaps the most popular cat saying is that they have "nine lives". This type of old wives' tale usually has a grain of truth behind it, especially since there is also an old veterinary school adage that states "If you put a cat and a sack of broken bones in the same room the bones will heal".

Most veterinary orthopaedic surgeons have observed how relatively easy it is to mend broken cat bones, as compared with dogs. In a study of "High Rise Syndrome" found in the Journal of the American Veterinary Medical Association, Drs. Whitney and Mehlhaff documented 132 cases of cats plummeting from high-rise apartments, the average fall being 5.5 storeys, or 55 feet. The record height for survival was 45 storeys. Ninety percent of the 132 cats studied survived even though some had severe injuries. There is also literature that suggests that domestic cats are in general less prone to post-operative complications following elective surgeries.

Cats do not have near the prevalence of orthopaedic disease or ligament and muscle traumas as dogs have, and non-union of fractures in cats is rare. Researchers believe that self-healing is the survival mechanism behind the purr. There is extensive documentation that suggests that low frequencies, at low intensity, are therapeutic. These frequencies can aid bone growth, fracture healing, pain relief, tendon and muscle strength and repair, joint mobility, the reduction of swelling, and the relief of dyspnea, or breathlessness.

In order to measure the domestic cat's purrs and how purr vibration is spread throughout its body ENDEVCO Model 22 accelerometers were used. Weighing a mere 0.14 gram, this is the world's smallest accelerometer. It mounts adhesively, requires no external power and is ground isolated. It is typically used on such small objects as scaled models, circuit boards and disk drives.

During tests, the cats relaxed on blankets, and were encouraged to purr by occasionally stroking them. The small, lightweight Model 22 accelerometers were placed directly on the skin of the cats and stabilised using washable make-up glue and medical tape. Each recording session lasted between 6 and 10 minutes. Data was recorded on DAT recorders and analysed.

Results indicated that despite size and different genetics, all of the individual cats have strong purr frequencies that fall within the range of a multitude of therapeutic frequencies and particular decibel levels. Frequencies of 25 and 50 Hz are the best, and 100 Hz and 200 Hz the second best frequencies for promoting bone strength. Exposure to these signals elevates bone strength by approximately 30%, and increases the speed at which the fractures heal.

PURRING THE PAIN AWAY

All the cats had purr frequencies between 20 Hz and 200 Hz. With the exception of the cheetah, which had frequencies ± 2 Hz from the rest, all the species had frequencies, notably 25 Hz, 50 Hz, 100 Hz, 125 Hz, and 150 Hz, that correspond exactly with the best frequencies determined by the most recent research for bone growth, fracture healing, pain relief, relief of breathlessness, and inflammation. All of the cats' purrs, including the cheetah, had frequencies ±4 Hz from the entire repertoire of low frequencies known to be therapeutic for all of the ailments.

The fact that the cats in this study produced frequencies that have been proven to improve healing time, strength and mobility could explain the purr's natural selection. After a day or night of hunting, purring could be likened to an internal vibrational therapeutic system, a sort of "kitty massage" that would keep muscles and ligaments in prime condition and less prone to injury. Additionally, the purr could strengthen bone, and prevent osteodiseases. Following injury, the purr vibrations would help heal the wound or bone associated with the injury, reduce swelling, and provide a measure of pain relief during the healing process.

* Reprinted with permission from *B&K Magazine* No. 1, 2003, pp. 24–25

AAS Council

Strategic Plan for the Future of the Society

At the end of May, Council held a two day workshop to discuss the future direction for the Society. The workshop was organised with the assistance of the Federation of Australian Scientific and Technological Societies (FASTS) and a professional facilitator. The meeting covered a very wide area including membership, professional recognition, management of the Society, what members want from the Society, methods of communicating with members, etc.

The starting point for the meeting was a report provided by Marion Burgess and Joseph Lai to identify the top ten issues of concern to the acoustic community. The results of this survey are discussed elsewhere in this journal. The second day of the workshop was spent developing a plan for the future direction of the Society for consideration at the Council meeting held on the third day. The following is a summary of the main decisions made:-

Membership Accreditation System - It was agreed to trial a self-regulated system of recording member's professional areas of competency. A list of Members (and their company name and address), showing their areas of competency, will be placed on the Society website. Five Professional Areas of Competence will be listed: Vibration, Industrial Noise, Architectural/Building Acoustics, Occupational and Environmental Noise. Any Member working as a consultant will have the opportunity to have their name included on the list. It is proposed to commence this accreditation system later this year.

Attract New Members - The membership of the Society has been stagnant over the last few years and yet there are many people working in acoustics who have not joined the Society. It was agreed to ask members to invite any of their colleagues, who are not members, to join the Society. The registration fee for the Society's annual conference has always been discounted for members. It was agreed to grant non-members attending the annual conferences one year's free membership at Subscriber grade. It was agreed to simplify the application forms for Students and Subscribers and to reduce the application fee to $25.00. In addition, it was agreed to grant new Student members free membership for their first year.

Top Ten Issues - The survey shows that members of the Society are concerned about the lack of support of government for research and education in acoustics. It is proposed that a FASTS Occasional Paper will be prepared and, with the assistance of FASTS, presented to the Federal Government.

Media - The Society in the past has had a low profile in regard to communicating with the media and government. It was agreed at the workshop that a Media Officer should be appointed to act as the spokesman for the Society. Initially, this place will be filled by the President.

Members Survey - The workshop identified a need to identify what members want from the Society. It was agreed to conduct a survey of members to determine their needs.

Communications - It was agreed to use email and the website more to communicate with members. The State Division meetings and news items will be placed on the website and a new "positions vacant" page established for those organisations wishing to advertise employment for acousticians.

Register And Directory Of Members - It was agreed to place a copy of the register of members on the Society website, with password protection, so that members can update their own personal details. The register will replace the Directory of Members that had previously been published on a CD ROM. It is hoped that this will facilitate the updating of the official Society Register and result in the directory always being correct.

Comments or suggestions from members on any aspects of the Society organization are very welcome and can be made to your State Committee or Councilor, or to the General Secretary, GeneralSecretary@acoustics.asn.au

Generic Email Addresses

The Council has now set up a group of generic email addresses for the key office bearers ie:

President@acoustics.asn.au,
VicePresident@acoustics.asn.au,
Treasurer@acoustics.asn.au
GeneralSecretary@acoustics.asn.au
Registrar@acoustics.asn.au
AcousticsAustralia@acoustics.asn.au.

Just a reminder that contact details for the federal and state committees plus a host of other information on the AAS are available from www.acoustics.asn.au

AAS AGM 2003

Normally the AGM for the Society is held in November during the annual conference. This year the Society is not holding an annual conference in November as it hosted the Wespac8 conference in Melbourne during April. It would be good to use modern technology and have a virtual AGM in November but this is not permitted under the legal requirements. So an advance notice is that the AGM will be held on:

Friday 14th November
6.30 pm in Brisbane.

This will permit members participating in AVPC2003 (see below) at the Gold Coast to attend the AGM function after Conference close. There will be a formal dinner and award presentation held after the AGM, hosted by the Queensland Division. Notices will be sent out in due course, however, should you have any matters you would like included on the Agenda please forward to the General Secretary at GeneralSecretary@acoustics.asn.au by Friday 17th October 2003.

Future Meetings

Acoustics 2004

The AAS Annual Conference, Acoustics 2004, will be held at the Gold Coast International Hotel in the heart of Surfers Paradise, November 3-5 2004. The conference will provide a forum for the presentation of a wide range of papers on all aspects of fundamental and applied Acoustics and Vibrations. Papers from all areas of acoustics are welcomed including Transportation Noise and Vibration, Environmental Noise, Occupational Noise, Architectural Acoustics, Underwater Acoustics, Industrial Noise & Vibration Control, Noise Legislation, Sound Measurement Techniques. Submitted papers will be peer reviewed, where requested, under the coordination of a scientific advisory panel. A series of workshops will focus on aspects of transportation noise.
aas2004@acran.com.au
www.acoustics.asn.au

Asia-Pacific Vibration Conference (APVC)

The APVC is a biennial international conference dealing with the varied aspects of dynamics, control, sound and vibration. APVC 2003 is being organised by the Queensland University of Technology (QUT) and will be held at the Royal Pines Resort, Gold Coast, Australia 12th-14th November 2003. The APVC 2003 is a refereed conference and brings together academics, practitioners and scientists from around the world, as well as showcases state of the art instrumentation and technologies.

The objectives of the conference are to promote research and practice in the field of dynamics, control, sound and vibration; strengthen the link between academic researchers and practitioners in the field; and showcase state of the art instrumentation and technology in sound and vibration measurement, analysis and control.

http://www.apvc.net/index.html

Internoise 2004

The 33rd conference for the International Institute of Noise Control Engineering, Internoise 2004, is being organised by the Czech Acoustical Society and will be held in Prague, August 22 to 25, 2004. The theme for the Congress is as broad as possible to cover all interesting aspects "Progress in Noise Control for the 21st Century". As in previous years, the congress is open to all innovative contributions from a variety of topics in noise control engineering. The organizing committee has taken great pains to arrange an outstanding technical program and exhibition. The congress will be held at the campus of the Czech Technical University. The buildings of the Faculty of Electrical Engineering and the Faculty of Mechanical Engineering offer all of the facilities necessary for a congress of this size. In addition, the main congress hotels are within easy walking distance. Last but not least, the city of Prague offers great architectural beauty and new-found dynamism.

Information about the conference including deadlines for abstract submissions etc is available from www.i-ince.org.

ICSV11

The 11th International Congress on Sound and Vibration was previously planned to be held in Singapore in July. In view of the concerns about holding international conferences in this area at this time the proposed venue has been postponed. It has recently been announced that the ICSV11 will be held in St Petersburg, Russia 5-8 July 2004.

It is anticipated the Congress will conform to the usual style with keynote addresses, papers, special sessions and tutorials. In addition, structured industry forums in areas of sound and vibration will be presented. Technical papers in all areas of sound and vibration across varied industries are welcome. The call for papers, deadlines, conference details etc will soon be available from www.iiav.org

16th AIP Congress

The 16th Biennial Congress organized by the Australian Institute of Physics (AIP) is entitled "Physics for the Nation" and will be held at ANU, Canberra January 31 - February 4, 2005. This will be a large congress covering topics in a very wide range. The AAS is supporting this conference by assisting with arrangements for two special sessions, one on physics and music and the second on ultrasonics. Further information on the conference is available from www.aip.org.au

Meeting Reports

WESPAC8

Wespac8 Conference, held in Melbourne at the Carlton Crest Hotel from Apr 7 to 9, officially began on Monday when Charles Don spoke as Conference and Wespac chairman, and AAS president. Victoria Division chairman, Norm Broner welcomed those present, while the Rt Hon Kelvin Thomson, Federal Shadow Minister for Sustainability and Environment, officially opened the Conference and outlined the variety of noise issues to be discussed. Some short musical items were also included. The main conference business then followed.

When registrations for the conference began to come in, a total of 317 indicated their initial interest. Nearer the conference, this number declined to a total of 233 registered with an additional 21 accompanying persons. Just before the conference, 34 of those registered cancelled their trips because of SARS and war hazards, etc.

The Monday evening trip to the Emu Bottom Homestead (included in the registration) included a BBQ dinner and billy tea around camp fires, entertainment by typically Australian activities such as a Bush Band Trio, Dave's Bush Music Show, sheep dogs at work, sheep shearing, boomerang throwing, two-up games, and art and craft stalls. Those who attended the conference dinner (109) not only witnessed the presentations and award, but also were entertained by, and greatly enjoyed the Australian Girls Choir's program of attractive choral arrangements of songs varying from the Aboriginal *Jabbin jabbin*, through *Aussie and Celebration Medleys* to *I still call Australia home.*

In all, 203 technical papers, including 3 plenary lectures, 6 distinguished lectures and 10 keynote lectures (each lasting 40 minutes), and 184 other lectures (each 20 minutes) were listed in the Wespac8 Program and Abstracts. Their authors were from 21 Pacific and other countries – Australia (60 papers), Japan (56), Korea (28), China (10), Taiwan (9), USA (8), New Zealand (6), Hong Kong (4), Singapore (2) and Canada (1) ; and France (4), Russia (3), Belgium, Denmark and Germany (each 2) and Finland, India, Italy, South Africa, Sweden and Thailand (each 1).

In the opening plenary lecture (AP1), Medical applications of acoustics, Lawrence Crum described the many medical uses (as distinct from engineering and other applications) to which ultrasonics are now being developed and applied. In the second (AP2), Does active noise control have a future? Colin Hansen affirmed that, though there are numerous difficulties in applying it, active noise control is feasible, and methods of applying it are being developed. In the third (AP3), From idea to acoustics and back again, Joe Wolfe described in considerable detail the uncompressed and compressed forms in which the information in musical sounds may be coded.

The six distinguished lectures were taken as three alternative pairs, and covered the Development of underwater acoustics in China (DA1) and Visualisation/Auralisation of sound fields for room acoustics (DB1), Applications of acoustic tomography to observations of mesoscale oceanic variabilities (DA2) and Acoustics for speech in classrooms and meeting rooms (DB2), and Interfacing sound quality and noise conrol, an aspect of perception-based engineering (DA3) and Speech corpus for speech science and technology (DB3).

The remaining 184 papers published the findings of a wide variety of recent research and investigations, and were arranged to be given in five parallel groups. Group A [38 incl 2 keynote papers] comprised the many aspects of Underwater Acoustics ; group B [39 incl 1 keynote] comprised Speech (24), Transducers (3), Sound Quality (4) and Musical Acoustics (8) ; group C [35 incl 3 keynote] comprised Auditorium and Room (16), and Building (11) Acoustics, Instrumentation (4) and the remaining Noise and Vibration papers (4) ; group D [42 incl 1 keynote] comprised Environmental Acoustics (26), Rail (5) and Road (2) Transport Noise, and Noise and Vibration (9); and group E [40 incl 3 keynote] comprised Instrumentation (5), Active Noise Control (15), Psycho- and Physio-logical Acoustics (9), and Ultrasonics (basic aspects 6, applications 4, biological 1).

Some of these papers (beginning with Patricia Davies' DA3) show that the perennial problem of noise and vibration not always being considered early enough at the design stage of buildings, appliances, equipment and machines is as much with us today as it was 50 and more years ago. One paper (TD34) demonstrated that many of our kitchen and other home appliances are still too noisy.

The proceedings are available on CD from GeneralSecretary@acoustics.asn.au for $100+ $10GST (incl postage & handling).

At its close (also including some short items of musical entertainment), Wespac8 was on all counts voted a very successful conference, not only because of the quality of the papers presented and the accompanying entertainment and social opportunities, but particularly because of the pre-conference preparation and conference organization of Charles Don, David Watkins, Norm Broner, their Victoria Division committee, and other helpers.

C Louis Fouvy

Acoustics in Schools

On May 5, 2003, CSR Gyprock & Fibre Cement held a seminar in Sydney entitled "To hear and to be heard in educational premises". The keynote speaker was Mr Carsten Svensson, Concept Developer – Education, from Saint-Gobain Ecophon, Sweden. The subject of the presentation was classroom design with the main emphasis centered on acoustical considerations.

The audience was a mix of acoustical designers and architects and for this reason the discussions were held to a fairly general level as far as the acoustic aspects were concerned. Ecophon has obviously spent considerable time and resources addressing efforts at providing better acoustic conditions for classrooms particularly in the area at absorbing the internal noise generated by room occupants – which is usually the main noise source. Numerous studies have shown that the most disturbing noise in classrooms is that generated by the activities and chatter of other pupils.

The initial design period is the stage that effective solutions to internal and external noise problems should be addressed. Prevention is the best solution, with the greatest and most effective input being at the commencement of the project. Retrofits are always difficult and expensive. Figures presented claimed that in Australia, on average, individuals will spend up to 20 years in a classroom learning situation. From my general knowledge this seemed a rather high figure (perhaps we are a bunch of slow learners!!) but with this many years spent in a learning environment students need optimal learning conditions not to mention acoustic comfort.

It is not only the acoustic comfort of the 'average' student that must be considered but also that of students who may be hearing impaired or those who have English as a second language. Comprehension of speech amongst background noise diminished rapidly for any aural impairment and for non-native speakers of a language. However, not only are we looking at the learning environment for the students but also at the work environment for the teacher. The higher the overall noise level the more the teacher needs to raise their voice in order to maintain a reasonable signal-to-noise ratio. Swedish figures show that large numbers of teachers suffer from voice strain. Lower classroom noise levels would certainly address this difficulty.

The presentation was excellent with a great deal of information, and well presented. For those with a further interest the work is also available in a book, published by Ecophon, and currently distributed in Australia through CSR Gyprock & Fibre Cement. In summary it was good to see a group focusing on classroom noise problems without the prime emphasis centered on winding up the signal-to-noise ratio through amplification alone.

Warwick Williams

ABC Studios

On 3 June 2003 the ACT Group had a technical meeting and tour of the ABC Studios in Canberra. These studios were recently refurbished along with construction of new office space. **Jim Wise**, the technical services manager outlined the extent of the recent construction work and then took us on a tour of the radio studios and their associated control areas. A major benefit of refurbishment rather than reconstruction was that the studios maintained their spaciousness, unlike the modern practice of smaller floor space for the studios. As part of the renovation a proper waiting area was created with good access to all the studios. The sound absorbing material on the walls has been modernised with the removal of the extensive dark timber perforated paneling. Major changes have been made to the consoles with the introduction of a variety of computer controls and monitoring screens. Improved performance in the recording and the use of headset microphones by the presenters have all contributed to a reduction in the high demand that used to be placed on the room acoustics for the studios. However it is still important to get the basics correct.

Marion Burgess

SA EPA Directions

The South Australian EPA held a roundtable forum to comment on their Draft Strategic Directions in May. There were approximately 120 delegates from industry, local government, and industry and environmental groups. The AAS was represented by Byron Martin (SA Chairman). The EPA put up eight Draft Strategic Directions for comment by the assembled body, who were divided into groups of ten, with all comments recorded for feed-back to the EPA. Our group (including one lawyer) commented that several of the Draft Strategic Directions were "motherhood statements" which were really part of a Business Plan. Our group conclusions were that :-

- All enforcement agencies should have adequate and consistent training.
- Guidelines and Codes of Practice should be regularly updated with industry consultation.
- The EPA should be able to advise their clients who the relevant (accredited) Consultants are.
- There is a need for an umbrella environmental policy in Australia.
- EPA officers should have "industry experience". This could be achieved through graduate development programs with industry.

Byron Martin

SA Division Noise Policy

On 26 March Jason Turner, Senior Adviser for the South Australian Environment Protection Authority, spoke on the new environmental noise policy that is currently being drafted to replace the existing policies that have effectively been in place for over 20 years. This presentation enabled the Authority to brief AAS members prior to release for broader public consultation and 11 members attended. A strong debate was generated, particularly with respect to the proposed link with the South Australian development assessment system. An overview of the presentation:

- The proposed Environment Protection (Noise) Policy (draft Noise EPP) will replace the two current Environment Protection Policies (EPPs) relating to noise in South Australia, the Environment Protection (Industrial Noise) Policy 1994, and the Environment Protection (Machine Noise) Policy 1994.
- The two current EPPs, which are based on the Noise Control Act 1977, incorporate to some degree outmoded technical criteria and deficiencies in applying the principles of ecologically sustainable development to various areas of community activity. For example, the policies do not adequately address the increasing interaction between rural living and rural industry activities.
- As well as providing an up to date response to noise issues, the new Noise EPP will provide clarity and transparency for industry, local government, planners, authorised officers and the residential portion of the community in securing of compliance with the Environment Protection Act 1993 (the EP Act).

- The Indicative Noise Levels provide protection from noise pollution for the community and are based on a recently completed World Health Organisation (WHO) study on, amongst other things, the effects of noise on physical and mental health as a result of long term annoyance and prolonged disturbance to sleep.
- The draft Noise EPP is separated into two distinct sections: a main section providing the general provisions as they are applied to existing situations and referred development applications. A second section provides various assessment methods applicable to specific issues, such as the development of wind farms and the use of audible bird scaring devices and frost prevention fans in the wine regions.
- The draft Noise EPP will provide a means for a more efficient and cost effective resolution of noise issues, and will promote resolution that is consistent with the planning process carried out under the Development Act 1993 without compromising environmental standards.

The first major consultation period for the Policy closed in late June for written submissions and culminated in a public hearing where oral submissions were presented. The EPA will use all the comments to refine the draft policy.

Dave Bies – 50 years PhD

On the 18th of June 2003, Dave Bies (FAAS) celebrated the 50th year of the granting of his PhD. The SA Division held a technical meeting on Saturday 21st June, at Peter Maddern's Normanville retreat on the coast south of Adelaide, to celebrate Dave's achievement. The technical meeting, attended by 20 divisional members and friends, revolved around a festive long luncheon and Dave's reminiscing about the past 50 years in acoustics and life. The discussions (or networking) went well into the night, lubricated by bottles of fine reds from the Barossa, McLaren Vale & Clare wine regions, care of Peter Teague! Peter Maddern's engineering skills converted his power hacksaw into a rotisserie. Luckily our (SA) EPA noise monitors were 40 kms away in Adelaide!!

Meteorology and Sound Transmission

On Wednesday 23rd July, Chris Purton of Tonkin Consulting spoke on Meteorology and Sound Transmission. This was a very engaging talk covering the influence of meteorological categories and Pasquill stability classes on the propagation of noise. Chris discussed the dispersion/diffusion and refraction effects of vertical wind and temperature profiles and turbulence, the accuracy and limitations of models based on 40 year old empirical data (eg CONCAWE) and the influence of local topography and heat storage/instability in urban areas. He presented Gaussian dispersion models and the measurement of vertical met parameters using sounding balloons plus more advanced ray tracing algorithms for more accurate simulation. Chris concluded by noting that model users should be aware of the limitations and assumptions in applying empirically based models.

FASTS

"SCIENCE MEETS PARLIAMENT" DAY

Planning for the "Science Meets Parliament Day" on October 14, 15 is progressing. This event has had a tremendous impact on Parliament, helping change the attitudes of Parliamentarians towards the funding and impact of science. For the first time the AAS is poised to participate in this event — see the call for expressions of interest in participation as insert for this issue or check the AAS web. The draft of the paper on AAS issues will be available as background briefing for those involved. Any suggestions for points to be discussed during this day are welcomed and should be forwarded to acoust-aust@adfa.edu.au or tel 02 6268 8241. More information about the event is available from www.fasts.org

LACK OF HONOURS FOR SCIENTISTS

In the last Australia Day Honours list, scientists were conspicuous by their absence. FASTS is encouraging all the member societies to consider nominating distinguished members for an award for his/her outstanding achievement. Details of the nomination process are given on www.itsanhonour.gov.au/about_honours.htm

Please forward any suggestions to: GeneralSecretary@ acoustics.asn.au

Standards

Below is a listing of the Standards Committees that the AAS has representation should any member wish to discuss aspects of the standards prepared by that committee

AV/1	Vibrations Terms, Units and Symbols - J Fowler G Harding
AV/2	Instrumentation and Measurement Techniques - P Alway J McLoughlin
AV/3	Human Effects - K Scannell W L Huson
AV3/3	Audiology - T Klar
AV/4	Architectural - N Gabriels, N Broner
EV/10	Community Noise - P Teague, A R Brown
AV/7	Noise from Office and Household Equipment - V Bray
AV/9	Vibration and Shock Applications - B Martin
EV/11	Aircraft and Helicopter Noise - R Bullen, A Lawrence
EV/16	Wind Turbine Noise - P Teague, K Williams

EV-010 Community Noise

Peter Teague is the AAS representative on this committee and currently Chair.

At the EV-010 Committee Meeting on the 15th April 2003 (previous meeting Feb 02), a number of major new items were raised and discussed. The committee also minuted the tremendous effort, support and direction for the committee that Prof Anita Lawrence provided over her many years as Chair.

The committee is reviewing the standard AS 2436-1981 *"Guide to noise control on construction, maintenance and demolition sites"* (from committee AV-006), with a focus on the revision of Table 2 *Typical A-weighted sound power levels from site equipment and possible adoption of the British Standard BS 5228 "Noise and vibration control on construction and open sites"*. The committee agreed that representation from more relevant organisations would be helpful in the process of the revision of AS 2436. Additional aspects to be considered in the revision of AS 2436 include time periods for construction, descriptors for rating/ measurement, sleep disturbance issues, planning issues, prediction, construction industry requirements, OH&S issues (AS 1269), community noise impact, community consultation. The committee is investigating the use of any appropriate sections of BS 5228 and NZS 6803-1999, noting that references to non-local legislation/ requirements and criteria be excluded.

The EV-010 committee is also considering a review of AS 1055 *"Acoustics – Description and Measurement of Environmental Noise"*, with consideration of possible adoption of the draft ISO standards, ISO/FDIS 1996.1 and 1996.2. I recommended that the AAS be given time to review the drafts and a member of the committee is preparing a list of differences between the AS 1055 and ISO 1996 series to assist in this process. It has been suggested that both ISO drafts offer more technical information than AS 1055 and that AS 1055 has been previously criticised for being too technical.

Another issue discussed by the committee was whether to develop a standard on microphone windshield testing, which came from an action passed on by committee EV-016 *Wind Turbine Noise*. The committee agreed that it should and I, as Chair, requested that the project be raised with the SAI board, with the consideration/ background that manufacturers of windshields typically do not provide valid technical data for their products and the lack of precision tolerances. A range of issues was raised for potential inclusion in the new standard, such as: durability, forms/materials of construction, range of wind velocity & direction, type of support, type of testing (static/dynamic), compliance testing, identification, traceability, types of applications/uses and monitoring systems.

The EV-010-04 *Railway Noise* subcommittee is preparing a new Australian Standard, as a committee draft EV-010-0746-2.2.3, on *"Acoustics - Railway noise intrusion - Building siting and construction"*. The subcommittee is waiting until the release of the draft NSW EPA Noise Policy before revising the draft standard. A NSW EPA representative will give a presentation on the draft policy at the next subcommittee meeting, at which further revision of the draft standard will be discussed. The new revised standard AS 2377-2002 *"Acoustics - Methods for the measurement of railbound vehicle noise"* was published and released on the 7th May 2002

The next meeting of the EV-010 Committee is scheduled for the 11th Sept 2003 to be followed by EV-010-04 Subcommittee on 12th Sept.

Peter Teague

EV-016 Wind Turbine Noise

Peter Teague is the AAS representative on this committee

There have been four meetings of the Standards Australia EV-016 Committee since the committee was formed in July 2002; on 2 Aug 02, 23 Sept 02, 25 Nov 02, 14 Apr 03. The committee is in the process of developing an Australian Standard *"Acoustics – Prediction and measurement of noise from wind turbine generators"* and hopes to produce a public draft for comment by the end of this year. The primary documents before the committee that are being used to help develop the draft standard include: SA EPA (Feb 2003) *Environmental Noise Guidelines – Wind Farms;* NZS 6808:1998 *Acoustics - The assessment and measurement of sound from wind turbine generators*; IEC CDV 61400-11 *Wind turbine generators - Part 11: Acoustic noise measurement techniques; and* ETSU-R-97 (UK DIT) *The Assessment and Rating of Noise from Wind Farms*

The committee has made significant progress by developing the proposed content and level of the most relevant sections. The SA EPA guidelines have been used as a good baseline for the development of the draft standard. The committee needs to produce a standard that provides a suitable/applicable framework for reference by the different state government authorities and industry.

The draft standard will cover: definitions, guide to setting acceptable noise limits, pre-installation predictions and measurements, instrumentation and calibration, background noise and wind measurements, data correlation and regression analysis, compliance testing, special audible characteristics, documentation and informative appendices. Careful attention is being directed towards appropriate and clear definitions for a range of terms; for example, what exactly constitutes a relevant receiver location.

The appropriate background noise level descriptor to use is the L_{90}, given that an L_{10} or Leq descriptor would be influenced by wind/extraneous noise effects (and given the relatively constant nature of wind turbine noise). The NZS uses the L_{95} descriptor but the L_{90} is more widely used and accepted throughout Australia. An informative appendix is being developed that discusses the relationship between L_{90} or L_{eq} for variable speed machines.

Careful consideration has been given to providing clear guidelines for the requirements for data collection, correlation and analysis. For example, the measured background noise levels are to be plotted against the measured wind speeds (from wind turbine cut-in wind speed to rated wind speed) and the data fitted with a regression curve, which in turn would be used to help define criteria. The committee has also considered the extent of wind induced microphone noise on measured background noise levels; data collected by the SA EPA shows that this is not likely to be a major issue.

For the purpose of calculating a preliminary estimate or indication of noise levels from a proposed wind farm, a basic equation is given as a conservative predictor which does not take into account wind, ground or topographical effects on propagation. A more detailed approach is described for more accurate prediction that incorporates an octave band analysis and more complex models that can include the effects of topography, ground effects, screening, reflections, the variation of atmospheric absorption and the propagation effects of wind. An informative appendix will provide a worked calculation example and discuss further the effects that more complex models may incorporate.

An important issue is the treatment of special noise characteristics such as tonality, modulation, impulsiveness, swish, infrasound and ultrasound. The committee agreed that reference should not be made of infrasound and ultrasound, as these are not characteristics of modern day wind turbines. An informative appendix is being developed that provides guidance on the characteristics that may occur and summarises the experiences of typical characteristics.

Another major issue discussed by the committee was microphone windshield testing. This was considered very important given that manufacturers of windshields typically do not provide valid technical data for their products and the lack of precision tolerances. A range of issues was raised such as durability, materials of construction, range of wind velocity & direction, type of support, type of testing (static/dynamic), compliance testing, identification, traceability, types of applications and monitoring systems. The committee agreed that it would pass on to the EV-010 committee for consideration and recommend the development of a new standard be raised with the SAI board.

The next meeting of the committee will refine the structure and content of the working draft to date and incorporate drafted informative appendices.

Peter Teague

New Members

Member

Densil Carbera (NSW)
Joseph Feltham (Qld)
Darren Jurevicious (NSW)
Gustaf Reutersward (Vic)
Karen Roberts (Qld)

Associate

Matthew Harwood (NSW)

Graduate

Steven Chamberlain (Qld)
Matthew Goodfellow (Qld)
Jennifer Uhr (Qld)

Student

Kenneth Fairbairn (NSW)

Subscriber

Fadia Sami (NZ/Qld)

News

Brisbane Noise Strategy

Brisbane City Council has recently introduced a draft Long-term Integrated Strategy targeting Environmental Noise, with the catchy acronym of LISTEN. The document provides a range of strategies and management actions and sets out tangible actions to be pursued, both collectively and individually, to manage the impacts of environmental noise. The document has an overview of noise and its effects then provides strategies for managing the impacts of noise from: domestic animals; construction and demolition; residential tools and appliances; industrial and commercial activities; and entertainment industry. The performance measures are to be based on reduction of complaints and on community noise surveys. Although the time for public comment has now passed copies of the document and further information is available from the Principal Environmental Health Officer, Frank Henry on pepo@brisbane.qld.gov.au.

Music Entertainment Noise

A revised version of the WA Code of Practice for Control of Noise in the Music Entertainment Industry is now available. This Code, developed by the WorkSafe Western Australia Commission, replaces the 1999 edition. The revision was needed to incorporate references to the current principal code - Managing Noise at Workplaces, and to the C-weighted peak noise level exposure standard. The code provides practical guidance on ways to assess and reduce noise exposure in entertainment venues.

Available as download from: http://www.safetyline.wa.gov.au/pagebin/codewswa0230.htm or purchase from (08) 9327 8775.

Active Noise Cancellation for Dairy

In February, 2003, an industrial active noise cancellation system was successfully installed and commissioned in a dairy factory by the ANVC Group from The University of Adelaide. The system controls tonal noise (with a frequency equal to the blade pass frequency of the fan) radiated from the exhaust stack of a spray dryer used for making powdered milk. The fan has a power of 200kW and the exhaust stack diameter is 1.6m. The temperature of the exhaust varies from 70° to 90° C and the blade pass frequency varies from 170 to 190 Hz. The installation would not have been possible without the financial support of the Dairy Research and Development Corporation (now Dairy Australia) and the financial and technical support from Murray Goulburn Pty Ltd.

There are several unique aspects, which characterise the system.

- Perhaps the most significant aspect is that it is a multi-modal controller, in that the frequency range of control includes the range where two higher order modes are propagating in the stack.
- Special waterproof coatings are used on the loudspeaker cones to allow steam cleaning.
- Loudspeaker life is prolonged by air cooling and provision has also been made for water cooling if this later proves necessary.
- The sound field in the stack is non-stationary and required a specially developed fast tracking control algorithm to be developed.
- A multi-channel control system with six control sources and 12 error sensors is used to control the multi-modal sound field. The reference signal is obtained from a magnetic pick-up adjacent to a gear wheel on the fan shaft.
- The cancellation path transfer function is continually updated on-line, using low-level random noise and very long averaging times.
- The control system can recover automatically from a power failure or transient, high-level noise event.
- Visual alarms indicate failure of the control system, loudspeakers and microphones. In the event of one or more loudspeaker or microphone failures, the controller will continue to operate until it no longer can produce a reduction in noise level.

For information: www.mecheng.adelaide.edu.au/anvc/home.shtml

Low Frequency Noise

Low frequency noise causes extreme distress to a number of people who are sensitive to its effects. However, there is relatively little information readily available regarding the effects, assessment and management of low frequency noise. As a response to this need the UK Department for Environment, Food and Rural Affairs (DEFRA) has recently published 'A Review of Published Research on Low Frequency Noise and its Effects'. This report was produced by Dr Geoff Leventhall; assisted by Dr Peter Pelmear and Dr Stephen Benton. It reviews the available literature in order to better improve our understanding. It should be of interest to low-frequency noise-sufferers, health professionals, environmental action groups, local authorities and acousticians. It can be downloaded in pdf from http://www.defra.gov.uk/environment/noise/lowfrequency/

Acoustics for UK Schools

The UK Department of Education and Skills has released the strict acoustic standards that will be applicable in UK schools from July 2003. There has been an extensive consultation process during the development of these standards. Not only are the usual aspects of room design for speech and music included but also the requirements for hearing impaired, assistive listening devices and sound filed systems. Some concerns have been expressed that the increased standards will put such an impost on the costing that the future construction of schools will be limited. The document can be found from the home page www.teachernet.gov.uk then type in a search for Acoustics Bulletin and you should get to Building Bulletin 93 on Acoustic Design of Schools. The aim of this Bulletin is to provide a simple but comprehensive guide for architects, building control officers, building services engineers, clients, and others involved in the design of new school buildings and Section 1 of Building Bulletin 93 describes the 'Specification of acoustic performance'. There is also a link across to the BRE's Acoustics Centre, which has an Excel spreadsheet and data bases to help designers carry out calculations of façade insulation and reverberation times in rooms.

UK Standards for Dividing Walls

In view of the ongoing saga regarding the proposed changes to the acoustic requirements for walls dividing separate apartments in the Building Code of Australia (BCA), the recently introduced changes to Building Regulations in the UK may be of interest. Approved Document E provides practical guidance for the Regulations and can be downloaded from http://www.safety.odpm.gov.uk/bregs/approvede/pdf/approvede.pdf. This 76 page document not only gives the requirements but also pre completion testing procedures and lots of technical information on how to achieve the values. The performance rating for walls dividing separate living units in purpose buildings is $D_{nT,w} + C_{tr}$ of 45 and for those formed by a 'material change of use' of 43.

For both categories the laboratory R_w must be 40. In a report on a meeting discussing the changes (Acoustics Bulletin 28(2) p6-8 2003) an explanation is given of how these standards represent an improvement in performance rather than the apparent reduction. To the former UK limit of 49 for D_{nTw} was added 3 to improve the performance, subtracted 5 because the new limits include C_{tr} and subtracted 2 for measurement uncertainty.

Approved Documents E also gives performance criteria for internal apartment walls of $D_{nT,w}$ + C_{tr} of 43 or 45 if it is separating from a stairwell. Performance criteria are also given for impact sound insulation for floors and for absorption in foyer areas.

Audiology in UWA

The Auditory Laboratory at the University of Western Australia is one of the leading centres in the world for research into hearing. It now has its own website www.audiologyuwa.com.au which includes information on the post graduate courses. Interestingly, to make the course cost-effective, enrolments for first year will only be accepted every second year commencing in 2004.

NuWave and Thermotec

In April 2003, Thermotec Pty Ltd purchased the business NuWave Noise Barrier Products. This merger will enable rapid development of the NuWave range assisted by Thermotec's 15 years of manufacturing experience in Australia. Ray Leach and Nicholas McGloin will continue to be involved in Thermotec's activities in noise insulation.

Contact details are now: tel 02 9771 6400 fax 02 9771 6466, PO Box 5085 Milperra 1891. Plant location: 168 Carrington St, Revesby NSW 2212. nick@thermotec.com.au and www.thermotec.com.au.

Fan Selection Tool

Selecting the right fan for the job is one thing. Ensuring that the fan will produce an acceptable noise level when installed on site is another. Fantech has developed a simple, yet effective tool to help avoid some of the difficult and costly noise problems that too often occur. As we are becoming more aware of the dangers of excessive noise exposure, and the loss of efficiency and output when personnel work in an environment of higher than suitable levels, it is becoming more important for designers and installers to consider the effects of fan noise.

As a means of simplifying the process, Fantech has developed a simple acoustic analysis technique that allows the user to work out the likely resultant noise level of a fan when it is located in various typical environments. Called the "Simplified Acoustic Analysis", it is readily available on the Fantech website, www.fantech.com.au. A suitable silencer can also be selected from 'Select Attenuator'

Aircraft Noise Information

DOTARS has recently released "Guidance material for selecting and providing aircraft noise information" which is freely available from the Department. This follows the release in March 2000, the Department of Transport and Regional Services (DOTARS) of the paper entitled "Expanding ways to describe and assess aircraft noise". The Guidance material document puts forward a number of aircraft noise information options and it is intended that these be selected and applied in a manner appropriate to the airport under consideration. The aim is to change the focus from "a debate on whether things are getting better or worse to one where both sides recognise that the nature of aircraft noise exposure patterns is changing and adopt noise descriptors which establish a common understanding of what is actually happening." The document summarises various approaches to consultation with the community to avoid 'surprise noise'. It presents alternatives to the ANEF contour map such as charts with tracks, track density, track heights, flight path movements, N70, single event noise contours and respite times. These can be produced for airports using the software developed by DOTARS (free ware) called Transparent Noise Information Package (TNIP). This package was discussed in the paper by Southgate (Acoustics Australia 28(1) pp 11-14) and has been considerably revised and expanded since then. Copies of the guidelines and more information on TNIP areavailable from DOTARS or download http://www.dotars.gov.au/avnapt /sepb/and/downloads.htm#DraftGuidelines

New Products

MSC
Simulation Software

ADAMS/Car Rides is a new plugin for ADAMS/Car. It has been developed in cooperation with major automotive manufacturers with the purpose of allowing virtual ride and comfort engineering upfront in the design process within the preferred automotive virtual prototyping environment. One objective of this activity was to elevate the Functional Digital Vehicle solution from handling to ride and comfort testing, including the required elements, models, and event definitions for building, testing, and post-processing within the ride frequency domain. The ADAMS/Car Ride user scenario is based on the existence of a vehicle virtual prototype. The same model database, which is used for handling, is used for ride and comfort engineering. The interface provides the capability of swapping the mathematical description of the components (dampers, bushings, hydromounts, tires) so that the level of fidelity is suitable for the phenomenon the user wants to study. The time-domain approach, based on ADAMS/Solver, provides accurate results including the effects of nonlinearities in the model, whereas the frequency-domain approach, based on ADAMS/Vibration, is an efficient tool for conceptual analysis in the modal space.

Further information from http://www.mscsoftware.com.au

CAUSAL SYSTEMS
ENC Software

ENC v1.183 evaluates practically all of the expressions and algorithms in the book, "Engineering Noise Control" 2nd edition by Bies and Hansen. Where appropriate, results are plotted on the screen and the plot can be copied directly into a word processor for reports.

Calculations include: basic sound level addition and noise reduction; speed of sound; hearing damage risk; NC, NCB, NR and RC numbers and plots; A-weighting; speech interference; loudness level; sound radiation from monopoles, dipoles, line sources and planar sources; far-field, near-field estimations; outdoor sound propagation, including ground effects, air absorption, meteorological influences and barriers; calculation of sound power from standard measurements; sound levels in rectangular, cylindrical, long and flat rooms; reverberation times in rooms and their optimisation; modal density and modal overlap in rooms; sound absorption coefficients for porous materials, including plastic and perforated plate protection; panel absorber design; sound transmission loss of single and double partitions (flat, corrugated, fluted and multi-leaf); ability to enter own material properties; machinery enclosure noise reductions; outdoor and indoor sound barrier noise reductions; pipe lagging noise reduction; impedance and pressure drop of reactive muffler elements; design of Helmholtz resonators, quarter wave tubes, expansion chambers, low pass filters and small engine exhausts; dissipative muffler and lined duct design, muffler pressure drop calculations; exhaust stack directivity; plenum chamber design; flow generated noise; duct break-out noise; vibration isolation (single and 4-isolator systems including effects of flexible supports); vibration absorbers; and sound power estimation for a large variety of industrial equipment from fans to control valves to gas turbines to transformers.

The software also has a detailed manual and extensive on-line help. A demonstration version can be downloaded from the www but note that the demo version resets itself every 60 seconds

Further information: Causal Systems, http://www.causalsystems.com/ or chansen@mecheng.adelaide.edu.au

DELTA
Propagation Software

The culmination of years of research in the Nord2000 project has led to the release of exSOUND2000 software package for outdoor sound propagation technology. It is our hope that based on your experiences and feedback, it will be possible to not only make more accurate predictions, but also to accelerate the standardisation process so that both noise producers and the population affected by noise will benefit from the improved accuracy.

Two versions of the package are available: the basic version with 1/1 octave and support of stationary sources, and the advanced version exSOUND2000+ with 1/3 octave prediction and support of stationary, road, and rail sources. exSOUND2000 provides for advanced modeling of complex terrain, screening, and for different weather prediction. Its higher accuracy is based on mathematical modeling of the physics of sound sources and propagation, instead of empirical modeling based on experimental data.

Information www.delta.dk/soundpredict/exsound or soundpredict@delta.dk

ACADS
Wombat

WOMBAT is a versatile Computer Program for analysing noise control in and around buildings. The program has been updated and now uses WINDOWS dialogue boxes, drop down selection lists and entry fields on a series of calculation screens. Results are displayed graphically and in a number of the screens results from different runs can be compared. The range of calculations include: Room Acoustical Properties, Composite Wall Transmission Loss, Barrier Wall Attenuation, Speech Interference and Speech Privacy NR and dBA Calculations R_W Partition Single Number Rating, One third to Octave Band Conversion, Sound Transmission Indoors and Outdoors, Air Conditioning Duct Attenuation, Break Out Loss.

Information: tel 03 9885 6586, acadsbsg@ozemail.com.au, or www.ozemail.com.au/~acadsbsg

CIRRUS
Sound Level Meters

The CR 272 from Cirrus research provides the functions for workplace assessments while being simple to use. It is a dual channel instrument and can measure equivalent energy levels and peak action levels simultaneously. The CR 703B is a precision data logging sound level meter. It can store up to 2,500 events and 100,000 time history elements and with various measurement parameters. The windows software supplied as standard can be supplemented with software for detailed analysis of download time history. The CR 812A is designed to meet the needs of the safety professional who demands performance in a simple to use package. All measurements can be viewed on the instrument or downloaded to a PC using the software supplied.

Information www.cirrusresearch.co.uk

PYROTEK
Silentstep

A new version of a proven acoustic underlay has been released by Soundguard, a division of Pyrotek, colour-coded to symbolise its superior noise-stopping abilities. With a red facing that says "no go" to sound through floors and ceilings, new Silentstep has proven effective against extremes of floor-to-floor "neighbour noises". These include through-floor noises in domestic situations such as between upstairs and downstairs apartments and in commercial premises such as isolating lounging areas from bars above or below where patrons like their music loud.

An Australian-made composite, Silentstep comprises a quality rubber underlay and a highly flexible loaded vinyl. Its construction makes Silentstep one of the most cost-effective soundproofing materials available to architects, interior decorators, floor-layers and building managers. Assigned sound transmission class STC 28, Silentstep not only scores high in strength tests but also in impact tests. Indeed, tests prove that Silentstep's original work compression is barely affected after 1000 impacts, delivering 90-95 per cent of the "as-new" figure. Soundguard offers Silentstep in 1100 mm wide rolls, 10 mm thick and 4000 mm long.

Information phicad@pyrotek-inc.com

BRUEL & KJAER
Acoustic Determinator

Acoustic Determinator Type 7816 is a very convenient and intuitive tool for acoustic engineers who want to find out the sound power level of industrial sources by measuring sound pressure levels in the field. Using data from field measurements, Acoustic Determinator can guide you in the determination of sound power levels of various sources in accordance with a wide range of leading national and international standards, such as ISO 8297 and ISO 3744.

When working with prediction software programs to calculate noise contributions in single receiving points or whole areas, it is required to have sound power data for each relevant noise source in question. Acoustic Determinator simplifies the overwhelming task of handling large amounts of (spectral) sound pressure measurements as well as the associated information about measurement positions including the selection of these positions according to various standards.

Classifier

Classifier, Types 7842-A-N and 7842-B-N, is a PC-based software package for Laboratory or Field measurement of Building Acoustics using Brüel & Kjær's PULSE version 7.x and 3560C, D and E frames.

Complete laboratory or field measurement tasks are made quickly and easily, and in accordance with a broad selection of national and international standards. An intuitive measurement job file structure ensures full overview, even if the task at hand consists of many individual measurements such as airborne sound insulation, impact sound insulation, reverberation time and absorption coefficient. Supporting techniques such as MLS, rotating microphone booms, and sound intensity methods make it possible to select the optimum setup for real-life measurements.

Information please contact your local Brüel & Kjær sales representative.

DAVIDSON HEAD Measurement System

The digital artificial head HMS-II is the result of further targeted development of artificial head technology by HEAD acoustics. With state-of-the-art 24 bit technology, the artificial head HMS-III.0 is able to achieve a dynamic range comparable to that of human hearing. The artificial head accurately simulates all acoustically relevant components of the human outer ear, and is thus able to achieve aurally-accurate, binaural recording of sound events, in which all features of human sound perception are supported.

The measurement electronics, along with an independent-of-mains power supply, are integrated in the head-and-shoulder unit, making the artificial head an easy-to-handle, use-anywhere measurement tool. Investigation of the sound quality of technical products and the possibility of product-specific sound design are some of the most important fields of application for the artificial head.

Larson Davis SLM/RTA

The Larson Davis System 824 combines sound level meter and real-time analyser capabilities in a small, rugged package. It empowers you with the five different virtual instruments in one user-friendly hand held design.

Integrating Sound Level Meter (ISM) meeting Type 1 Standards with simultaneous measurement of sound pressure levels using fast, slow, and impulse detectors, for A, C, and flat frequency weightings which we call ANY LEVEL™. It measures 48 sound pressure parameters at once! All this with a 105 dB linearity range!

Sound Spectrum Analyser (SSA) with ANY LEVEL™ simultaneous sound pressure level measurement, real-time 1/3 octave frequency analysis, spectral L_{ns} and multiple time histories. This is your do everything at once instrument.

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Information: Nicholas McGloin, tel 02 9771 6400, Fax 02 9771 6466, nick@ thermotec. com.au, www.thermotec.com.au

Book Review

Tyre/Road Noise Reference Book

Ulf Sandberg and Jerzy Ejsmont

Publisher and distributor: Informex Ejsmont & Sandberg Handelsbolag, Harg, SE 59040 Kisa, Sweden, Price EUR 190 or USD 230 or www.informex.info, 640 pages, hard cover, ISBN 91 631 2610 9.

The engine and exhaust noise of cars has been reduced significantly with time and the information in this book shows there is great scope for the reduction of the road/tyre noise. The quality of the content in this book is a reflection of the devotion to the subject by the authors. It is truly a reference book representing the state of the knowledge on the topic.

The book itself is easy to read with clear print, good quality paper, excellent diagrams and photos, most of which are in colour. The list of contents is very detailed making it easy for the reader to find just the topic they are seeking. The first three chapters deal with introduction and basic concepts of sound and noise and occupy only 20 pages. The remainder of the book is focused on tyres, roads and the interaction between the two. There are even chapters indicating futuristic tyres and road surfaces which could be developed to further reduce noise.

The book is truly a great achievement and the title of reference book is most appropriate. Anyone with even a passing interest in traffic noise would find the content fascinating and the book hard to put down. It is certainly a book that should be in every office and library where there is any involvement in road traffic noise.

Marion Burgess

Marion Burgess is a Research Officer in the Acoustics and Vibration Unit of UNSW at ADFA, Canberra.

Diary...

2003

24-27 August, KOREA
Internoise 2003
Fax + 82 2762 4946, www.internoise2003.com, internoise2003@covanpco.co.kr

1-4 September, GENEVA
Eurospeech 2003,
SYMPORG SA, Avenue Krieg 7, 1208 Geneva, Switzerland, Fax: +41 22 839 8485, http://www.symporg/eurospeech 2003

7-10 September, PARIS
World Congress on Ultrasonics
http://www.sfa.asso.fr/wcu2003

23-25 September, SENLIS
2nd Int. Symp. on Fan Noise
CETIAT, B.P. 2042, 69603 Villeurbanne cedex, France,
Fax: +33 4 72 44 49 99,
http://www.fannoise2003.org

5-8 October, HONOLULU
2003 IEEE Int. Ultrasonics Symposium
W.D. O'Brien, Jr., Bioacoustics Research Laboratory, Univesity of Illinois, Urbana, IL. 61801-2991
Fax: +1 217 244 0105, http://www.ieee-uffc.org

12-14 November, GOLD COAST
Tenth Asia-Pacific Vibration Conference
http www.apvc.net/index.html

2004

31 March - 3 April, NARA
ISMA2004
Int. Sympt. on Musical Acoustics
http://www2.crl.go.jp/jt/a132/ISMA2004/

4 - 9 April, KYOTO
18th International Congress on Acoustics (ICA2004)
http://ica2004.or.jp

11-13 April, HYOGO
Int. Symp. Room Acoustics
http://rads04.iis.u-tokyo.ac.jp

17-21 May, MONTREAL
International Conference on Acoustics, Speech and Processing
http://www.icassp2004.com

6 to 9 June, GDYNIA
XIII Int Conf Noise Control 04 "Testing and Measurements" www.ciop.pl/noise_04

5 - 8 July, ST PETERSBURG
ICSV11
11th Int. Cong. Sound & Vib.
http://www.iiav.org

11 - 16 July, CAMBRIDGE
12th Int. Symp. Acoustic Remote Sensing (ISARS).
http://www.isars.org.uk

3 - 7 August, EVANSTON
8th Int. Conf. of Music Perception and Cognition
School of Music, Northwestern University, Evanston, IL 60201, USA
http://www. icmpc.org/conferences.html

24-27 August, PRAGUE
Inter-Noise 2004.
www.i-ince.org

3-5 November, GOLD COAST
Acoustics 2004
AAS Annual Conference
PO Box 760, Spring Hill, QLD 4004, Australia, aas2004@acran.com.au
www.acoustics.asn.au

2005

19 - 23 March, PHILADELPHIA
Int. Conf. Acoustics, Speech, and Signal Processing,
http://www.icassp2005.com

6-10 August, RIO DE JANEIRO
Inter-Noise 2005
www.i-ince.org

Short Courses

CANBERRA
25-26 November

Basics of Underwater Acoustics
27 November

Impact of Noise on Marine Animals
m.burgess@adfa.edu.au
www.adfa.edu.au/bdo/courses

Obituary

ROBERT CYRIL GREEN: 05.05.1922 - 05.07.2003

Robert Green was born in Fairfield, NSW, and attended Fairfield Primary and Parramatta High, then Sydney Technical College. In 1939 he enlisted for military service and served in Darwin after bombing, until 1945, and during this time he volunteered participation in mustard gas experiments. Robert married Flora Taylor during early 1945.

Following his return from military service, he studied architecture, then science, at Sydney University, and later architectural acoustics at the University of New South Wales. Robert retired from acoustic consulting about two years ago. The reader may have perused the article following Bob's retirement, published in Acoustics Australia, August 2002, Vol.30 (2), where some of his achievements in acoustics were reported.

But Bob Green was a person of wide interests. He enjoyed all sorts of studies and activities, to include astronomy, statistics, history, classics, philosophy, abseiling and gliding. To cap this, he was an entertaining story teller, particularly "shaggy dog" stories.

Robert Green was laid to rest at the Northern Suburbs Crematorium on 10 July, 2003. A moving service was conducted by Rev Peter Davis, and concluded with a recording of one of Bob's favourite pieces, "The Prisoners' Chorus" from Verdi's Opera "Nabucco"

Robert Green is survived by his wife Flora, and sons Peter, Stephen, and families.

Donald Woolford

Letter

Origins of "noise"

Recently one of my students presented me with a draft of his thesis which is concerned with a particular aspect of road traffic noise. In the usual introductory section where he was defining noise as unwanted sound, he went on to state that the word noise originated from the Latin word nausea. He then claimed that the latter means "a feeling of sickness with an intention to vomit". I was rather surprised at all this so I consulted the Oxford Dictionary and sure enough the confirmation was there. According to this impeccable source, nausea is itself sourced from the Greek nausia, which, in turn, is from naus meaning "ship".

So there we have some interesting acoustical trivia. I wonder if any of our Australian acoustical fraternity could shed any further light on the origins of noise?

Stephen Samuels, FAAS

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