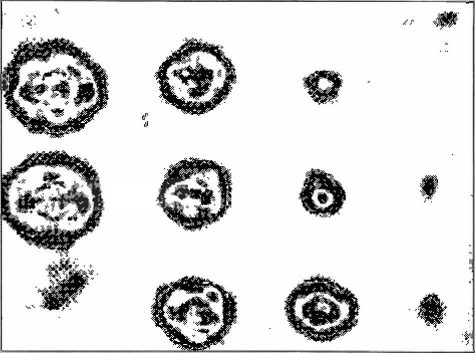
Acoustics Australia



- Acoustic NDT
- Cochlear Implants
- Hospital Noise
- Undersea Sonar
- Noise Effects 98
- Operatic Duets

Australian Acoustical Society

Vol. 27 No. 2 August 1999

Acoustics Australia

Acoustics Australia General Business
(subscriptions, extra copies, back issues, advertising, etc.)

Mrs Leigh Wallbank
P O Box 579
CRONULLA NSW 2230
Tel (02) 9528 4362
Fax (02) 9523 9637
wallbank@zipworld.com.au

Acoustics Australia All Editorial Matters
(articles, reports, news, book reviews, new products, etc)

The Editor, Acoustics Australia
Acoustics & Vibration Unit
Australian Defence Force Academy
CANBERRA ACT 2600
Tel (02) 6268 8241
Fax (02) 6268 8276
email: acoust-aust@adfa.edu.au
http://www.users.bigpond.com/Acoustics

Australian Acoustical Society Enquiries see page 72

Acoustics Australia is published by the Australian Acoustical Society
(A.C.N. 000 712 658)

Printed by
Cronulla Printing Co Pty Ltd,
16 Cronulla Plaza,
CRONULLA 2230
Tel (02) 9523 5954,
Fax (02) 9523 9637
email: print@cronullaprint.com.au

ISSN 0814-6039

Vol 27 No 2

CONTENTS

August 1999

ARTICLES

RESEARCH NOTE

COVER ILLUSTRATION: *Impact damage test on an aircraft panel —see paper by Dickinson and Thwaites*

From the Acting President

THE ISSUES WE FACE.

In the December issue of Acoustics Australia our President Graeme Yates exhorted members of the Australian Acoustical Society to give thought to the bigger picture, the *'where should we go from here'* issues in 'science and technology and acoustics in particular', and he expressed that it is *'only by taking action ourselves that can we influence the way ahead'.*

With this very much in mind I am sure, Graeme stood aside temporarily from his position as President of the Society to focus on his own life issues and influence his own way ahead, having been diagnosed with a lymphoma which requires immediate treatment. I take this opportunity on behalf of the Society to thank you Graeme for your significant contribution to the Society in your role as President and express the care and concern of all Society members to you, your wife, Marilyn and daughters Jennifer, Elisabeth, Katherine and Carolyn.

Our President has set us a challenge to *'get involved'.* A positive opportunity for members' in this regard is to attend and contribute to the **Acoustics Today, H. Vivian Taylor Memorial Conference** to be held 24th to 26th November which is shaping up to be a most informative conference and of course the final Australian Acoustical Society conference this millennium. Technical papers are to be presented on a range of acoustic issues including current acoustic research projects and investigative consultancy projects on aspects of acoustics which impact on society. There is still a brief opportunity for acceptance of a late technical paper if you now feel motivated. Please give it some serious thought and make contact with the Conference Secretariat.

Associated with the 1999 Conference will also be the final Council Meeting for this millennium. Councillors will be giving attention to the affairs of the Society with particular emphasis on the future. We would sincerely welcome input from members to assist in refocussing and re-positioning the Society for the acoustic challenges of the future.

I look forward to the opportunity of meeting you at the **Acoustics Today Conference** with a welcome on behalf of the Victoria Division hosting the conference. I trust the few days we will share together focussing on acoustics issues will be most valuable and will indeed help in *'influencing the way ahead'.*

Geoff Barnes

Acoustics Today Conference
Melbourne, 24-26 Nov
Details:Acoustical Design
Tel (03) 9720 8666,
Fax (03) 9720 6952,
Acousticdec@bigpond.com

AUSTRALIAN ACOUSTICAL SOCIETY - SUSTAINING MEMBERS

ACOUSTIC RESEARCH LABORATORIES
LEVEL 7 BUILDING 2
423 PENNANT HILLS ROAD
PENNANT HILLS 2120

ACRAN
127 BANDARA STREET
RICHLANDS QLD. 4077

ACU-VIB ELECTRONICS
UNIT 2/2 CHARLOTTE STREET
ASHFIELD 2131

ADAMSSON ENGINEERING PTY LTD
PO BOX 1294
OSBORNE PARK 6916

ASSOCIATION OF AUSTRALIAN ACOUSTICAL CONSULTANTS
C/- HERRING STORER ACOUSTICS
34/11 PRESTON STREET
COMO WA 6952

BARCLAY ENGINEERING
31 FELSPAR STREET
WELSHPOOL 6106

BORAL PLASTERBOARD
676 LORIMER ST
PORT MELBOURNE 3207

BRUEL & KJAER AUSTRALIA PTY LTD
PO BOX 177
TERREY HILLS 2084

CHADWICK TECHNOLOGY
9 COOK STREET
FORESTVILLE 2087

CSR BRADFORD INSULATION
LEVEL 4, 9 HELP STREET
CHATSWOOD 2067

DALLOZ SAFETY PTY LTD
19 TEPKO ROAD
TERREY HILLS 2084

ENCO NOISE CONTROL P/L
50 RIVERSIDE ROAD
CHIPPING NORTON 2170

G P EMBELTON & CO PTY LTD
147-149 BAKERS ROAD
COBURG 3058

INC CORPORATION PTY LTD
22 CLEELAND ROAD
OAKLEIGH SOUTH 3167

JOYCE FOAM PRODUCTS
5-9 BRIDGES ROAD
MOOREBANK 2170

NSW ENVIRONMENT PROTECTION AUTHORITY
LOCKED BAG 1502
BANKSTOWN 2200

NOISE CONTROL AUSTRALIA P/L
70 TENNYSON ROAD
MORTLAKE 2137

PACIFIC NOISE AND VIBRATION
71 CONSTITUTION AVENUE
CANBERRA 2601

PEACE ENGINEERING PTY LTD
2-20 MARIGOLD STREET
REVESBY 2212

PYROTEK PTY LTD
PO BOX 260
TOONGABBIE 2146

SOUND CONTROL PTY. LTD.
61 LINKS AVENUE NTH
EAGLE FARM 4009

VIPAC ENGINEERS AND SCIENTISTS LTD
275 NORMANBY ROAD
PORT MELBOURNE 3207

WORKCOVER ACOUSTICS
919 LONDONDERRY RD
LONDONDERRY 2753

CHARACTERISATION OF SOFT IMPACT DAMAGE IN COMPOSITE SANDWICH PANELS USING A "PITCH-CATCH" ACOUSTIC PROBE.

Laurence. P. Dickinson & Suszanne Thwaites
CSIRO Telecommunications and Industrial Physics
Sydney NSW 2070

Abstract: This paper discusses an investigation of the detection of low-velocity, soft impact damage in Nomex honeycomb cored, carbon fibre composite sandwich panels using a low frequency acoustic technique. A commercially available probe head was used on an automated scanning table to perform a raster scan on prepared test panels. Various processing techniques were used to analyse the data but it was found that a simple integrated difference algorithm provided a surprising amount of detail about core damage that is virtually invisible on the panel surface. The patterns that emerged from the scans appear mode-like and the complexity looks to be related to impact severity.

1. INTRODUCTION

Carbon-fibre skinned, Nomex (paper-resin) honeycomb cored sandwich panels are widely used in the aerospace industry. During their lifetime these panels are often subjected to myriad impacts including, for example, dropped tools, stones flung up from the runway and hail. It has been found that a particular form of impact that results from collisions with soft-bodied objects travelling at low velocities (eg detached fragments of tyre tread or birds) can create core damage which is invisible on the surface. This damage is frequently very difficult to detect using conventional NDT techniques employed for in-service panel inspection. These techniques include such methods as acoustic, ultrasonic, thermographic and X-Ray. The most common of the above are acoustic where commercially available systems use mechanical impedance, resonance and so called "Pitch-Catch" approaches. This study centres on a Pitch-Catch acoustic, commercially available probe.

2. THE PITCH-CATCH PROBE

The Pitch-Catch probe is one of a number of acoustic probes available with many commercial scanning systems such as those used in the aircraft industry. This instrument works on the general principle of using vibration to detect changes in the mechanical properties of a test piece, associated with some form of defect, in the region local to the probe / panel contact. A "Pitch-Catch" probe refers to the fact that there are two piezoelectric accelerometers spaced a fixed distance of 10 to 20 mm apart. One of these accelerometers acts as a transmitter (hence the "Pitcher"), and the other is a dedicated receiver (the "Catcher"). The accelerometers are symmetrical with regard to drive and receive channels and have contact pins that are a push fit, not bonded to the bottom of the accelerometer housing. Fairly compliant springs are employed to hold each tip against the object being examined, a dry contact – no couplant is used. These springs also provide some isolation from the probe housing and reduce any cross talk between the two tip accelerometers. These features are shown schematically in Figure 1.

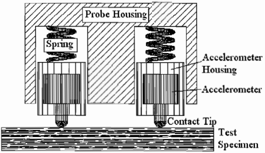


Figure 1 A diagrammatic representation of a Pitch-Catch probe used in the study

Typical use in a commercial system involves transmitting a sinusoidal tone-burst into the panel under examination and the signal received (from the catcher) is digitised. According to operating instructions, the operator is first asked to place the probe on a supposedly "good" section of panel. A series of digitized reference waveforms is then obtained while the burst frequency is incremented over the range 5 kHz up to 40 kHz. A second series of samples is taken over a known defect, which is normally a test panel that has had various defects introduced into it such as milled holes to simulate core damage, or Teflon wafers to represent disbonds. A comparison is then made between the two sets. For example, a single point may be chosen in the time-domain and the amplitude and phase difference between the reference waveform and a waveform from the known defect sampled at the matching frequency are used to indicate that damage is present. The working frequency is chosen such that there is the greatest difference seen between the known defect and the reference panel. This frequency is often in the region of 20 to 25 kHz where the strongest output signal from the probe can be obtained.

Once a working frequency is chosen and a sample waveform is stored of a "good" section of panel, the operator can then pick and place the probe by hand over areas of interest.

3. THE PROBE – UNDERSTANDING ITS BEHAVIOUR

A calibration of the probe by the CSIRO National Measurement Laboratory Acceleration Standards group revealed some interesting behaviour. Figure 2 shows a calibration of one of the probe tips for loaded drive response. The tip was excited with a constant sine wave of 5 volts amplitude and its output was measured on a force transducer mounted on a heavy inertial block. The probe displayed two high Q resonances, one of which is in the range 20 to 25 kHz.

Examination of the probe structure, shown in Figure 1, suggests that a probable source of these resonances is the spring-mass system consisting of the accelerometer mass and the compliance associated with the contact tip. The large spring will also have a resonance associated with it but this is at a much lower frequency, well below the useable range of the instrument. A very rough model for the probe tip is that of a simple vibrating rod loaded with a mass at one end. The termination at the other end will vary considerably depending on the panel impedance and coupling efficiency. From [1] the angular vibrational frequencies of a free-free bar are

$$f_n = \frac{n}{2}\frac{c}{L} \qquad (1)$$

where $n = 1$ for the fundamental resonance, c is the compressional wave velocity and L is the length of the contact tip.

This frequency is considerably lowered by the mass on the end. The end-correction to the length is given approximately by the factor $(1+M/m)^{-1}$ where M is the added mass and m is approximately half the tip mass.

Assuming that the tip material is Nylon, c is in the range 1600 to 2670m.s^{-1}. If this is inserted into equation 1 with measured values for m, M and L, the fundamental loaded resonance frequency is in the range 22 to 36 kHz in agreement with the peaks seen in Figure 2. Little useful information can be obtained if the working frequency for the probe is chosen to be close to these resonances.

To illustrate the effect of these resonances on the probe response when in use on a panel, the probe was driven with a step excitation. The dark line in Figure 3 shows the spectrum of the output over a good region of panel and the light coloured line shows the spectrum over a known impact site.

The two dominant peaks in both spectra above 20 kHz are artefacts of the probe more that any effect of the panel. However there is a marked peak unique only to the sample over the damage at a much lower frequency of about 11 kHz. On the basis of these results, a sine burst in the region of 11 kHz is the optimum test excitation to use for this type of panel and form of defect. To further reduce the effect of the probe characteristics, and those from mounting mechanism noise, a 2 kHz and 13 kHz band pass filter should also be used.

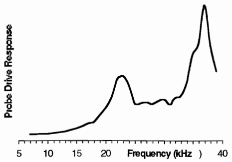


Figure 2 Calibration of one of the probe tips for drive response

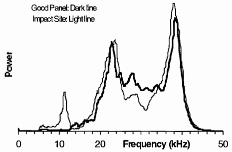


Figure 3 Spectra of probe's output with impulse excitation over an area of good panel and an impact site

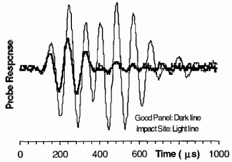


Figure 4 Response of the probe driven with a 2 cycle, 11kHz tone burst over an area of good panel and an impact site.

Figure 4 shows a time waveform taken from the probe's response while being driven with a 2 cycle, 11kHz sine burst with the band pass filter on the receive channel. The waveform from the region over the impact site (light coloured line) shows a pronounced resonance at approximately 11 kHz, as expected from the results in Figure 2. This paper does not examine the mechanisms behind these local panel resonances, but they are discussed in [2] & [3] where plate modes were explored and a relationship between damage area and impact severity was drawn.

4. PRODUCTION OF TEST SAMPLES

Information obtained from panel manufacturers and aircraft testing laboratories suggests that the type of defects present in the test panels provided with commercial NDT systems, a few of which were mentioned in a previous section, are uncharacteristic of damage the panel is likely to encounter in its service life. Of much more interest is impact damage that crushes or "crazes" the paper honeycomb core but leaves no visible indication on the panel's surface. We have conjectured [2] that skin failure may be bypassed in the damage process if the projectile's surface is non-rigid. The impact then occurs over a longer time and alternative mechanisms of energy dissipation such as full panel strains and vibration modes can occur. The strain may then be sustained elastically by the skin.

A series of test panels with known characteristics and damage profiles was essential for this investigation. In particular, damage imposed on these panels needed to be controlled and repeatable. To this end a drop impact apparatus was designed that allowed adjustable impact head (commonly referred to as the "tup"), mass and velocity. The apparatus was built around an 84mm diameter Perspex tube, through which the tup falls and is guided by Teflon runners. A system was also devised to catch the tup after the initial impact to prevent multiple strikes. This consists of an optically triggered shutter at the base of the tube that is closed when the tup has hit the panel and has travelled past the end of the tube on its rebound. To provide a non-rigid impact surface, the tup was covered in 6mm thick extruded rubber, Durometer (A) hardness of approximately 65, that was machined to give it a rounded profile.

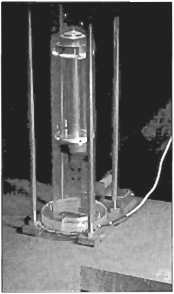


Figure 5 Apparatus to create repeatable low velocity, soft-bodied impacts. A 2.5kg, 69mm diameter tup is shown about to strike a test panel

5. AN AUTOMATED SCANNING SYSTEM

Although the probe we obtained was intended for hand held use, some trials repeatedly placing the probe by hand onto the same spot showed that the received waveform can vary considerably, due to pressure exerted on the tips and contact angle, occasionally leading to false positives. To overcome this, a holder based on a gimbal joint was designed for the probe. This holds the probe perpendicular to the panel surface with a constant pressure exerted on the tips. The holder was attached to a computer controlled moving gantry that enabled the probe to be moved in the X and Y directions with a resolution in position of 1 mm. A programmable signal generator was used to produce a tone burst of a few cycles of a sine wave with a peak of 8 volts to drive the transmit tip. A band-pass filter was included to reduce the effect of the mechanical resonance of the probe (> 15 kHz) and the mechanical resonance of the scanning table (< 1 kHz). A digital oscilloscope was used to digitize the returned waveform, which was then downloaded to a computer and saved in its entirety to disk for future analysis.

A simple indicator, I, summarising the result at each sample position was formed by summing the point by point difference between the reference waveform and the test waveform according to the following expression,

$$I = \frac{1}{n}\sum_{i=1}^{n}\left|\varphi_i(t) - \varphi_{Ri}(t)\right| \qquad (2)$$

where φ is the sampled waveform, φ_R is the reference waveform and n is the total number of points in the waveform (default 500).

This method makes use of the entire waveform and reflects how 'different' the panel is at the current scan location when compared to a good region of the panel. A relatively small value of I represents little deviation whereas a large value is a significant difference. Organizing these indicator values into a 2D matrix and applying some artificial colour coding produces an image that can aid further analysis of the raw data. Subsequent sectioning of the panels demonstrated that this image provides a clear indication of any damage the panel has sustained to its core, and the impact area boundary to within ±1 mm, without any false positive indications. Some clues to the nature of the damage itself can also be seen.

6. SCANNING RESULTS

Figure 6 shows a scan performed on a section of 22 mm thick Nomex core, carbon fibre skinned aircraft panel similar to that used in the elevators of a Boeing 777. The panel had been prepared with 12 soft-bodied impacts ranging from a 5 cm drop height of a 25 mm diameter 1.8 kg tup to a 120 cm drop. All but the 5 cm impact can clearly be seen in the images. Only those impacts for heights greater than 20 cm could be seen as visual indentations on the skin surface. Later examination of the panel by cutting it open with a very fine diamond saw revealed no damage had resulted from the 5 cm drop.

The images in Figure 6 employ two different forms of colour coding to represent the 2D index values to highlight several aspects of the scan. The first shows the mode-like

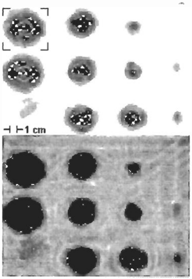


Figure 6 Two representations of a scan performed on a 22 mm thick Nomex cored, carbon fibre skinned panel that has been damaged by soft impacts from a Δ25 mm, 1.8 kg impactor dropped from heights of:
90, 50, 20 and 5 cm - Top row
120, 60, 30 and 10 cm - Middle row
10, 70, 40 and 15 cm - Bottom row

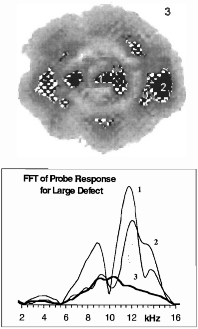


Figure 7 Enhanced image of the large soft-bodied impact highlighted in Figure 6 and a selection of associated FFTs performed on the sampled waveforms.

behaviour of the skin over the impact sites. The second image in Figure 6 highlights the background interference pattern in the areas adjacent to the damage. These are mainly due to interference caused by the panel defects and panel boundaries. Other details that also would normally be seen in the scans are structures such as joins in the skin ply and changes in thickness of the core, although none of these were present in the panel sample shown above. The diffuse indication, seen around the second 10 cm drop position at the lower left corner, is probably due to some defect already present in the panel.

Figure 7 shows a detail from this scan with some examples of the waveform spectra gathered. In the Figure, position 1 represents the approximate centre of the impact area, position 2 is on the edge of the impact site and position 3 was taken over an undamaged part of the panel. These spectra confirm the modal origin of the structure in response to the effect of the probe.

The mottled texture of the image in Figure 7 is probably due to the image enhancing techniques used rather than the structure of the panel.

7. CONCLUSION

Due to the nature of its design, the "Pitch-Catch" type probe can have undesirable mechanical properties leading to regions of large resonances within its stated operating range. An operator can easily be misled into thinking that these resonances are a suitable working region, as the output from the probe is a maximum, but the cost is significantly reduced detection reliability.

With the use of aggressive filtering and intelligent selection of excitation burst frequency and wave shape, the probes can be reliably used for detecting significant core damage in composite honeycomb where no surface damage is visible.

Ideally, a redesigned probe allowing use at frequencies greater than 20 kHz would open up scope for specific damage type identification such as skin delamination as opposed to core crushing. This would probably involve redesign of the probe contact tips and mounting.

8. ACKNOWLEDGMENTS

The authors would like to thank Norm Clark (CSIRO retired), and Neville Fletcher (ANU retired) for their valuable contributions during the course of this study.

This work was carried out as part of a collaborative research agreement between CSIRO and the Boeing Commercial Aircraft Group.

9. REFERENCES

[1] L. E. Kinsler, A. R. Frey, A. B. Coppens & J. V. Sanders. "Fundamentals of Acoustics", 3rd Edition. Wiley. 1982

[2] Suszanne Thwaites & Laurence. P. Dickinson "Detection of Invisible Damage in Honeycomb Sandwich Panels", Proceedings 6th International Congress on Sound and Vibration, Denmark. 1999

[3] Suszanne Thwaites & Laurence. P. Dickinson "NDT of Honeycomb Sandwich Panels using a Pitch-Catch Probe", CSIRO research report. Telecommunications and Industrial Physics. 1998

THE PERCEPTION OF PITCH BY USERS OF COCHLEAR IMPLANTS: POSSIBLE SIGNIFICANCE FOR RATE AND PLACE THEORIES OF PITCH

Robert Fearn*, Paul Carter† and Joe Wolfe*
*** School of Physics, The University of New South Wales, Sydney 2052 Australia**
† Cochlear Ltd, Lane Cove, 2066 Australia

ABSTRACT This study used subjects who had lost their hearing after acquiring language and who used cochlear implants. Trains of electrical pulses with different rates were sent to electrodes in different positions along the cochlea. Subjects reported perceived pitch using an arbitrary scale which was later normalised among subjects. At low rates of stimulation, the reported pitch depended on both electrode position and stimulation rate. Perceived pitch increased approximately logarithmically with rate, but decreased with the distance of the stimulation area from the cochlear windows. At high rates of stimulation, perceived pitch also decreased with distance from the windows, but had little dependence on stimulation rate.

1. INTRODUCTION

For more than 150 years, scientists have debated the way in which the ear encodes pitch. The debate concerns the relative importance of the rate of stimulation, and the place in the inner ear where that stimulation occurs. The basilar membrane of the inner ear has mechanical properties which vary with position in such a way that high frequency vibrations cause maximal motion at the window end and low frequencies cause maximal motion at the apical end [1]. It is therefore difficult to separate the effects of rate and position of stimulation on the perception of pitch in the normal ear because these parameters are inevitably correlated. Cochlear implants (CIs) include a linear array of electrodes which lie near to the basilar membrane (Fig 1). This allows the position and rate of electrical stimulation to be varied almost independently. In this study, CI users who had lost their hearing after acquiring language used pitch scaling to report the perceived pitch produced by series of electrical pulses with a range of rates and electrode positions.

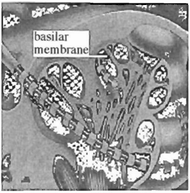


Figure 1. A schematic cut-away diagram of the implanted cochlea. The electrode array enters near the window at left and follows the first 1.5 turns towards the apical end (top right). The basilar membrane separates the two chambers of the cochlea.

The cochlea of the normal inner ear transforms an input mechanical vibration (essentially a filtered version of the acoustic signal input to the ear) to action potentials in the fibres of the auditory nerve. The cochlea is a rigid, coiled tube, divided mechanically into two along its length by the basilar membrane. The small bones of the middle ear input a displacement signal to one side of the tube via a window. This signal drives a transverse wave in the basilar membrane, whose cutoff frequency decreases along its length. As a result, high frequencies cause maximum vibration at the window end, and low frequencies cause maximum vibration at the other. In the normal ear, action potentials are produced in an array of hair cells which reside on the basilar membrane. Ohm [2] and Helmholtz [3] proposed that pitch was encoded tonotopically, i.e. by the place along the basilar membrane of the nerve stimulated (place theory). Seebeck [4] argued that nerve pulses were produced by each vibration and that their rate determined the perceived pitch (rate theory). Using place theory, it is difficult to explain the observed fine resolution of frequency (~0.2%). On the other hand, the rate theory cannot readily explain the perception of tones with frequencies many times greater than the maximum firing rate of neurones. Despite many elegant acoustic experiments, the relative importance of rate and place are still debated because, in the normal ear, the rate of mechanical stimulation of the basilar membrane is strongly correlated with position. Cochlear implants allow the local electrical stimulation of different regions of the cochlea at different rates. A range of experiments have studied pitch using CIs: Simmons et al [5] reported pitch estimates from a single subject with low resolution in position. Pitch as a function of stimulation rate was reported by Pijl [6] and by Collins et al [7].

Our study extends the work by these researchers and uses the method of pitch scaling [7,8] which has the advantages that it does not require matching of percepts that may differ in several different perceptual parameters, and that it can readily be understood and used by subjects with little knowledge of music. We studied six volunteers with implants which allowed fine resolution in both rate and place, and we present perceived pitch as a function of rate and place of stimulation. The results show remarkable consistency, given the subjective nature of the test.

2 METHOD

Six adults volunteered for this study, which is part of a project to improve the performance of CIs in delivering perception and appreciation of music. Their ages ranged from 35 to 72, and they had lost their hearing at ages between 5 and 45 years. All subjects normally use NucleusTM CI22M implants and either SPECTRA-22TM or SPrintTM processors programmed with the SPEAKTM coding strategy (Cochlear Ltd.). All subjects normally use biphasic pulses applied between pairs of electrodes separated by one temporarily inactive electrode; that stimulation mode was used in this study.

The stimuli were 1.00 s pulse trains of biphasic rectangular pulses: a 100 μs pulse, a 25 μs gap then a 100 μs pulse of equal magnitude but opposite polarity. The stimuli were loudness balanced. Each subject was asked first to increase the control of the current level to achieve a level judged to be "medium-loud", then to compare all stimuli in turn with the middle rate, middle position stimulus until the subject was satisfied with loudness equivalence.

Seven examples of each stimulus were delivered and evaluated. Presentation order was random and a training block was presented before data collection. Pitch was reported using the pitch scaling method [7,8]. Values on arbitrary scale from 0 (very low pitch) to 100 (very high pitch) were assigned by the subject to each stimulus. The values were then normalised: for each subject in each of two measurement sessions, the responses were scaled as a percentage of the total range used by the subject in that session. Electrode number was converted into position using the average values measured in another study [9].

The number, time and good will of volunteers are generous but finite. This limits the volume of parameter space that may be investigated. For each subject, one measurement session investigated rates from 100 to 500 pulses per second (pps), applied between the three pairs of electrodes at the end of the array most distant from the round window. Five of the subjects returned for another experiment in which rates between 100 and 1000 pps were applied to three pairs of electrodes widely spaced along the array.

3 RESULTS AND DISCUSSION

Figure 2a shows the result for the experiment over the larger range of stimulation rates. At low frequencies, the pitch is strongly dependent on both rate and place but, at rates above several hundred pps, the stimulation rate has little effect and pitch decreases with distance from the round window.

Figure 2b shows the average of the scaled pitch for all subjects for the experiment with smaller rate and place range. The difference between electrodes at 15.5 mm and 16.3 mm is significant at 0.05, which suggests that the resolution of position in this context is less than or of the order of one electrode spacing (0.75 mm). The logarithmic dependence of pitch on rate invites comparison with normal hearing, where notes in the equal tempered chromatic scale of Western music are equally spaced on a log frequency scale.

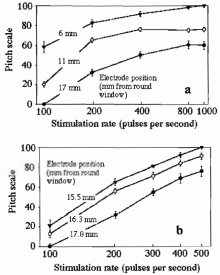


Figure 2. The average of the scaled pitch estimate (± s.e.) as a function of stimulation rate and electrode position. Higher number electrodes are inserted further into the cochlea (most distant from the window).

For the CI subjects, pitch also depends on place of stimulation, decreasing with distance from the round window. This can be compared with the tonotopic arrangement of the normal ear where a doubling in the frequency of the acoustic signal corresponded to a displacement of about 4 mm along the basilar membrane for frequencies above several hundred Hz, and smaller displacements for lower frequencies [10]. Because the pitch scales shown in Fig 2b are approximately logarithmically dependent on rate, we can calculate that a doubling in stimulation rate corresponds to a displacement of about 2 mm in this range. For the series of experiments reported in Fig 2a, the displacement corresponding to a doubling of stimulation rate depends on position and rate. It is about 4-6 mm at low rates and decreases for higher rates. The results for electrodes at 17 mm are slightly different between the two experiments. This may be due, in part, to the arbitrary nature of the pitch scale and the fact that the measurement sessions were conducted at different times. It is also possible that the task of assigning pitch is more difficult over a much larger range of the parameters.

The apparent saturation of the dependence of pitch on stimulation rate is not surprising at rates which are greater than the maximum firing rate of neurones. These results may not simply be compared with normal hearing, however, because the differential mechanical stimulation of hair cells is rather different from the electrical stimulation by the CI of many or all of the cells between or near the two electrodes. The influence of rate and place on pitch perception for these post-lingually deafened subjects nevertheless suggests that both rate and place are important in pitch coding for normal hearing at low frequencies, but that place alone dominates at sufficiently high frequencies.

ACKNOWLEDGEMENTS.

RF was supported by an Australian Postgraduate Award (Industry). We thank Stephanie Shaw and our volunteer subjects.

REFERENCES

[1] G. von Békésy *Experiments in Hearing*, McGraw-Hill, New York (1960)

[2] G.S. Ohm "Über die Definition des Tones, nebst daran geknüfter Theorie der Sirene and ähnlicher tonbildender Vorichtungen." *Ann. Phys. Chem.* **59**, 513-565 (1843)

[3] H.L.F. von Helmholtz *Die Lehre von den Tonempfindungen als physiologische Grundlage fur die Theorie der Musik,* (1863) published in translation *On the Sensations of Tone as a Physiological Basis for the Theory of Music.* Dover, New York (1954).

[4] A. Seebeck "Über die Definition des Tones." *Ann. Phys. Chem.* **60** 449-481 (1843)

[5] F.B. Simmons, M.K. Herndon, L.E. Atlas, R.L. White, and L.J. Dent "A mutielectrode modiolar stimulation: some selected psychophysical and speech results." *Adv. Audiol.* **2**, 163-169 (1984) .

[6] S. Pijl "Pulse rate matching by cochlear implant patients: effects of loudness randomization and electrode position." *Ear & Hearing* **18**, 316-325 (1997)

[7] L. M. Collins, T. A. Zwolan, and G. H. Wakefield "Comparison of electrode discrimination, pitch ranking and pitch scaling data in postlingually deafened adult cochlear implant subjects." *J. Acoust. Soc. Am.* **101**, 440-455 (1997)

[8] P. A. Busby and G. M. Clark "Pitch and loudness estimation for single and multiple pulse per period electric pulse rates by cochlear implant patients." *J. Acoust. Soc. Am.* **101**, 1687-1695 (1997)

[9] M.A. Marsh, J. Xu, P.J. Blamey, L.A. Whitford,S.A. Xu, J.M. Silverman and G.M. Clark. "Radiologic evaluation of multichannel intracochlear implant insertion depth." *Am. J. Otol.* **14**, 386-391 (1993)

[10] D.D. Greenwood. "A cochlear frequency-position function for several species - 29 years later." *J. Acoust. Soc. Am.* **87**, 2592-2605 (1990)

QUIET PLEASE IT'S A HOSPITAL

K. Mikl & K. Mathiasch
WorkCover NSW
919 Londonderry Rd
Londonderry NSW 2753

ABSTRACT: Traditionally one would expect a hospital to be a quiet place in which to work with no risk of noise induced hearing loss. This study examines common noise sources in 32 hospitals around NSW. The noise sources are grouped according to function and section to determine average noise levels, their range and standard deviation. Due to the newly introduced measure for peak noise, peak noise levels were also measured, even though the 140dB peak limit was not expected to be exceeded. Results show that a hospital is not necessarily quiet and that a significant number of noisy jobs exist, particularly in the carpentry, engineering and gardening sections.

1. INTRODUCTION

Over recent years many claims for noise induced hearing loss have been made against the workers compensation system. In 1997 WorkCover NSW paid out $70,682,000. Persons whose occupation was not traditionally considered "noisy" have brought many of these claims. One such area was hospital employees. Therefore it was decided to carry out a systematic study of the types and levels of noise present in hospitals as these would normally be considered a 'quiet' environment.

In NSW the Occupational Health and Safety (Noise) Regulation 1996[1] regulates exposure to noise, it declares a workplace "..unsafe and a risk to health if any person is exposed there to noise levels:

(a) that exceed an 8-hour noise level equivalent of 85 dB(A); or

(b) that peak at more than 140 dB(lin)."

The regulation is complemented by the Code of Practice[2] which explains methods for noise management available to enable conformance with the regulation.

This study assesses the likelihood of noise levels above these criteria being present but does not assess the time of exposure, as this will vary enormously from person to person and from day to day.

2. METHODOLOGY

To establish the likely exposure of hospital employees, an effort was made to target this section of the work and also to go back through old reports to extract data available from WorkCover files [3]. New sites were also visited during the year as time permitted. Hospitals visited were limited to NSW and ranged from large metropolitan to small country hospitals. All results were extracted, pooled and then categorized according to function and occupation. All measurements were carried out using class 1 or class 2 integrating sound level meters or personal sound exposure meters in accordance with AS 1269 and the noise regulation current at the time of the test. Analysis was carried out using Lotus 123 and the statistical functions available therein. At the conclusion a search of noise information was carried out and extracted data compared with this study.

3. RESULTS

A compilation of every result available was made with readings for $L_{Aeq,T}$ and peak. These were ordered and separated into functional areas to enable comparison. Each area was analyzed and graphically represented. For comparison, data from the Canadian CCINFO [4] studies were downloaded and presented. By the conclusion of the study, 632 measurements were compiled from 32 hospitals throughout NSW and 122 results from the CCINFO database were analysed.

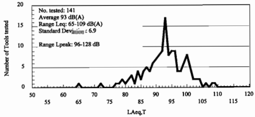


Figure 1. Distribution of noise levels for carpenters.

From the example of results shown in Fig.1, it is interesting to note the large number of tools and equipment used which generate noise levels above 85 dB(A) and the dominance of noise sources with levels above 93 dB(A). Using the equal energy principle (3 dB exchange rate) and assuming a 94dB(A) noise level from tools, a carpenter's allowable daily noise exposure of 85dB(A) would be exceeded in only 1 hour of work with these tools. As one hour of tool work could not be considered unusual in an 8 hour day, it is important that a specific 'safe system of work' is implemented in such areas.

Results in the form of Fig 1 and Table 1 were compiled for each area. Due to space limitations of this article, all the data relating to the measurements is available from the authors as an addendum. This addendum of 8 pages provides the above information for each occupational group shown in Table 2.

A further analysis for other sections of the hospitals is summarized below in Table 2. This shows that the carpentry, engineering and gardening sections all have a propensity to exceed statutory limits depending on length of operation. The range of noisy equipment should also be considered as well as the peak measurements. For example, the medical and auxiliary range was 58-96dB demonstrating the diversity of

Table 1. Noise levels for carpenters in hospitals.

Tool	High $L_{Aeq,T}$	Low $L_{Aeq,T}$	Average $L_{Aeq,T}$	SD	Number tested	Peak high	Peak low
Compressed air nozzle	106		*	*	1	120	
Compressor	85	82	*	*	2	100	
Drill	104	88	*	*	2	119	102
Fan	72	65	*	*	2		
Jointer	92	78	85	*	3	127	109
Key cutter	91		*	*	1		
Laminex trimmer	88		*	*	1	103	
Linisher	89	82	*	*	2	105	
Nail gun	94		*	*	1	128	
Planer	100	88	94	3.5	11	122	105
Router	104	81	95	5.3	19	118	100
Sander	98	77	88	5.7	16	112	96
Saw	109	80	94	5.9	69	128	101
Spindle	93	79	87	*	3	115	112
Thicknesser	99	85	92	5.2	8	117	100

* = insufficient data

functions from the dialysis machine to a compressed air nozzle and bone and plaster cutting saws. No peak measurement approaching 140dB was measured.

To benchmark the data to other work, a brief search of literature revealed a Canadian [4] study. The results of this are compared with the present NSW case. The agreement is good with divergence explained primarily by sample size. However, in the case of 'Medical', the sample source differed. The Canadian Study concentrated on laboratory technicians only, whereas this study examined all medical areas from bone cutting and plaster saws to dialysis machines.

4. CONCLUSIONS

Although one would expect a hospital to be a quiet place of work with no risk of noise induced hearing loss, this is not the case. This compilation of 632 noise level measurements in hospitals shows a different picture. The carpentry, engineering and gardening sections all exhibit areas of high noise exposure. Interestingly a significant number of contested hearing loss claims originate from the laundry, kitchen and cleaning areas. These areas were found not to be excessively noisy.

Of the 632 noise level measurements taken 286 were above 85 dB(A), 118 were above 95 dB(A) and 47 were above 100 dB(A). All these have a propensity to produce noise injury and the old road sign "Quiet Please - Hospital" takes on a meaning not originally intended.

Full results of all defined areas and equipment types are available separately from the authors.

REFERENCES

[1] WorkCover NSW "NSW Occupational Health & Safety (Noise) Regulations" (1996).

[2] WorkCover NSW "Code of practice for the management of noise at work " May (1996).

[3] WorkCover NSW internal reports and surveys.

[4] Canadian Centre for Occupational Health and Safety "CCINFO DISK": Nova Scotia Hearing & Speech Clinic (1995); New Brunswick OH&S Commission (1981)

Table 2. Comparison of noise levels in different areas of hospitals and between NSW and Canadian results.

Occupation	NSW Hospitals 1997-98				Nova Scotia Hearing & Speech Clinic 1995 New Brunswick OH&S Commission 1981[4]		
	No. tested	Range $L_{eq,T}$ dB(A)	Average $L_{eq,T}$ dB(A)	Range peak dB(lin)	No. tested	Range $L_{eq,T}$ dB(A)	Average $L_{eq,T}$ dB(A)
Carpenter	141	65 - 109	93	96-128	3	91 – 97	95
Cleaner	70	63 - 90	76	76-105	7	74 – 94	79
Kitchen	72	68 - 95	80	83-127	17	70 – 94	79
Printer	4	76 - 91	82	100-120	10	65 – 96	82
Medical	78	58 - 96	74	90-121	61	58 – 88	69
Engineer	189	64 - 110	88	-	17	75 – 107	87
Gardener	66	79 - 104	91	81-111	3	92 – 100	95
Laundry	12	64 - 83	75	-	4	68 – 82	76
TOTAL	**632**				**122**		

SONAR SYSTEMS FOR SEA BED IMAGING[1]

Bryan Woodward FIOA
Professor of Underwater Acoustics
Department of Electronic and Electrical Engineering
Loughborough University, UK

ABSTRACT: A review of the operation and capabilities of various undersea sonar systems, including synthetic aperture sonar, the seismic profiler, and parametric sonar.

1. INTRODUCTION

Discovering the secrets of the sea has been a long-sought aim for decades, yet surprisingly few of these secrets have been revealed despite determined efforts by scientists and engineers using a variety of techniques. This paper is more concerned with the sea-bed than the sea itself because the sea-bed and the underlying sediments hold further secrets that present an even greater challenge to investigate. One way to study the sea-bed is to lower a television camera and observe it directly, but this may yield little information other than to give an idea of the topography, the presence or absence of sea life, or the location of debris such as wrecks.

If the camera is mounted on a remotely operated vehicle (ROV) or on an autonomous underwater vehicle (AUV), it is possible to cover a large area and therefore to build up a better impression of what the sea-bed looks like. The problem with a camera is that it can only be used very close to the sea-bed, which usually involves an expensive operation to place it there, and in turbid water its use is ineffective.

Another way to study the sea-bed is to deploy an underwater acoustic system, generally referred to as a sonar, an acronym for SOund Navigation And Ranging that has now crept into general usage. Many types of sonar systems have been designed for exploring and surveying the sea-bed and for identifying and characterising sediments. All of them are active systems, because they operate in both transmit and receive modes, as distinct from passive systems that only work in receive mode. They are classified here under two main categories, 'non-penetrating' and 'penetrating'. The main feature of a non-penetrating system is that all the acoustic energy incident at the sea-bed is scattered, some of which is intercepted by a receiving transducer or array. Processing the received signals can yield some kind of 'image' of the sea-bed. This may be a 'one-dimensional' depth profile, ie the topography along a particular line, or a 'two-dimensional' plan view showing the presence, shape and orientation of natural features or objects. The main feature of a penetrating system is that some of the incident energy is scattered and some is transmitted into the sea-bed to be subsequently scattered from sub-bottom interfaces or absorbed. Processing the received signals in this case is much more complicated but can lead to a 'two-dimensional' sub-bottom profile, ie a sectioned view of the sea-bed and the underlying structure. Examples of non-penetrating systems are the conventional depth sounder, side-scan sonar, sector-scan sonar (which can be mechanically or electronically scanned), 'multi-beam' phased array sonar and synthetic aperture sonar. Examples of penetrating systems are the sub-bottom profiler, seismic profiler and parametric sonar.

Even the simplest type of sonar system, a conventional echo sounder, may be used to profile the sea-bed, something that can not be done conveniently with a camera. All that is necessary is to traverse the area of interest, transmit short pulses of sound vertically downwards and detect the echoes. The 'round trip' flight time of each pulse, from the instant it is emitted to the reception of its echo, when multiplied by the average velocity of sound in the water, gives the depth at some location. Modern echo sounders, as well as displaying the instantaneous depth numerically, provide a graphical display of the sea-bed profile along the track of the vessel. Depending on the frequency of operation and its power output, the sounder may also produce echoes from under the sea-bed, but is not usually suitable for studying the nature of the underlying sediments.

More sophisticated types of sonar may be used to produce two-dimensional images of the sea-bed. These include the side-scan sonar, the sector-scan sonar and the multi-beam phased array sonar. A side-scan sonar system usually has two horizontal linear arrays of elements that are mounted in a towed body, or tow-fish, in such a way that they transmit a fan-shaped beam, narrow in the vertical plane, on each side of the towing vessel's track. According to a well-known principle of acoustics, the longer the arrays the narrower are the two beams. Generally, the axis of each beam is inclined slightly downwards so that echoes are produced from different distances, typically from almost vertically down to almost horizontal. One system that has been used for many years for long-range surveying at oceanic depths is GLORIA, which uses a carrier frequency of a few kilohertz [1]. Most side-scan sonars have a graphical display that provides a two-dimensional image of the sea-bed, showing features such as rock formations, reefs and the position and orientation of wrecks and other man-made objects. The image is essentially a 'picture' of the sea-bed but it is usually distorted and needs an experienced eye to interpret the features. At low frequencies, say less than 20 kHz, the acoustic energy can penetrate the sea-bed but because of the long wavelength and large 'footprint' the spatial resolution is poor. Smaller footprints are possible if the sonar array is mounted on a deep-towed vehicle such as TOBI [1]. By using a higher frequency,

[1] Reprinted from *Acoustics Bulletin* March/April 1999

say 100 kHz, there is less sea-bed penetration but better resolution of detail.

Perhaps the commonest type of scanning sonar is the mechanically-scanned version. This works on a 'ping-and-listen' principle, rather in the way a radar system operates. Most commercial systems can transmit while rotating through a sector or through a complete circle, either in the horizontal plane or inclined downwards at some angle. The echoes following each ping are processed to build up an image of the insonified area.

An electronic sector-scan sonar system usually has a wide-beam transmitting transducer or array and a narrow-beam receiving array comprising many elements. In a 300 kHz 'within-pulse' version designed and built at Loughborough University, the linear transmitting array comprises 75 elements mounted on a convex curve and the linear receiving array comprises 75 elements mounted on a flat base. Each transmitted pulse insonifies a 30° wide sector, giving rise to echoes at any angle within this sector and at any range out to a maximum determined by the pulse repetition rate of 4 Hz.

A delay is introduced between the signal arriving at element 1 at one end of the array and at element 2; the same delay is also introduced between the signal arriving at element 2 and element 3, and so on all along the array. This clearly introduces a phase difference between the signals arriving at adjacent elements and means that at any instant the receiving array is sensitive to echoes arriving from only one direction. At a later instant, when the phase difference is altered, it is sensitive to echoes from another direction. With the correct phasing, the effect is to create a sensitivity 'beam' that scans continuously through the sector of the transmit beam. In the Loughborough University system the scanning frequency is 10 kHz. The system may be used as a 'look-ahead' sonar for detecting obstacles or to look sideways for mid-water targets, but it may equally well be used to look vertically downwards to image the sea-bed.

A more complex system working along broadly similar lines is the multi-beam phased array sonar. This has two multi-element linear arrays, which for sea-bed surveying may be mounted on the bottom of the hull of a vessel. The transmitting array is mounted along the fore-aft line and generates a 'fan-shaped' beam vertically downwards; this beam is wide in the port-starboard direction and narrow in the fore-aft direction. The receiving array is mounted at right angles to the transmitting array (and generally slightly astern of it) and therefore is sensitive to echoes arriving in a fan-shaped sector that is wide in the fore-aft direction and narrow in the port-starboard direction. Instead of just one phase delay being applied to all adjacent elements across the receiving array, which makes the receiver sensitive in one direction at a time, many phase delays are applied in parallel (as many as 128 in one commercial system) so that the receiver simultaneously processes signals from all directions within the insonified sector. With this system a two-dimensional plan-view image of the sea-bed is built up pulse by pulse.

Another system of interest but one still in the research stage for use at sea is the Synthetic Aperture Sonar (SAS), which is a specialised system that allows the imaging of finer detail than is possible by most other techniques [2-4]. This example of a 'non-penetrating' type of sonar system is presented in more detail below.

The side-scan sonar, sector-scanning sonar, multi-beam phased array sonar and synthetic aperture sonar are not generally suitable for sub-sea penetration because they operate at too high a carrier frequency. Systems that may be used to characterise sub-sea sediments include the seismic profiler [5-8], the sub-bottom chirp profiler [9], the parametric sonar [10-19] and hybrids such as the 'scatterometer' [1]. The seismic system is used to profile the sea-bed on a large scale, with penetrations of hundreds of metres or more; the others are used to profile on a smaller scale, typically tens of metres at the most. In the case of the sub-bottom profiler, either a single-frequency tone or a wide-band chirp may be used. The lowest frequencies, typically 5 kHz, obviously allow the deepest penetration and can give a picture of coarse stratification, but the higher frequencies, typically up to 20 kHz, offer the best depth resolution and can therefore show finer detail. The choice of frequency usually depends on the application. To illustrate a 'penetrating' type of sonar system, a brief description of the principles of the seismic profiler is presented below, together with a more detailed description of a parametric sonar system with a steerable beam.

2. SYNTHETIC APERTURE SONAR

Synthetic Aperture Sonar is of interest because it has the potential to produce high resolution, two-dimensional images of targets by synthesising the effect of a very long phased array [2-4]. The principle of aperture synthesis consists of storing successive echoes obtained from a moving platform, in practice a tow-fish but ultimately an AUV, then synthesising the effect of a large along-track phased array by correcting the phase excursions of echoes in a given direction and summing the sequence of echoes, hence providing high along-track (cross-range) resolution.

Traditional techniques such as side-scan sonar are good enough for general surveying and for identifying wrecks but do not have sufficient resolution for displaying particular features. The main reason for this low performance is the limited aperture size available with commercial systems. Synthetic aperture techniques are well advanced in radar and known as Synthetic Aperture Radar (SAR). By comparison, only a limited amount of research has been carried out on SAS and this has highlighted the main problems that prevent the direct translation of SAR techniques. These problems are that transducer motion produces smearing of the image, and ray bending produces a bias in the apparent direction of detected objects. The solutions used to eliminate these problems in SAR are auto-focus techniques that rely on contrast enhancement, but these are of limited success with SAS because of the relatively large transducer movements encountered in practice, together with very low towing speeds, narrow bandwidth and restricted range.

The aims of recent work at Loughborough University, carried out jointly with University College London, covered four main areas: (i) the design of signal processing algorithms to compensate for transducer platform movement and ray bending; (ii) the design of algorithms for interferometric reconstruction of three-dimensional surface images; (iii) the design of algorithms for moving target tracking using SAS; and (iv) testing an experimental system in the controlled environment of a sonar test tank.

Motion compensation

The approach to the problem of motion compensation was to consider that the true signal is effectively convolved with an error function that corresponds to the true trajectory of the transducer platform. At sea, with transducers mounted on a ship or in a towed array, waves can cause gross deviations from an assumed straight line trajectory that may be several wavelengths at the transmission frequency. One solution is to measure actual platform movement and do explicit de-convolution. The preferred solution, which obviates the need for accelerometers or inertial gyroscopes, is to perform blind de-convolution based only on measurements made by the transducer array itself. Three options were considered: (i) statistical de-convolution based on Higher Order Statistics (HOS), which is applicable to motion perturbations that are fairly predictable (eg cyclic) compared with the random nature of the data field; (ii) compensation based on frequency diversity, which requires separate measurements in different bands using the same transducer and may compensate for ray bending but not for motion errors; and (iii) compensation based on spatial diversity, which can provide multiple snapshots of the same data field and also allows for adaptive tracking of errors induced by motion.

Interferometric reconstruction

The interferometric processing consists of registering two images of the same scene taken at slightly different positions, and comparing the phases of the two images on a pixel-by-pixel basis. This yields a fringe pattern, which is a function of the interferometric baseline and geometry, the wavelength and the surface topography. Provided the baseline, geometry and wavelength are known, then in principle the surface can be reconstructed from the fringe pattern to the same spatial resolution as the original images.

The main problems are: (i) the two images suffer a degree of de-correlation due to the different angles of observation and the finite signal-to-noise ratio, which causes phase noise in the fringe pattern; (ii) 'shadowing' and 'layover' cause distortion of the sonar image with respect to the true surface; and (iii) there is an ambiguity between phase and topography, and the process of reconstructing the topography unambiguously ('phase unwrapping') is made more difficult in areas of rapidly varying topography and poor signal-to-noise ratio where the fringes may be closely spaced or indistinct. The approach was to simulate the imaging of arbitrary topographic scenes, taking account of the problems listed above, then to devise algorithms to reconstruct the original topography. The idea was to optimise the geometry and processing algorithms for the experimental part of the research.

Imaging moving targets

This is an important problem with SAS and has so far remained unsolved. Unlike for SAR, the situation is more complicated because the target is close enough to the synthetic array, which may be several kilometres long, that it presents different Doppler shifts to different parts of the array. This complicates the aperture synthesis processing. The problem may be approached by analysis, deriving expressions for the phase history of echoes as a function of the array-target geometry and motion, and using these to define the form of processing required to estimate the target motion and image the target. This algorithm can then be combined with that for the platform motion compensation to define the processing required in a practical SAS system, but further research is needed to fully achieve this aim.

Tank experiments

An important part of the research was to apply the various algorithms mentioned above for use with an experimental system, in the controlled environment of the test tank at Loughborough University. This provides a valuable test facility for the theoretical aspects of the project. An advanced SAS system was built for use in the tank, measuring 9 m long, 5 m wide and 2 m deep. It has a carrier frequency of 40 kHz, a maximum aperture of 4.5 m and a maximum range of 8 m. The platform carrying the transmit and receive arrays can be moved under computer control by two stepper motors; a third stepper motor is used to introduce across-track motion errors.

The transmitted pulse is generated by a signal generator that can be connected to a computer bus by an interface card. The system can be programmed to generate either a sinusoidal pulse with adjustable amplitude, carrier frequency, pulse length and repetition rate, or more complicated signals such as a weighted pulse or a chirp. The transmitted pulse is fed to the transmitter array by a power amplifier to ensure maximum power transfer. The system allows the feasibility of generating high resolution SAS images, including three-dimensional images, by extracting features and training the system to identify certain objects automatically using neural networks. This is an area of research in which many problems remain unsolved.

3. SEISMIC PROFILER

Seismic profiling is a means of studying the stratification of sub-bottom layers on a large scale, that is to depths of perhaps hundreds of metres or even kilometres [5]. The applications include geological mapping, environmental studies and surveying for cable routes and pipelines. The basic requirement is a sound source with a high Source Level and a receiving array of geophones to detect reflected and scattered pressure impulses. This type of profiling is attributable to the fact that sound waves propagate with little attenuation in media with elastic properties. Any abrupt changes of acoustic impedance causes refraction and reflection and the generation of compressional and shear waves, referred to as P-waves and S-waves respectively. Measurements of the arrival times of the detected acoustic signals are used to work out the sub-bottom geological structure [6].

The velocity of P-waves in the top 50 metres of sediment is typically 1450-2200 m/s, whereas the velocity of S-waves is much lower, between about 10 m/s and 400 m/s. Much of the information on sediment structure comes from the timed returns of reflected and refracted P-waves. There is usually a good correlation between shear velocity and shear strength, an important parameter in geophysical studies, especially for applications such as the construction of oil and gas production rigs where sea-bed stability is a vital factor. In some places, sediments are too soft to be sheared so no shear wave data can be obtained. The commonest method of determining shear strength is to take a core from the sea-bed and make measurements in the laboratory but by removing the sample there may be some change in the sediment properties; this is why an in-situ method is preferred [7].

One way this problem has been addressed is to study interface waves, such as Rayleigh, Stoneley and Scholte waves, which propagate along the water/sea-bed interface [8]. The idea is that since the velocity of such boundary waves is linked with the shear wave velocity of the top sea-bed sediment, information about the shear strength of the sea-bed can be obtained without disturbance. By contrast, there seems to be little dependence on the state of gas saturation in sediments, such as those found in the Arkona Basin in the Baltic Sea.

Low frequency seismic sources (20–200 Hz) are used for penetration sediments to depths of the order of kilometres, while higher frequency sources (100 Hz–10 kHz) are used for penetration to depths of hundreds of metres. Typical source durations are 0.1–1s and sources include boomers and sparkers, which are omni-directional transducers that can generate stable pressure signals.

Other sources include explosives and mechanical devices such as air guns and water guns. The array of geophones is either towed behind a vessel or from a sledge that is itself towed along the sea-bed by the vessel. In one system, the sledge stops briefly for each measurement while the vessel steams at a constant speed*. The array is normally in the form of a streamer comprising many geophones in an oil-filled plastic tube that is transparent to sound. A problem with such an array is that it is subject to noise from flow, turbulence, bubbles, waves and ship noise.

4. PARAMETRIC SONAR

A parametric sonar system makes use of the non-linearity of acoustic wave propagation in water [10-19]. The principle of operation is to drive a transducer array at two primary frequencies, f_1 and f_2, near the resonance frequency f_0 of the array, where $f_0 = (f_1+f_2)/2$, to generate new waveforms, the lowest of which is at the difference frequency, or secondary frequency, $f_d = f_2-f_1$. The generation of this secondary frequency waveform along the transmitted beam direction gives rise to the concept of a virtual end-fire array, the effective length of which is given by $(2\alpha)^{-1}$, where α is the small signal attenuation coefficient in nepers/metre. At primary frequencies of 20 kHz, 40 kHz and 80 kHz, the virtual array lengths are approximately 1500, 400 and 100 metres respectively for transmission in sea water.

The advantage of a parametric sonar is that it can generate a sidelobe-free, narrow beam at the difference frequency, using an array that is small compared to one that would be needed to generate the same frequency directly. A further advantage is that it allows sediment penetration to depths of several metres at difference frequencies of less than 10 kHz. The disadvantage is that it operates at a very low efficiency, about 1%, a figure that depends directly on the step-down ratio $f_0{:}f_d$. The low efficiency therefore necessitates the generation of high-power primary frequency waveforms. This means that the Source Level at the difference frequency is typically 40 dB less than either of the two primary frequency Source Levels for a typical step-down ratio of 10, eg a difference frequency of 7.5 kHz from primary frequencies centred on 75 kHz. (Source Level is defined as $10 \log_{10}P_a$ + DI, referenced to 1 metre from the acoustic source transducer or array, where P_a is the transmitted acoustic power in watts and DI is the Directivity Index, which depends on the geometry of the source.)

In several recent European Commission projects,** a narrow beam was needed for accurate profiling of the sea-bed to characterise sediments and to detect and identify buried objects. As the difference frequency beamwidth is approximately that of the primary frequencies, the beamwidth defines the dimensions of the array. For a step-down ratio of 10 (ie $f_0{:}f_d$), the active surface area of the array need only be 1/100th of that of a conventional linear array for the same beamwidth.

This is a big advantage in terms of expense, size, weight and handling of the array at sea. The array consists of a titanium plate with 729 integral elements, resonant at 75 kHz and arranged in a 27 × 27 matrix with approximately 0.75 spacing. It has an area of $20\lambda \times 20\lambda$, with a resultant –3 dB beamwidth of 3° × 3° and a bandwidth of 6 kHz. The transmit Directivity Index is 35 dB so for an acoustic power of 10 kW the maximum predicted Source Level for a single carrier frequency is SL_0 = 246 dB re 1μPa at 1 m. The array provides 13 resolvable beams, each about 3° wide, within its phase-steerable sector; since the inter-stave spacing at 75 kHz is 1.5λ the scanned sector is ±18°, which allows a wide variety of incidence angles to be selected in order to apply inverse algorithms to compute sediment characteristics from measured compressional and shear wave data. The programmed signals transmitted may be continuous sine wave pulses, 'raised cosine' pulses, and linear frequency modulated pulses (chirps).

The scenario for sea trials conducted at various sites off the coast of Brittany, France is shown in Figure 1. The array, together with other systems, has been deployed at depths of 10–20 metres in a tow-fish specially designed and built by IFREMER, the French Oceanographic Institution. A 40 metre seismic hydrophone streamer is towed some 25 metres behind the tow-fish to detect forward-scattered signals from the seabed. The mechanical mounting arrangement, shown in Figure 2, allows three possible fixed angles for the transmission axis, 10°, 15° and 20° with respect to vertical, when the dynamic steer angle is programmed to be 0°. When the beam is steered vertically downwards to the sea-bed, the array may also be used in a back-scatter depth sounding mode.

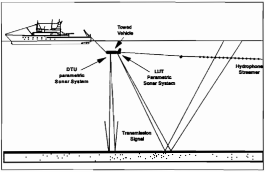


Figure 1. Deployment of a parametric sonar array and hydrophone streamer.

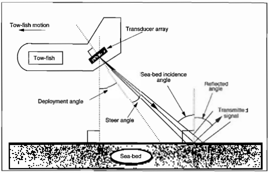


Figure 2. Configuration of electronically steered parametric array in a tow-fish.

Instabilities in the motion of the tow-fish, such as pitch, roll, yaw, heave, swell and surge, can lead to a departure from the desired sea-bed incidence angle. Any error in this angle may lead to a misalignment of the streamer with respect to the scattered signals. This in turn may produce either no data at all or data that yields spurious results when applied to the inverse algorithms that are applied to quantify the sediment parameters. Sensors are therefore attached to the array to monitor the pitch, roll and depth of the tow-fish to correct for some of the instabilities.

Since the beam cannot be steered athwartships, there is no correction for roll; but if the roll angle of the fish exceeds about 3° the forward-scattered signals would not be detected by the hydrophone streamer so transmission for such angles can be temporarily halted. For any pitching of the fish, the beam angle is dynamically adjusted so that the angle of incidence at the sea-bed remains unchanged. The hardware of the system allows the individual addressing of eight separate sections of the available memory that store the required waveforms to provide a series of phase-steered signals for a range of angles. When the sensors attached to the array detect a change of pitch, the appropriate waveform is selected and the beam is therefore steered to compensate for the movement. A series of eight signals allows near-instantaneous correction of the beam direction due to the sensed movement. With eight possible angles and a total phase steer capability of ±18°, the angular separation of the beams is 4.5°. A further consideration is the problem of alignment of the sonar beam and the streamer when the sea-bed is sloping and several methods have been studied to determine the slope. The simplest method is by depth sounding, which can be done by periodically steering a primary frequency beam vertically downwards. A more complex method is to steer two primary frequency beams at different angles, say one slightly fore of vertical and one slightly aft of vertical, then measure the time difference, which in turn allows the slope to be determined. A suitable way to do this is to correlate the envelopes of the two back-scattered signals; the two narrow beams would make the array appear like a Doppler sonar but instead of measuring a frequency difference, a time difference is measured. The method is therefore similar in principle to the operation of a correlation velocity log.

Although a parametric sonar system is fairly complex and is difficult to deploy, it allows the study of sediments remotely, since it can operate near the sea surface to examine the characteristics of sediments on the continental shelf.

5. CONCLUSIONS

Many types of sonar system have been designed for the detection of objects underwater and for the surveying or imaging of the sea-bed. There are many variations on a theme available and there is no one system or technique that is 'better' than all the others: the measurement capability or precision depends to a large extent on the application considered. Whatever the technique used it is always necessary to consider what result is expected; the resolution achievable, whether coarse or fine, is invariably of paramount importance and worth special consideration [20].

In this paper, the various sonar systems have been arbitrarily categorised as 'non-penetrating' and 'penetrating' to distinguish between types that are mainly used for imaging the sea-bed and those that are mainly used to profile sub-bottom sediments. One of the major challenges to sea-bed exploration is to find a technique or a combination of techniques to enable sediments to be identified and characterised without the need to take cores or to disturb the sea-bed directly. This has been a major research theme of the European Commission's MArine Science and Technology (MAST) programmes**. In the MAST programme research described here the broad aim has been to design new, remotely operated systems for characterising the sea-bed and the sub-bottom structure entirely by acoustic means. While the use of non-penetrating systems such as the side-scan sonar have been used routinely for decades to image the sea-bed, it remains a major challenge to determine the exact nature of the underlying sediments using penetrating systems such as the parametric sonar. The ultimate objective is to develop an acoustic technique such that following the propagation of a coded ping or a series of pings, the scattered or reflected acoustic signals may be analysed to reveal the nature of the sea-bed parameters directly without recourse to direct non-acoustic techniques that are used now. Present techniques, although advanced and sophisticated, are a long way from achieving this objective. Future applications of this technology may include dredging, material exploitation, sedimentology, propagation modelling and the detection of buried objects.

ACKNOWLEDGMENTS

The author is indebted to the following colleagues for their many and varied contributions: Paul Connelly, Professor Colin Cowan, David Goodson MIOA, Professor Hugh Griffiths FIOA, the late Professor Roy Griffiths FIOA, Paul Lepper and Dr Tahsin Rafik.

* The research on synthetic aperture sonar described in this article was funded by the Engineering and Physical Sciences Research Council under Grant GR/J71106 (Loughborough University) and Grant GR/J81082 (University College London) and by the Defence Evaluation and Research Agency under Agreement 2170/128.

**The research on parametric sonar described here was funded by the European Commission under MAST-II contract MAS2-CT91-0002C (REBECCA), International Scientific Cooperation contract CI1*-CT94-0093 (ACUSTICA), MAST-III contract MAS3-PL95-0009 (DEO) and MAST-III contract PL96-1111 (SIGMA).

REFERENCES

[1] M.L. Somers, "The IOSDL acoustic scatterometer for sediment studies", *Proc 2nd European Conference on Underwater Acoustics, Copenhagen*, 497-502 (1994)

[2] J. Chatillon, M.E. Zakharia and M.E. Bouhier, "Wideband synthetic aperture sonar: advantages and limitations", *Proc 1st European Conference on Underwater Acoustics, Luxembourg*, 709-712 (1992)

[3] L.J. Cutrona, "Comparison of sonar performance achievable using synthetic aperture techniques with the performance achievable by more conventional means", *J. Acoust. Soc. Am.*, **58**, 336-348 (1975)

[4] P.T. Gough, "A synthetic aperture sonar system capable of operating at high speed and in turbulent media", *IEEE J Oceanic Eng*, **11**, 333-339 (1986)

[5] P.G. Simpkin and P. Geo, "Seismic profiling in shallow water - a novel approach", *ProcIOA*, **15**, 279-283 (1993)

[6] S.E. Dosso and G.H. Brooke, "A high-resolution geoacoustic study in the Canadian high Arctic: sea-bed characterisation using non-linear acoustics", *Proc 2nd European Conf on Underwater Acoustics, Copenhagen*, 857-862 (1994)

[7] F. Theilen, F.C. Kogler, K. van Bocxlaer, M. de Batist, T. Missiaen, G.G. Ori, G. Ollier, T.M. McGee and P. Brussaard, "GISP - Geophysical In-Situ Probe", Proc 1st European Conf on underwater Acoustics, Luxembourg, 481-484 (1992)

[8] J.M Hovem and S.A. Frivik, "Marine geotechnical investigations using interface waves", *Proc 2nd European Conf on Underwater Acoustics, Copenhagen*, 869-874 (1994)

[9] S.G. Schock, L.R LeBlanc and L.A. Mayer, "Chirp sub-bottom profiler for quantitative sediment analysis", *Geophysics* **54**, 445-450 (1989)

[10] P.J. Westervelt, "Scattering of sound by sound", *J. Acoust. Soc. Am.* **29**, 199-203 (1957)

[11] P.J. Westervelt, "Parametric acoustic arrays", *J. Acoust. Soc. Am.* **35**, 535-537 (1963)

[12] B.V. Smith, "An experimental study of a parametric end-fire array", *J. Sound Vibr.* **14**, 7-21 (1971)

[13] W.L. Konrad, and M.B. Moffett, "Specialised drive waveforms for the parametric acoustic source", *Proc Oceans 77, Los Angeles*, 16-19, (1977)

[14] J.G. Willette, "Harmonics of the difference frequency in saturation limited parametric sources", *J. Acoust. Soc. Am.* **62**, 137-138 (1977)

[15] T.G. Muir, L.L. Mellenbruch and J.C. Lockwood, "Reflection of finite amplitude waves in a parametric array", *J. Acoust. Soc. Am.* **62**, 271-276 (1977)

[16] M.B. Moffett and R.H. Mellen, "Effective length of parametric acoustic sources", *J. Acoust. Soc. Am.* **70**, 1424-1426 (and errata 71, 1039) (1981)

[17] B. Woodward, J.C. Cook, A.D. Goodson and P.A. Lepper, "A phase-steered parametric array for sub-bottom profiling", *Proc 6th Int Conf on Electronic Engineering in Oceanography, Cambridge, UK*; IEE Conference Publication No. 394, 77-82 (1994)

[18] B. Woodward, A.D. Goodson, J.C. Cook and P.A. Lepper, "Sea-bed characterisation using non-linear acoustics", *Proc 2nd European Conf on Underwater Acoustics*, 875-880 (1994)

[19] S. Englebrecht, N.G. Pace and L. Bjørnø, "The interaction of a parametric array with the sea-bed", *Proc 2nd European Conf on Underwater Acoustics* 893-898 (1994)

[20] M.L. Somers, "Resolving the issue, a look at resolution and related topics in sonar" in "Man-Made Objects on the Seafloor, Discovery, Investigation and Recovery," *Proc Society for Underwater Technology Int Conf, London*, 1-2 Feb, 41-58, ISBN 0-906940-26-5 (1995)

NOISE EFFECTS 98 – A SUMMARY

7th International Congress on Noise as a Public Health Problem. 22–26 November 1998, Sydney Australia

Jerry V. Tobias
Tobias Consulting,
Box 1609, Groton, CT 06340-1609, USA

On my first visit to Sydney, not only did I have the pleasure of participating in the 7th International Congress on Noise as a Public Health Problem, but I picked up some unexpected information. First, I learned that boomerangs are coming back. I learned that half-way around the world is actually further away than all the way around. And I learned from a taxi driver from Kenya that the best way to eat an elephant standing in your path is to cut it up in little pieces. The challenge of writing a short narrative that highlights the findings of well over 200 papers is enormous. My job is to eat an elephant.

We are learning to build mathematical models of the auditory system that are good enough to predict impulse-noise hazards. We are discovering that community exposures to potentially harmful noise can be successfully decreased. However, developing universally accepted noise-control and noise-exposure policies is almost always more political than mathematical. Decision makers have so many non-scientific forces to contend with, that policies need to be compromises. Research workers – and it doesn't matter whether they study auditory effects or non-auditory effects of noise – need to remember that maintaining public health requires strong political support. It's never enough to write a perfect proposal. It's never enough to get all the money you need. It's never enough to find a better measurement technique or to write the best predictive equation that's ever been seen. And it's never enough to define the exact maximum safe noise level for every foreseeable condition. First the researcher has to understand the political basis that will eventually determine whether a standard will be set and, if it is, what it will be.

Researchers and politicians have a basic obligation to keep each other educated about the factors each has to work with. The World Health Organization is pointing the way by looking at abatement, at forecasting and assessment of source controls, at setting standards, and at testing compliance with current standards.

Political decision-makers recognize that we need to be able to compare annoyance measurements made in one country with annoyance measurements made in another. But how can we do that job when our questionnaires are in so many different languages? Luckily, statistical scaling techniques are making it possible to find both equidistant values and comparable anchor points. The object is to create a universal annoyance scale, and it's nice to recognize that so far, the biggest problems are mathematical rather than political.

Obviously, variations derive from language differences – even the word *annoyance* in my native language and my native country conveys a meaning that the word may not carry when directly translated into another language. In fact, it may not convey quite the same meaning in another country whose native language is English or even in a different part of my own country. If we want French anchor points and scales to match Japanese anchor points and scales, for instance, we will probably have to expand the vocabularies we use to gauge people's reactions to noise. We will likely have to deal with *nuisance* and *disturbance* as well as *annoyance*. And we will have to ask subjects to scale their responses to noise rather than simply give us a dichotomous judgment. As ancient research shows, it's still unlikely that using more than five or six scale points will increase our accuracy or improve our knowledge.

Now to data. We know that the reaction to a noise from one source seems to be unaffected by noises from other sources. The reason may be as simple as the fact that adding additional equally-intense or less-intense sounds to an annoying signal increases the loudness only slightly. The reason may be far more complex than that. We've learned that low-frequency noise indoors is more annoying than other noises at the same loudness levels. Outdoors, near wind turbines, mid-frequency sounds, amplitude modulated at about 20 Hz, were the most acceptable. This modulation frequency is more in the *roughness* category than the *beating* category. Also, turbine spectra with enough high-frequency components to make a swishing or whistling sound were quite annoying. An intuitively satisfying study shows that home owners who bought houses in noisy neighborhoods are less disturbed by increases in the noise level than home owners who bought houses in quiet neighborhoods. Attitude clearly affects reactions to noise.

We are beginning to see more countries concerned about the monetary costs of noise and especially of transportation noise. Researchers and government officials have an opportunity to join together in figuring out optimum ways to measure those costs. Costs also influence how we do laboratory experiments. In that context, there's an intriguing finding from an Australian study – the ratings for 10-second signals are as reliable and accurate as the ratings for 2-hour signals.

One thing that fascinates me as we move in five-year increments from Congress to Congress is how measurement techniques change. For example, EEG is still used as a primary physiological measure of sleep quality, but more and more studies are using global measurements of activity. We've learned from interviews with a wide range of noise-exposed people that significant sleep effects occur only for adults in the age range between 21 and 40. Older people must be less sensitive to noise during sleep. Objective increases in sleep problems, though, were smaller than subjective ratings suggested they would be. Age, gender, and personal and work habits seem to matter more than the ratings.

The acoustics in 28% of American schools are bad enough to interfere with students learning and teachers teaching. A majority of schools in the UK have the same problem. Noise dose measurements in Danish kindergartens come out as high as 85 dB(A), and teachers complain of tinnitus. Noise and acoustic problems are the second most common school-environment difficulty in Sweden. Other countries are equally concerned about classroom noise. The biggest noise problems seem to be those that the students create themselves. They talk, they move around, they shift their chairs and tables. The noise levels seem worst in the backs of the classrooms. So my old teachers may have had the right idea when they moved the slower and more distractable students to the front of the room. But interestingly enough, despite the fact that they recognize that the greatest noise comes from people, teachers and students both say that they'd prefer going to school in a quieter part of the city.

In preschool, the quieter the classroom is, the better the reading readiness and language competence scores are. In the early school grades, chronic exposure to aircraft noise leads to reading deficits and long-term annoyance. Maybe it also reduces language mastery, cognitive processing, and memory, although one study shows that chronic noise may not affect long-term memory or motivation at all. On the other hand, children performed a vigilance task and a highly frustrating task – that's not a puzzle, but a completable task – did better when it was noisy than when it was quiet. But children who live in quiet areas (and whose sleep is therefore not disturbed by noise) make fewer errors in discriminating details and they complete more test items. One interesting confirmation of the noisiness of little children is that people who work in day-care centers often seek medical help for voice disorders, apparently because they have to speak loudly over long periods of time.

To move on to adult environments, we've learned that noise-created distraction is unrelated to the level of the sound and that it probably doesn't matter whether the distractor is speech or non-speech. Unpredictability and variability seem to be the distracting elements. So all the past reports that people adapt to railway noise much more easily than to highway noise make good sense. Train noise is more predictable.

If you're faced with the task of having to classify a sound emanating from something or someone, you will be handi-capped if you can only use one sense. But that's exactly what happens with many visual-display systems. Relatively recently developed 3-D-audio displays used in conjunction with visual displays ought to help air-traffic controllers, pilots, trained observers, and others who are involved in search tasks, maybe even in noisy environments where they have to wear hearing protectors.

People who have to use hearing protectors in noisy environments do continue to complain that they can't hear what their coworkers are saying. Two approaches are being studied more closely than they have been. One is the attempt to select protectors that optimize speech understanding rather than noise attenuation. The other is to use active-noise-reduction headsets. When the noise level is extremely high, active-noise-reduction is probably the only reasonable choice. When the noise level is comparatively low, tuning hearing-protector response is likely going to help. But when we're dealing with the usual work-environment, decreasing attenuation may not be a very safe idea. An old solution may work better. Remember that we each select a level for our speech that depends on feedback to our own ears. Wearing hearing protection decreases the apparent noise level, so most of us tend to talk more quietly. Call it an inverse Lombard effect. We need to remember to say to workers, "When you put on hearing protectors, people can't hear *you*." They should all just raise their voices.

Now to a few practical points about noise and communication. The first one is that in a military tank where the noise contains high-level low-frequency components, the tank drivers select communication sound-pressure levels close to 110 dB. That's considerably more than the upward-spread-of-masking standards predict. You have to use Zwicker's masking curves in order to predict accurately the speech-to-noise ratios needed for good understandability. Next, in relatively quiet environments, speech probably conveys the best emergency information. But in noisy situations where complex signals might be misheard, simple shifts in pitch and in the rate of change of the signal lead intuitively to correct interpretations of what a helicopter pilot, for example, needs to do. Faster change means faster. Rising pitch means go up. And so on. Also, if you customize a standard active-noise-reduction headset to meet the signal requirements of someone with even a profound hearing loss, the user will hear less noise and better speech. That means that for comparatively little money, we may be able to help people who are currently unable to work effectively in noise.

We have every reason to believe that noise creates physiological changes outside the auditory system. And yet one interesting new finding is that if you think noise won't affect your health, it probably won't. Still, subjects who fill out questionnaires report increased physical and mental problems as a function of increases in high-level noise.

Let's get to actual physiological measurements. One study showed that office noise probably doesn't affect the quality of work, but it does raise catecholamine levels and may decrease motivation to complete challenging tasks. Another study, on sleep effects, showed that although noise creates changes in stress hormones, the changes adapt out. Most people present only small effects. High levels of traffic noise don't seem to change hypertension much at all. But moderately high levels may slightly increase the risk of ischemic heart disease. It may be that people who are particularly annoyed by the noise are at a higher risk. But today, there's no clear evidence. We've learned that workplace noise levels above 95 dB(A) are related to menstrual abnormalities. We don't know yet what the effects of hearing protection might be, but it should provide a valuable topic to study. Also, there's an interesting finding that noise sensitivity-not noise, but sensitivity to noise-is related to mental disturbance.

We need to see a lot more studies of the auditory and non-auditory effects of noise when other stressors are present. It would be particularly interesting to learn more about how commonly used drugs interact with noise, how heat and light and vibration interact with noise, how work interruption and complex mental tasks and fatigue interact with noise, how air and water pollutants interact with noise, and so on and so on and so on. An especially well done piece of work from China tells us that carbon monoxide may magnify the effect of noise on hypertension. But being old and male is still more likely to be related to hypertension than noise exposure is. Russian researchers have a fairly long history of studying physiological effects of noise and of interactions. A new Russian study hints at visual and autonomic changes when people are subjected to combined noise and heat. But the data suggest that we really have to see more multi-stressor studies with good controls.

Studies of noise-induced hearing loss are producing some fascinating information. For instance, we know that one effect of noise exposure is a kind of poisoning of the inner ear. It looks as if cell-killing proteins and other such chemical factors can be counteracted so we can treat or even prevent noise-induced hearing loss. Some of the suggested antitoxins may be difficult to get into living human cochleas, although some may be dropped onto the round window through the tympanic membrane. Probably infrequently. But injections or even oral doses of magnesium can increase levels in the perilymph. And that seems to reduce permanent threshold shift significantly. That's very exciting. We are blessed with some large-sample longitudinal studies that are already providing useful information and should continue to give us stable data for years to come.

We are also blessed with a new set of tools to measure and predict hearing damage: the several varieties of otoacoustic emissions. Emissions that are evoked by transient signals seem to be good and sensitive measures of outer-hair-cell deterioration. I am a little concerned about the predictive value of otoacoustic emissions because they are generally calibrated against temporary-threshold-shift data. Now TTS has proven to be a valuable tool. But we still don't have a clear, longitudinal demonstration that TTS predicts permanent threshold shift. With that in mind, the consensus is that if you measure otoacoustic emissions, particularly those that are evoked by transient signals, you can detect considerably smaller threshold shifts than you can with Békésy audiometry, you can do it a lot faster, and you don't need to be quite so fastidious about the acoustic environment in which you do your testing. One limitation to otoacoustic-emission testing is that current equipment is limited to just a couple of kinds of emission-evoking signals. We ought to try to learn more about the effects of differently shaped waveforms and envelopes before we decide that the kinds of signals we use today are adequate for the predictions we ultimately want to make.

Now let me talk a moment about theory and then about practicality. First, the equal-energy hypothesis is still with us as it should be. It works well. If it worked perfectly, then, for example, 20 short pulses of a sound at a given amplitude ought to produce the same threshold shift as 10 similar pulses but with the pulse duration doubled. But that doesn't happen. Maybe the reason is that the ear adds the energy of its own resonances to click-like signals. Maybe not. But the data show that if you make your impulses shorter or if you increase the number of short pulses, you'll get more temporary threshold shift than the equal-energy hypothesis suggests.

Now for the practical. Apparently a first-rate education program can save a large number of young ears. In Norway, extensive public information about the hazards of loud music has been circulated via television, radio, newspapers, teen magazines, and warnings on headsets. Pre-military high-frequency hearing loss among 18-year-old men increased from 15% in 1981 to 35% in 1987. Then, with the advent of the education program, it began to fall – to 31% in 1990, 25% in 1992, and so on down to 11% in 1996. In Sweden, comparable measurements have shown a fairly consistent 14% of young men with high-frequency losses. In 1993 in Britain, though, 45% of 20-year-old men had hearing losses. I don't know the Australian figures, but we've learned that Australian rock concerts are very loud. And the tested young people who work in them, either as musicians or as sound engineers, all had hearing losses except for one student who always used earplugs. On the other hand, age-corrected audiograms for symphony musicians look normal. That finding is a little troublesome to me. First, it's still likely that a significant proportion of the age correction actually reflects effects of noise exposure. If symphony musicians show the same age effects as people whose work and recreation put them in noisy places, they may indeed have some noise-induced hearing loss. Second, there's a long history of violinists who play several hours a day having progressive losses in their left ears. Because I've tested several of them myself, I worry that the current research didn't discover some.

The people who keep trying to force us sedentary types to exercise have a little more data to support their ideas. We've learned that although strenuous large-muscle activity during or immediately following noise exposure doesn't affect the amount of temporary threshold shift, it cuts recovery time by a significant fraction.

Not too many years ago, the only things that roared were waterfalls and windstorms and thunder. Then came engines and sirens and electronic amplifiers. It's an easy intuitive leap to suppose that the masking and the startle effects produced by cars zooming by or by jets passing overhead should interfere significantly with wildlife. Apparently that intuition is nearly worthless. For example, past researchers have pointed out the presence of thriving colonies of game birds beside major highways and contented cows grazing between the runways at major airports. Aircraft noise, even with sudden level changes, has no noticeable effects on osprey mating behavior. Large, flightless birds may run around together saying to each other, "What was *that*?" If there are effects on most bird populations, they are subtle, so we need samples that are much larger than anyone has put together so far. Wind-created background levels of low-frequency noise in the quiet ocean seem to be as high as the noise levels in major shipping lanes. So marine animals have probably always been subjected to as much communication interference as they are during this mechanical age. Sudden changes in noise created by ocean-surface activity may have a behavioral effect on whales, but some of the observed behaviors occurred without any rapid noise-level changes.

A couple of unrelated findings may be pointing the way toward some clinically useful information. First, some rats have cardiovascular systems that react to noise. Those rats show significantly greater threshold shifts than rats whose cardiovascular systems don't react to noise. Also, noise appears to encourage the growth of extra supporting cells and ganglion cells in newborn chicks. It's not clear whether those new cells provide protection against further noise damage, and it's not clear whether the newly grown cells ultimately might provide working hair cells that could create an auditory sensation. But the rat studies and the newborn-chick studies look as if we ought to find out more about the underlying processes.

My general reaction to the Congress papers and workshops is glowing. But while I have the opportunity to make them, I do have a few extra comments. First, we still face a problem that dates back before the earliest of these Congresses: much community-response research, some sleep research, and some physiological research continue to measure noise levels at varying distances outside test rooms rather than inside. As a result, we don't know what noise subjects received. We can't make successful comparisons of data from one study with data from any other study. We can't even compare the noise exposure of a subject in one study with that of another subject in the same study. Even if you correct for the distance between your sound-level meter and your listener, buildings have walls that are different from each other. And they don't just attenuate. They also filter. A wall in Fiji is likely to transmit sound differently from a wall in Sydney or a wall in Helsinki. We don't need to know how much sound the automobile or airplane makes. We need to know the sound that the subject hears. The common explanation for continuing to use doubtful signal measurements is the trouble and expense of valid metering or recording. But the fact is that the money spent on collecting 40 years of equivocal data could have bought lots of clean data based on actual noise exposures.

Second, as happens at many meetings, a few papers at this Congress discussed results as "borderline significant" or "nearly significant" or "marginally significant." One of my least-liked but most respected statistics professors used to remind us regularly that confidence levels are not data; they are criteria. He told us repeatedly that you choose a confidence level *before* you start work and then measure your results against it. If you do that, you'll never be tempted to use "borderline" or "nearly" or "marginally" significant. You'll just write "insignificant" instead.

Third, we haven't scratched the surface yet of the potential noise problems created by digital recordings. For example, a session at last year's Cannes Film Festival was called "Are Movies Too Loud?" They are. It's true that with digital recording, the noise floor can be dropped pretty much as far as you'd like. But a side effect is that theater operators can turn up the gain enough to get Godzilla to scream at sound pressure levels of 110 or 115 dB for five minutes or more.

I'm happy to see our consensus that we must work more closely with developing countries. ICBEN can offer those countries considerable help, and they can offer us new kinds of problems to solve and new groups of people to test.

Finally, an original and unique purpose of these Congresses has been to bring together three groups of inter-dependent people who seldom get to explain their needs to each other: representatives from the research community, from the industrial community, and from the governmental / political community. As in most years, a majority of the papers I've summarised were from researchers. And although I would always like to see even more industrial and governmental participants, both on the platform and in the audience, the opportunity to interact with Congress delegates from all three groups improves everyone's understanding of the problems we are all trying to solve. Congratulations to everybody and especially to the program committee. It's a real pleasure to find so much good work from so many parts of the world. And we have papers from countries that never participated before. That's very gratifying.

Many of the reports offered at this Congress are important, and several are exciting. New methods and novel approaches are providing us with a better grasp of noise effects and, sometimes unexpectedly, non-effects. I can hardly wait to hear what we'll know at the next Congress in 2003. It's an honor to thank everyone who made this serious work so much fun. Dix Ward, to whom this Congress is dedicated and who is, in a sense, the father of us all, would have been pleased. I am too.

Research Note

VIBRATO FREQUENCY AND PHASE LOCK IN OPERATIC DUET QUALITY

Melanie Duncan*, Carol Williams, Gordon Troup†**

***Music Department, **History and Gender Studies Department,**

†Physics Department, Monash University, Clayton 3168

For a singer, trained in the 'bel canto' tradition, vibrato is defined as a periodic variation of the fundamental frequency of the sung note, accompanied by a periodic variation of intensity with the same period. The maximum of the intensity usually coincides with that of the pitch, but can be in antiphase in some singers. Tremolo is a periodic variation in intensity only.

The locking of vibrato frequencies in unison soprano choirs has been reported and studied by Sacerdote [1].

In a review article on the physics of the singing voice [2], published in 1982, the following surmise occurs: 'It may well be that the pleasing or less pleasing quality of harmony in a vocal duet, for example, depends on whether or not the vibratos of the singers synchronise. This does not appear to have been investigated.'

We are happy to report work in progress which agrees with this surmise: recordings of Dame Joan Sutherland singing the same duet with each of three different singers were used. The 'Flower Duet' from the opera 'Lakhme' was the piece investigated: the other singers were Jane Berbie, Marilyn Horne, and Huguette Tourangeau. Naturally, in each case, Sutherland was the soprano! The duet has a number of unaccompanied passages, so that the voices can be analysed without interference from the orchestral music. The new and very powerful 'Spectra Pro' software, downloadable from the internet and free of cost for one month, was used for the analysis. In fact, 'Spectra Pro' proved so powerful that the work did not need to be restricted to the unaccompanied passages.

Our initial results show that Berbie is the closest to locking in phase in the vibrato frequency variation for most of the segments studied: Tourangeau tends to lock in antiphase, and Horne tends to wander without locking. It seems quite remarkable that such a complicatedly coupled system as two singers singing a duet (and therefore often with different fundamental frequencies) behaves so like a classical coupled 2-oscillator system as far as the vibrato is concerned (presumably the coupling is psychophysical as well as physical). In the simple classical system, depending on the coupling and the natural frequency of each oscillator, we can get an in-phase mode, or an out-of-phase mode, or no joint mode at all (wandering). The analysis of the pairs of singers shows these characteristics.

It should be clear that, for the vibrato, the in-phase mode will give maximum consonance (or minimum dissonance), while the out-of-phase mode will, on the average, give maximum dissonance. Wandering, or lack of lock, will produce noise, and therefore increase the perceived dissonance above the minimum dissonance of an in phase lock. Clearly, a number of factors can affect phase lock, and more clarifying work is under way.

The vibrato frequency of each singer lies in the range 5 to 6 Hz., so the locking failure is not due to the frequencies being too far apart. It manifests itself as a change in frequency with time, as if 'hunting ' is occurring.

Rumour has it that the Sutherland-Berbie recording is regarded as the 'definitive' version. A carefully prepared questionnaire has been sent to noted singers and teachers about this. Of the nine replies so far received, seven agree with 'rumour'. Again, a pleasing result.

The next project is the male duet 'In the depths of the temple', from 'The Pearl Fishers'. The Jussi Bjorling-Robert Merrill version is regarded as the 'definitive' one, but there are problems. It appears that Bjorling recorded this with no other baritone, and we have had difficulty tracing a Merrill recording with another tenor. Any assistance in this regard would be most welcome!

[1] Sacerdote, G.G., Researches on the singing voice, *Acustica* **7**, 61-68 (1957).

[2] Troup, G.J., The physics of the singing voice, *Physics Reports* **74**, 379-401 (1981).

Letter...

The following two researchers are employed until the end of August as Teaching and Research Assistants at the University of Le Mans and are interested in positions in Australia.

Helen Bailliet (28) has experience in musical acoustics, thermoacoustics, physical acoustics, speech, and nonlinear acoustics. She has 5 published papers plus 11 conference papers. Her thesis (on thermoacoustic engines) received "les felicitations du jury". She also has a masters degree in musical acoustics from the University of Wales and a graduate diploma in solid-state physics engineering.

Vincent Valeau (28) has experience in signal processing, musical acoustics, laser Doppler anemometry, metrology, aeroacoustics, and fluid mechanics. He has 1 published paper (2 in preparation), 7 conference papers and 3 reports. He also has an engineering diploma in sea hydrodynamics and spent a year at the University of Ireland in Dublin.

The contact e-mail is:
helene.bailliet@laum.univ-lemans.fr

THE AUSTRALIAN ACOUSTICAL SOCIETY IN THE 21st C WHERE TO NOW? TIME TO RECONSIDER?

The Australian Acoustical Society recently celebrated its 25th anniversary and it has evolved considerably since its creation. From a small membership in three states on the eastern side of the country, it has grown to the stage where its membership now exceeds 400, spread through five divisions right across Australia. During that time, acoustics too has changed in Australia: new technologies, more consultancies, legislation, wider public awareness of noise and its hazards, acceptance of the role of acoustics in architecture and a more prominent image for the Australian Acoustical Society. It is a cliché, but true none the less, to say that the Australia of today is not the place it was twenty five years ago, indeed the world is an entirely different place, so perhaps it is appropriate that we ask the question "is the Australian Acoustical Society still operating in a manner most appropriate to its Membership and to its role in modern Australia?"

An excuse for an appraisal

While I'm not one to be particularly impressed by a roll-over of the date from 1999 to 2000, it strikes me that the approaching end of the millenium at least provides us with an excuse to re-evaluate our Society and to ask (i) is it still doing what our membership wants and (ii) what is its most appropriate role as the only body in Australia addressing the scientific and technological aspects of acoustics as well as the interests of the community in acoustical issues? Each year Federal Council, the elected body charged with running the affairs of the Society, holds two Annual Council Meetings in association with the Annual Conference, in whichever state is hosting the Conference that year. This year I am proposing that Council set aside a significant part of at least one of its Meetings in Melbourne to address the future role of the Acoustical Society: to ask where are we going, what are we trying to achieve, are we going about it the right way, are we satisfying our members' needs? I hope it won't be just a talk-fest. I hope it will lead to some genuinely useful re-appraisal of the Society. Perhaps we'll discover that things are exactly right just as they are, in which case we can all congratulate ourselves and continue on, or perhaps we'll discover that there are some things which need to be changed. Whatever the outcome, I'm convinced it would be remiss of us not to reassess ourselves sometime in the very near future.

Now comes the sales pitch. Council has been elected by you, the members. In case you're unfamiliar with the procedure, Councillors are elected by the Divisional Committees, who are in turn elected by the Divisional membership at each Division's Annual General Meeting. Apart from some legal requirements, Councillors are supposed to represent your interests at Council and to take decisions that are in the interests of all states, all members, and of acoustics too. Council is not the only body which can change the Society, but it is the most powerful in this respect and is certainly the most appropriate forum in which changes should be considered. But Councillors do not by themselves know what is right for the Society. They can't know what is appropriate for us unless they have adequate input from the membership. I had hoped we might survey your views in a formal manner, in a questionnaire to be circulated within this issue of Acoustics Australia. Unfortunately, personal circumstances forced me to stop work temporarily on this project and it is now too late to make such a survey, but there is still plenty of time for a more informal approach.

Gathering the ideas

In the next two months I'd like to hear from you. I'd like to know what you see as the role of the Australian Acoustical Society. Ask yourself why you originally joined the Society? Why do you still pay your annual subscriptions? What is the appropriate role of the Society? Should it be doing more? Less? Is it oriented too much towards technical acoustics? Too much towards legislation? Standards? Should it take more of a lead in public debates on noise or lobbying governments? Should it be playing more of an educational role for its members? For the general public?

Of course, we have to be realistic here. We are all unpaid officers and members of the Society and can't take on huge burdens without the appropriate resources to carry them through. Any new initiatives must be realistic, but unless we know what it is that we should be doing, then it is certain that we won't be doing it.

I hope we can have several opportunities for this review. First I'd like immediate feedback from you, both directly to me and to your Divisional Committees. I'd like your Committees also to consider the future of the Society in much the way I have outlined. Then the Divisional Councillors can bring your ideas to Council in November. Written submissions are preferred because they can be given more reflective consideration, but I also hope that we can find an opportunity at the Melbourne Conference, perhaps at a symposium scheduled out of normal conference timetables, at which some of the more interesting proposals can be discussed directly. It is then my intention that Council should consider all the proposals and, assuming some interesting ideas are developed, prepare some discussion documents to go back to you. The timetable from then will depend entirely upon the nature of those proposals.

If this opportunity (excuse) for a review is missed, it might be a long time before we attempt it again.

Graeme Yates
President

Book Reviews...

Wave Scattering from Rough Surfaces 2nd Ed

A Voronovich

Springer Verlag Publishers, 1999, pp 236, Hard cover, ISBN 3 540 64673 6, Australian Distributor, DA Information Services, 648 Whitehorse Road, Mitcham, 3132, Australia, tel 03 9210 7777, fax 03 9210 7788. Price A$141.75

The first edition of this book was reviewed by Marshall Hall in Vol.32 of Acoustics Australia and many of his comments remain relevant for the second edition. It is a little unusual to see a new edition of a research monograph appear within five years, but in this instance it reflects the intensive research in the area. In particular the author has taken the opportunity to discuss the "operator expansion technique" due to D.M Milder in a new section 6.7, probably because this method has proved to be particularly successful in comparison with what have now become routine numerical solutions of scattering from surfaces varying in one dimension only.

As a whole, the book reflects the author's interests and his own significant contribution to the field, principally in the development of the "small-slope approximation". There is a rather dense introduction to the basic equations and ideas needed in Chapter 2, but one that will reward the careful reader by providing the basic tools for reading the literature, both for acoustic and electromagnetic waves. Chapter 3 includes a discussion of the Rayleigh hypothesis, that the field at any point away from the surface can be regarded as a superposition of outgoing plane waves, and demonstrates that this is true if the surface is of sufficiently small amplitude, laying the basis for some of the perturbation expansions in succeeding chapters. In section 3.4 there is a nice physical discussion showing why the apparent objection to the Rayleigh hypothesis, i.e. that both upgoing and downgoing waves are needed very close to the surface, is not necessarily valid.

One of the difficulties in reading the literature in this area is that there is a plethora of different analytical techniques and approximations available for the problem of determining the scattered field from a rough surface (either from a single surface or from a statistical ensemble of surfaces) and at first sight it is not clear which approach is valid in a particular situation. From the theoretical point of view, the range of techniques available is reasonably comprehensively addressed in Chapters 4 through to 6, with considerable efforts made to compare and contrast the different approaches, and to determine their various ranges of validity. However, a weakness here, and indeed throughout the book, is the lack of reference and discussion of detailed applications and the almost complete neglect of numerical techniques, except where used as a benchmark. For the numerical material at least, a useful but now somewhat dated book is that by J.A. Ogilvy: Theory of Wave Scattering from Random Rough Surfaces, Adam-Hilger, 1991.

In summary, this new version of the book remains a useful introduction to the field and general reference for those interested in a detailed analytical analysis of the problems involved in rough surface scattering. It is not so illuminating for the less mathematically-oriented reader wishing to obtain an overview of current research and an understanding of the basic physical mechanisms involved.

Charlie Macaskill.

Charlie Macaskill is a Senior Lecturer in the School of Mathematics and Statistics, at the University of Sydney. He has worked on ocean acoustic propagation problems and has carried out numerical studies of acoustic scattering from rough surfaces.

Fundamentals of Noise and Vibration

Frank Fahy and John Walker

E&F Spon, 1998, pp 518, Soft cover, ISBN 0419 277 008, hard ISBN: 0419 241 809, Australian Distributor, John Wiley & Sons Ltd, Park Rd, Milton, QLD 4064, tel 1800 777 474, fax: 1800 802 258 Price soft A$115.00, hard A$340.00

The preface states that this book is based on the first semester of the postgraduate course at the ISVR, University of Southampton. The main objective of this course is to provide students with the skills and knowledge required to practice in the field of noise and vibration control technology and its related environmental and human effects.

Each of the 8 chapters are by different authors: Introduction to acoustics by P A Nelson, Fundamentals of Vibration by N Lalor, Fundamentals of human response to sound by I H Flindell, Fundamentals of human response to vibration by M J Griffin, Fundamentals of noise and vibration control by F J Fahy, Fundamentals of signal processing by J K Hammond, Fundamentals of underwater acoustics by T G Leighton and Fundamental principles of measurement and analysis techniques by R J Pinnington.

From this list of chapter headings it can be seen that there is a thorough coverage of the topics on noise and vibration. Most books with similar titles tend to have an engineering approach and it is rare to find a full section on human response to vibration and underwater acoustics. The potential problems arising from a large number of authors have been largely overcome with consistency of presentation and cross referencing. It can be said that the style differences of the chapters make the book more interesting to read.

The figures are clear and complement the text. Each chapter has a good list of references which will assist those seeking more information on the topics covered. A list of questions is included at the end of most chapters. The solutions to these questions are not included in the book but an associated Solutions Manual (which has no ISBN) is available only by request direct to the publishers. It may have been preferable for the solutions to be included within the book rather than requiring purchase and delivery, with the inevidable delay, of a separate solutions manual.

This is an excellent reference book for students, researchers and practitioners.

Marion Burgess

Marion Burgess is a Research Officer with the Acoustics and Vibration Unit at the Australian Defence Force Academy in Canberra.

Sounds of our Times
Two hundred years of acoustics

Robert T Beyer

AIP Press, Springer Verlag Publishers, 1999, pp 444, Hard cover, ISBN 0 387 98435 6, Australian Distributor, DA Information Services, 648 Whitehorse Road, Mitcham, 3132, Australia, tel 03 9210 7777, fax 03 9210 7788. Price A$92.75

Acoustics, as we all know, has a history going back at least 2500 years to the time of Pythagoras. The earlier years have been documented in the short book "Origins in Acoustics" by Frederick V. Hunt (1978), reprinted in 1992 by the Acoustical Society of America, and R. Bruce Lindsay has edited a fine collection of reprints "Acoustics: Historical and Philosophical Development" published in 1998 by Dowden, Hutchinson & Ross. Robert Beyer's excellent book first reviews the state of acoustics in 1800, and then carries through the story in detail up to almost the present day.

Looking back, one realises how difficult was the detailed study of acoustic phenomena without the help of microphones, oscilloscopes, and other electronic equipment we now take for granted. Despite this, the nineteenth century began on the basis of a good understanding of vibrations and sound propagation. There was considerable interest in synthesising the human voice by mechanical means, but little understanding of hearing, apart from studies of the anatomy of the ear.

The first half of the nineteenth century extended this knowledge in similar directions, but the great advances were made in the second half of the century by those giants of acoustics von Helmholtz and Tyndall, who share a chapter, and Rayleigh, who gets a chapter to himself. The treatment of these people and their achievements is delightfully readable. Not only do we learn about the acoustics involved, but also the intellectual and economic climate in which they lived and worked. Did you know, for example, that Rayleigh accepted the chair of physics at Cambridge because of the financial pressures of an agricultural depression, and left the post after only four years when conditions on his family estate had improved? As a nice touch, an appendix gives Helmholtz's reviews (in Nature) of the two volumes of Rayleigh's great work "The Theory of Sound" published in 1877 and 1878.

The next chapter is devoted to the great inventors of the late nineteenth century: Henry, Cooke, Wheatstone, Bell and Edison. Between them they revolutionised acoustic instrumentation and laid the foundations of the modern world of communications. Like the chapters on Helmholtz, Tyndall and Rayleigh, this is the story of people and their achievements, and the next chapter ties it all together in a survey of the advance of the science of acoustics between 1850 and 1900.

As in most fields, the pace of advance increased greatly during the twentieth century, and for that reason the story is divided into 25-year segments. In each, as in the earlier half-century chapters, advances in a large number of sub-fields of acoustics are described in a clear and interesting fashion, so that the story is filled out to perfection. As the author admits, the final quarter century is difficult to assess from within it, so the choice of subjects is eclectic but appropriate.

I found this book fascinating to read. The material is well chosen, the writing is clear and elegant, and the book is illustrated with figures taken from the original publications of the people concerned. For those who want to delve deeper, the early chapters have around 100 references each, and the later ones around 200. I recommend this book to anyone with an interest in the development of our subject – and that should be all of you!

Neville Fletcher

Neville Fletcher is a physicist who has lectured and written widely on many acoustical subjects. He holds visiting appointments at ANU and ADFA and is Editor of this journal.

News...

AAS on WWW

The Australian Acoustical Society has recently updated its page on the www. The various pages which were set up by the journal and by some of the Divisions have now been coordinated by the General Secretary, David Watkins, with a standard style and with a new address. Do have a look and please update any links that you may currently have.

http://www.users.bigpond.com/Acoustics/

1999 AAS Conference

As most now know, the Society's *Conference* is being hosted by Victoria Division and will be held in Melbourne from Nov 24 to 26 at the Hilton Hotel. A notice elsewhere in this issue, and the enclosed brochure give details, and are a further reminder of this important forthcoming event for 1999.

Preparations for the conference are progressing well. An interesting technical program has been put together with at least 25 papers now accepted for presentation, covering a wide spectrum of acoustical activity from architectural acoustics to acoustical and vibration measurements, several aspects of noise control, and acoustic and psycho-acoustic modelling, together with an historical review of and forward look at acoustics in Australia.

The venue itself is most convenient and well equipped for the conference, and includes well located and ample spaces for trade exhibits (most already allocated).

Those intending to attend the conference are reminded that registrations received before Sep 6 benefit from a $ 30 concession. Also, the Conference Dinner and national AGM will be incorporated in an excursion to the Dandenong Ranges on the Puffing Billy Night Train. Because of limited seating (about 80), register and book early for this trip.

The Victoria Division is looking forward to welcoming a large attendance at Conference 99, including a good representation of visitors from beyond Victoria.

Further information: Mr Geoff Barnes, c/o Acoustical Design Pty. Ltd., 2/72 Bayfield Road, Bayswater, Victoria 3153, tel: 03 9720 8666, fax: 03 9720 6952, Acousticdes@bigpond.com

ICSV7

The 7th International Congress on Sound and Vibration (ICSV7) will be held July 4 - 7, 2000, in the modern Convention Center of Garmisch-Partenkirchen, the famous mountain resort in the Bavarian Alps, Germany, about one hour south of Munich. The congress is sponsored by the International Institute of Acoustics and Vibration, IIAV and follows congresses held in the USA (1990 and 1992), Russia (1993), Canada (1994), Russia (1996), Australia (1997) and Denmark (1999).

The key dates are; abstract submission 1 November 1999, acceptance 15 January 2000, manuscripts (8 printed pages) 15 April 2000. Expression of interest forms and further information are available from *http://www.iiav.org and Congress Secretariat ICSV7, Congress & Seminar Management, Industriestrasse 35, D-82194 Groebenzell, Germany. Fax: ++49 8142 54735 info@csm-congress.de*

INTER-NOISE 2000

The 29th International Congress on Noise Control Engineering to be sponsored by I-INCE, the International Institute Noise Control Engineering, will be held in Nice on the French Riviere from August 28-30, 2000. The theme of Internoise 2000 will be closely related to transport and community noise but all subjects in noise and vibration engineering will be discussed including noise sources: emission and control, measurement techniques and analysis, modelling and prediction, environmental noise, effects of noise, sound quality, transport noise control, building noise control, noise policy, standards and regulations. A technical exhibition will be held during the conference.

The deadlines for Internoise 2000 are: receipt of abstracts 15 January 2000, acceptance notification 29 February 2000 and manuscripts by 30 April 2000.

Expression of interest, call for papers and further information are available from http://internoise2000.loa.espci.fr/ or the congress secretariat SFA, 23 avenue Brunetière, 75017 Paris, France; Fax: +33 1 4788 9060;

Two joint events to be held around the time of Internoise 2000 are:

• **NOVEM Noise & Vibration:** Pre-design and characterisation using energy methods 31 August - 2 September 2000, Lyon, France.

Details: Goran Pavic, lva@insa.insa-lyon.fr fax: +33 4 7243 8712 http://lva.insa-lyon.fr/novem2000/

• **5CFA: Fifth French Congress on Acoustics** 3-6 September 2000, Lausanne Switzerland.

Details: Michel Bruneau, cfa2000@univ-lemans.fr http://cfa2000.univ-lemans.fr

Pacific 2000

UDT (Undersea Defence Technology) Pacific 2000 - Asia Pacific's only established undersea defence conference and exhibition - will take place at the Sydney Convention Centre, Australia, 7-9 February 2000. This conference is the undersea defence community's only dedicated exhibition

and offers the opportunity for interaction between Defence, contractors and researchers. The inaugural event, when over one thousand delegates and visitors attended UDT Pacific 98 was a tremendous success. The Australian

Acoustical Society is a co-sponsor of this event so intending participants should seek information on the special registration fee.

Details from http://www.udtnet.com

Noise Effects 98 - Sydney,

'Noise Effects 98' (the 7th International Congress on Noise as a Public Health Problem), held in Sydney in November 1998, was a great success. Although attendance from Australia was less than expected (probably due to Internoise 98 being held in New Zealand in the week preceding Noise Effects '98) there was a large overseas attendance from every continent. Well over 200 papers on all aspects of the effects of noise on people and animals were presented at plenary sessions, team sessions, workshops and poster sessions. The proportion of papers reporting new research was high. A workshop on economic assessment of noise impact was included for the first time. Many congratulations were received from delegates on the smooth running of the Congress, and at its conclusion Dr. Soames Job (Congress Vice President) was made Secretary of the International Commission on Biological Effects of Noise, and Dr. Norman Carter was appointed 'Member-At-Large' of the Commission. On the financial side, the Congress broke even, possibly the most desirable outcome since it meant that services to delegates were optimised. This excellent financial result was due largely to generous sponsorship from the U.S.A., with 65% of total sponsorship coming from U.S. Government agencies and professional societies concerned with noise issues. Substantial support also came from Australian government agencies, but curiously none of the many Australian companies approached agreed to sponsor the Congress. (Sponsors are listed in Noise Effects 98 Proceedings). Loans from the Australian Acoustical Society were critically important, especially in launching the Congress organisation.

The 8th Congress in this series will be held in Rotterdam in 2003.

Norman Carter

President, 7th International Congress on Noise as a Public Health Problem (Noise Effects 98)

NSW Environment Legislation

The Protection of the Environment Operations Act 1997 (POEO Act) took effect on 1 July 1999 replacing key environmental laws including the Noise Control Act 1975. The POEO Act consolidates and clarifies the regulatory powers available to the NSW EPA and local councils and focuses more on improving environmental management and promoting cleaner production. After 1 July, the EPA will regulate larger industries that have more potential to cause environmental harm while local councils will have the power to issue clean-up and prevention notices in order to regulate other industries. More information on the POEO is available from the www.epa.nsw.gov.au/legal

C-Tick Regulations

Did you know that from January 1 1999 all new electronic equipment sold in Australia must be C-Tick approved? Substantial fines may apply to equipment supplied after that date which is not C-Tick approved. Possible seizure of non-compliant equipment may also occur.

What does C-Tick cover? All electrical and electronic products that fall within the scope of the mandated standards. Affected products range from fridges, hairdryers, electric tools, toys, computers and audio equipment to sound level meters. "This is a requirement that has crept up on us" says John Searle, Victorian State Manager of Acoustic Research Laboratories. John went on "I am constantly surprised at how many people around our industry have never heard of these new regulations."

To protect yourself, when purchasing new electronic equipment ask your supplier whether it is C-Tick approved. For further information on C-Tick, contact the Australian Communications Authority Office in your State.

STANDARDS AUSTRALIA Committee News

Standards Australia Committee AV/1, Acoustics/Vibration Terms, Units and Symbols, is currently revising AS 1633-1985, *Acoustics–Glossary of terms and related symbols*. The main objectives of the revision are to augment and update the list of terms provided in the glossary, and to make the Standard more user friendly. The revised Standard will take cognisance of definitions of acoustic terms included in recent Australian, New Zealand, Australian/New Zealand and international Standards. Terms will be grouped into broad categories, such as occupational acoustics and environmental acoustics, and the Standard will include an index for easy reference. It is anticipated that a draft for public comment will be available in late 2000. This will be circulated to all Standards Australia acoustics committees.

Committee AV/3, Acoustics, Human Effects, is finalising the revised Standard AS/NZS 1270, *Acoustics–Hearing protectors*. Publication is anticipated later this year. The major changes from the 1988 edition concern the method for measuring the real-ear attenuation of hearing protectors; the physical test methods have not been revised. However, a working group under the auspices of AV/3 is assessing the need to revise the physical test methods, including options for harmonisation with international, or de facto international, Standards. The working group has scheduled an August meeting with the convenor of the European Committee for Standardisation (CEN) working group on hearing protectors to discuss the ongoing revision of the EN 352 series of Standards, *Hearing protectors – Safety requirements and testing*.

Standards Australia has been asked to consider revising the AS 1088 series of Standards on hearing aids, most of which date from 1987. These Standards are the responsibility of Committee AV/3. Planning is under way for a one-day workshop to be held in Sydney later this year to discuss the need for and approaches to the revision of AS 1088. Individuals and organisations interested in participating in this workshop are invited to contact Jill Wilson at the address below.

Committee AV/4, Acoustics, Architectural, is in the process of revising AS 2107-1987. A draft for public comment, DR 99367, *Acoustics-Methods of measurement and recommended design sound levels and reverberation times for building interiors*, will be available in August 1999. Drafts for comment are now available free-of-charge on the Standards Australia website (www.standards.com.au) as well as from Standards Australia sales offices. Committee AV/4 is also proposing the adoption of ISO 140-9:1985, *Acoustics-Measurements of sound insulation in buildings and of building elements*, Part 9: *Laboratory measurement of room-to-room airborne sound insulation of a suspended ceiling with a plenum above it to supersede AS 2499-1981, Acoustics-Method for laboratory measurement of airborne sound attenuation of ceilings (two-room method)*. In addition to providing a method for laboratory measurement, ISO 140-9 specifies requirements for the construction and dimensions of the test facility. Comment on the proposal will be solicited through the Standards Australia public comment process. It is anticipated that a draft for comment will be available in September 1999.

A subcommittee under the auspices of Committee EV/10, Acoustics, Community Noise, has commenced development of a new Standard on railway noise intrusion in response to a request from the State Rail Authority of New South Wales. The new Standard will be modelled in part on the existing aircraft noise intrusion and road traffic noise intrusion Standards. The subcommittee on railway noise has also been charged with revising AS 2377-1980, *Methods for the measurement of airborne sound from railbound vehicles*.

Enquiries: Jill Wilson, Projects Manager, Standards Australia, PO Box 1055, Strathfield, NSW 2135, tel (02) 9746 4821, fax (02) 9746 4766, e-mail jill.wilson@standards.com.au.

Virtual standards

Howard Paul from Standards Australia has stated that they have 'created the true virtual standard - a document which from the moment of conception to its application by the user, exists only in electronic form. No other national Standards body is in the same position and the benefits to the Australian community are considerable. As well as speeding up the development of technical Standards, it ensures that Australian Standards are the lowest cost, highest value.'

Via the internet a customer can now search the catalogue, order and download any standard order paper copy, charge the cost to credit card, download draft Standards (mostly free of charge), search for any current amendment and download free of charge.

The Aust Standard, June 99

FASTS

Commercial research

A report from FASTS shows that scientists and technologists still have to battle when it comes to commercialising the results of their work. The report indicates that the innovation process in Australia is at an immature stage, as scientists, industry, research organisations, Government and investors search for the magic formula to generate new industries and jobs out of Australian research.

"Scientists commercialising their research" is published by the Federation of Australian Scientific and Technological Societies (FASTS). Based on discussions with 126 scientists and technologists across Australia, it provides a snapshot picture of the way scientists see the commercialisation process and the obstacles which stand in their way. Professor Peter Cullen, President of FASTS, said the report shows Australia has a long way to travel if the nation wants to make the best use of its high-quality research. Prominent among the discouraging factors identified by participants were:

- timid industry reluctant to invest in Australian ideas
- lack of recognition within research organisations for commercially-orientated ork
- colleagues who looked down on commercial work as second-rate
- lack of good advice on how to commercialise work
- capital gains tax (CGT)

Some confessed to becoming so weary with battling against the odds that they walked away from trying to commercialise promising new ideas, in order to concentrate on the traditional means of achieving a successful academic career through publishing papers. The report also identified possible solutions. These included developing a long term strategy to change cultural attitudes in Australia, to foster acceptance and support for research-driven, high technology industries as creators of wealth and jobs

Both an executive summary and the full report are available from FASTS (tel 02 6257 2891)

Science and Parliament

The policy debate rages in Canberra, and there is a whole raft of issues where impending announcements will have major implications for the way science and technology conducts its business in Australia. The opinion of FASTS is increasingly sought. Part of this stems from membership of the Prime Minister's Science Council (PMSEC), which brings regular contact with Ministers covering portfolios ranging from Health to Education and the Environment.

The matters on which FASTS are asked to comment are becoming increasingly technical, with capital gains tax and the future of the tax concession to industry for R&D two examples of issues with a maze of unintended consequences and side effects. Both are two key issues for the science and technology community, and both should be seen in the context of clear political signals that neither major party is convinced that money going to R&D is an investment in Australia's future rather than a drain on the public purse.

One new issue is the increasing difficulty of arranging scientific exchanges, particularly at the postdoctoral level because of immigration policies in Australia and overseas. Until recently, postdoctoral study overseas was the norm for Australian Ph.D. graduates. Australian laboratories derived substantial benefit from foreign researchers at this level. But many opportunities to fund international exchange visits by scientists are being lost as government policies increasingly favour the appointment of locally qualified people. Postdoctoral training in Europe is almost prohibited except where individuals have European passports or work permits. Should we be arguing for open borders, or is overseas training and experience no longer important for the next generation of Australian scientists?

Pride in Science

In early 1999, an international survey to find what it was that made people proud of their country. The Melbourne Institute of Applied Economic and Social Research study showed Australians ranked science and technology second highest on their list, behind only sport. This was the second highest ranking for science and technology in the 24 countries, and adds weight to FASTS suggestion to the Government to capture the imagination of all Australians with landmark S&T-based projects to mark the Year 2001.

Science Awareness

FASTS has urged the science community to speak out strongly in a review of a national program for science awareness. The President of FASTS said the review should be seen as an opportunity to set new objectives and a new direction for the program, and to reverse savage cuts announced in the last Budget.

The Commonwealth Department of Industry, Science and Resources (ISR) currently spends \$2.6 million each year on initiatives like the Australia Prize (\$500,000,) National Science Week (\$450,000), Science Olympiads (\$250,000), ABC Science Development Project (\$330,000), Michael Daley Awards (\$48,000), STAP small grants (\$1,000,000) S&T Communication activities (\$45,000) and Survey and Evaluation (\$25,000). The 1999 Budget reduced the total to \$1.5 million and then \$800,000 over the next two years.

Professor Cullen said. "We need to identify exactly what we want to achieve from this Program, and the best way to achieve these objectives. How much science do people need to know? What is the best way to get these ideas across? Where should we spend the money, and how much do we need to spend? It's a crucial issue, one we need to get right."

Green Paper Discussions

On July 14, a forum at the National Press Club, organised by FASTS provided Australian leaders from business, industry, government and research a first opportunity to discuss the Government's Green Paper on research and research training. The Green Paper and the Innovation Summit scheduled for February 2000 are important policy stepping-stones for Australia, and will have far-reaching implications for industry and research.

Professor Peter Cullen, President of the Federation of Australian Scientific and Technological Societies (FASTS), said he applauded Government moves to locate innovation at the centre of the Australian economy. "But such a move requires a whole-of-Government approach, where research is embedded in a national innovation policy," he said.

Acoustics and Education Quality

Extremely poor acoustics in classrooms is causing education of children to suffer, making it hard for students to hear and understand their teachers, a pioneering study of classrooms has found. Both the acoustic quality in over 100 UK classrooms, and the effects of poor acoustics on the students' education, were tested by researchers from Heriot-Watt University, Edinburgh and funded by Ecophon. Their alarming findings concur with previous research carried out in other countries, suggesting that inadequate acoustics and high noise levels in the majority of classrooms are significantly damaging the learning process.

"We found design of schools to be extremely important," said head of the research project at Heriot-Watt University, David MacKenzie during his recent series of seminars in Australia. "Both older and modern schools were found to have poor acoustic environments." However the design of modern schools, often constructed of lightweight materials, contributes greatly to the problem.

Open plan classrooms, common in modern school design, were particularly noisy. The hard, shiny surfaces in schools, chosen for low maintenance and resilience, contributed heavily to lengthy reverberation times, found to be up to 4 times the recommended level of 0.8 seconds (although research suggests this is inadequate for intelligible speech). "The shape of many ceilings caused dead spots where almost none of the teacher's voice was intelligible," David MacKenzie said.

Many Australian educational institutions remain unaware of the detrimental interaction of background noise with the reverberation of sound off the hard surfaces, commonly used in schools. David MacKenzie plans to extend his research project to schools in Australia. Further information from CSR designLINK on 1800 621 117.

Visit to BTR

On Jun 16, the Victorian Division arranged a site visit, attended by 13 members, to the BTR Automotive Textiles factory at Dandenong. Kendy McCulloch of BTR spoke first of the manufacture of BTR's textile fabrics, which, inter alia, have acoustical applications. These fabrics consist of nylon and polyester fibres fused or 'melded' in an oven to give them the necessary strength and dimensional stability. Standard fabric thicknesses are 25 and 50 mm ; other non-standard thicknesses can be made to order. This was followed by a tour of the factory, where these processes were observed.

Following the factory tour there was further discussion of the fabrics' acoustical properties and uses, including a brief description by Geoff Barnes of their use by Acoustical Design in panels manufactured for the control of theatre and room acoustics. INC also uses BTR textiles. Typical acoustic properties of these textiles, when mounted on suitable backing materials, vary from NRC ratings of from 0,15 to 0,80 (from acoustic absorption coefficients of from 0,06 to 1,00 at octave centre frequencies of 250, 500, 1000, 2000 and 4000 Hz). Those who attended enjoyed an interesting and informative evening, and at the close expressed their appreciation to BTR and Kendy McCulloch.

Louis Fouvy

Double Helix Prize

The NSW Division has contributed to the prizes for a competition within the Double Helix Club. This Club is organised by the CSIRO with the aim to encourage interest of school children in science. For this competition a new type of instrument has to be designed. The five best will receive an acoustic kit which includes a poster on the function of the ear, a personal radio/cassette, a mini didgeridoo, a tuning fork and a bird whistle. Information about the Double Helix Club can be found on http://www.csiro.au

Traffic Noise NSW

The NSW EPA have recently released the 'Environmental Criteria for Road Traffic Noise'. This can be downloaded from http://www.epa.nsw.gov.au or copies obtained from the EPA, tel 13 1555.

Endevco & B&K

Endevco and Bruel & Kjaer Sound & Vibration have joined their expertise. The extensive B&K distribution network will now be responsible for the complete range of products and services of both companies.

Australian Event Diary

The Scientific Suppliers Association of Australia have launched what is planned to be Australia's most comprehensive Scientific Event Diary. The listing allows for searching in up to 32 professional disciplines or by type of event on http://www.ssaa.asn.au/

Lockheed Martin & Vipac

Vipac has signed agreements with Lockheed Martin USA in the areas of structural life extension, noise reduction and control strategies and treatment for miliary aircraft. The noise control work is for the new generation Hercules aircraft for the RAAF.

Academy Science Volunteers

The Australian Academy of Science needs volunteers with an eagle eye for typographical errors. They need the help to check the biographical material on scientists for the www site. You can be anywhere around Australia as they will post the printouts and enclose a prepaid return envelope. Contact Maureen Swanage on 02 6247 5385 or pm@science.org.au

Noise and Vibration Worldwide

On line subscriptions for Noise and Vibration Worldwide are now available. This journal is published 11 times per year and the on-line subscription rate of UK £25 represents a great saving on the hard copy subscription. Further information from http://www.multi-science.co.uk

JSV+

Academic Press is pleased to announce the launch of JSV+, a timely and much needed repository for fast communication and exchange of results and ideas among scientists worldwide.

JSV+, edited by Professor Bobrownitski from the Russian Academy of Sciences, complements the printed version of the journal by offering:

Supplementary Material - Authors of articles published in JSV can provide material to accompany that published in the journal. This enables the publication of large sets of illustrations, colour figures, lengthy data tables, videos (including sound and animation), long derivations of formulae, extensive results of computer simulations, explanations of processing and analysis of data links from JSV+ to electronic journals, repositories of data or other addresses on the WWW with information relevant to the topic under consideration.

Discussions - Contains comments and notes on recently published JSV papers. Readers are welcome to express their opinion and ask for clarification. We hope that this constructive exchange of thoughts will provide a deeper understanding of the published material and lead to a wider dissemination of the research.

Conference Announcements - Providing up-to-date information about forthcoming congresses, meetings, and short courses. Readers are very welcome to contribute to this section

Both readers and authors are invited to join the initiative by contributing to JSV+ and access is from www.academicpress.com/jsv

New Members...

NSW

Member	Mr Christopher Schulten
Associate	Mr David Wilson
Subscriber	Mr Matthew Pringle

QLD

Member	Mr Michael Caley, Mr Shane Elkin

VIC

Member	Mr Andrew Nicol, Ms Sarah Alper

WA

Graduate	Mr Trevor Holland
Subscriber	Mr Stephen Bridges

New Products...

HEWLETT PACKARD
Spectrum Analyser

The HP ESA-E series analysers have the best speed, accuracy, dynamic range and resolving power in their price class. Available in frequency ranges us to 26.5Ghz, they can be upgraded for enhanced performance as the test needs change. For critical R&D Measurements, optional 10Hz digital filters improve the analysis of closely spaced signals and boost resolution. They have a rugged case that withstands abuse in field applications.

Further information: Hewlett Packard, tel 1800 629 485, info_hptmo@aus.hp.com

ARL
New Noise Logger.

Acoustic Research Laboratories have released two new environmental noise loggers, the EL-315 and the EL-316. Both are capable of precise long-term, unmanned monitoring of noise levels in harsh environments. The EL-31X series represent a major evolution from the current EL-215 logger in terms of accuracy, functionality and usability.

Maintaining the low power consumption of the EL-215, the EL-31X in standard trim can operate for up to 3 weeks without the need for any user intervention. Through the use of the in-built dual timer control or the addition of the optional solar panel, logging time can be extended almost indefinitely. Packaged in a tough Pelican case, the EL-31X is capable of withstanding adverse weather conditions - even able to operate in standing water.

Both loggers conform to the requirements of AS1259 Part 1. They boast a continuous dynamic range from 30dB to 120dB, with resolution to 0.1dB. The EL-315 is a Type 2 variant, whilst the EL-316 provides accuracy to Type 1 specifications.

Aside from its statistical logging capabilities, the EL-31X can also log the occurrence of event-based trigger conditions. Optional peripherals for the loggers include analogue tape recorders, modems and solar panels.

Developed with the acoustic consultant in mind, the EL-31X feature intuitive Windows 95 based host software for easy configuration and fast data recovery. The loggers also have a dedicated on-board interface (OBI), which allow logging to be controlled in the field without the assistance of a PC.

Further information: Acoustic Research Laboratories. Tel. 02 9484 0800, Fax 02 9484 0884 or your local branch of ARL or http://www.hutch.com.au/~acoustic

BRUEL & KJAER
Portable Pulse

With the introduction of the compact, rugged and battery operated Portable Pulse, Bruel & Kjaer introduces a complete new analyser concept. The intelligent front-end offers plug and play connectivity for TEDS (Transducer Electronic Data Sheet IEEE P1451.4) equipped transducers, whereby avoiding setup of channel sensitivities and transducer types - it's all done automatically! Portable Pulse uses a simple LAN connection between the front-end and the PC, so you can connect with a LAN cable, a wireless LAN or any other LAN.

The unique signal analysis engine runs directly on the PC processor (min 300 MHz Pentium II, 128 MB RAM, 4GB Hard disk, Windows NT 4.0). Thereby the signal analysis power will grow with faster PC's and not depend on the front-end. Also it lets you analyse and post analyse any recorded signal without having the front-end connected. Combining the compact front-end with a standard notebook turns Portable Pulse into an true in-field analyser, trouble shooter and data recorder.

Some key specifications: Up to 6 input channels (DC-25.6 kHz) and 2 signal generators. Gap free data recording to PC hard disk. Performance example: 4 channels real-time. simultaneous 1/3-octave analysis on 2 channels (10mHz - 20kHz) and 800 line FFT on two channels (over 25.6 kHz) and broadband levels on 2 channels. Three hours of battery operation. Batteries replaceable without interrupting measurement.

Pulse plus MeScope:

Most of the time spent on modal analysis is used for setting up the actual measurement. Most solutions available on the market are divided into an FFT analyser (doing the transfer function measurements) and a Modal package (doing the model of the structure, calculate the curve fitting and the modal parameters).

The Bruel & Kjaer Pulse Modal Test Consultant integrates the Pulse analyser totally with the modal package MeScope from Vibrant technology whereby the setup and measurement time can be cut in half. No tedious file transfer - no remembering which point was where and what direction was measured. Brüel & Kjaer is certified for training and reselling MeScope.

Further information: Bruel & Kjaer tel (02) 9450 2066. bk@spectris.com.au or www.bk.dk

SYSNOISE 5.4

LMS has recently released the new version of SYSNOISE Rev 5.4. SYSNOISE predicts the acoustic field generated inside and outside a vibrating structure and utilises state-of-the-art numerical methods based on the direct and indirect boundary element method (DBEM and IBEM) and a pressure formulation for acoustic finite and infinite element modelling (FEM and I-FEM).

A new generation of solvers (for BEM, FEM and modal extraction) deliver blazing speed when compared to previous revisions. Also LMS has released Pre/SYSNOISE, a meshing tool that automates the creation of acoustic meshes from the original structural FE model.

Other additions include the acoustic transmission loss of non-planar structures placed in infinite baffles and a new library of I-FEM elements licensed from Lucent Technologies.

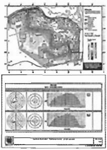
LMS OPTIMUS

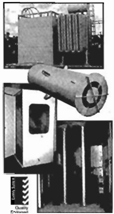
LMS OPTIMUS is a CAE product for multidisciplinary optimisation. It manages multiple simulation packages from any vendor to achieve an optimal design. The software drives and manages the exchange of data between multi-disciplinary simulation tools, and modifies the product design based on the outputs until an optimal design is found. In this way OPTIMUS frees the analyst to concentrate on the human part of the decision making process.

OPTIMUS is like a management framework that sits above various simulation packages.

For example, LMS OPTIMUS has been used to optimise an automotive floor pan impression height to minimise the noise level. The design variables were defined in MSC/Nastran Input file, whereas the design outputs were extracted from LMS/SYSNOISE. The analysis sequences were defined in OPTIMUS. The objective was to minimise the radiated sound power from 60 Hz to 360 Hz. The design variables were the thickness of the thirteen sections. This problem was solved in OPTIMUS by applying the Gradient Techniques to the Analysis Sequence.

Further information: COMPUMOD Australia, Tel. 02 9283 2577 Fax 02 9283 2585. warwick.marx@compumod.com.au or www.compumod.com.au





Diary...

1999

September 12-15, LAS VEGAS
Int Symp Acoustic Scattering
ASMEConf Vibration & Noise).
Details: P. K. Raju, Mech Eng, Auburn University, Auburn, AL 36849-5341, USA, Fax: +1 205 844 3307;
pkraju@eng.auburn.edu)

***September 22-24, SYDNEY**
Metrology Conference
Details: Dr Suszanne Thwaites, National Measurement Laboratory, PO Box 218, Lindfield NSW. Tel; (02) 9413 7416, Fax; (02) 9413 7161,
suszanne.thwaites@tip.csiro.au

October 8-9, PHILADELPHIA
47th Symp on Occup Hearing Loss
Details: American Institute for Voice and Ear Research. 1721 Pine Street, Philadelphia PA 19103 USA.
Fax: + 1 215 735 2725, johearingl@aol.com

November 1-5, COLUMBUS
138th Meeting of ASA
Details: ASA, 500 Sunnyside Blvd., Woodbury, NY 11797 USA. Fax +1 516 576 2377, asa@aip.org

***November 24-26, MELBOURNE**
Acoustics Today
AAS Annual Conference
Details: Acoustical Design, 2/72 Bayfield Rd, Bayswater Vic 3153. Tel (03) 9720 8666, Fax (03) 9720 6952, Acousticdec@bigpond.com

December 2-4, FORT LAUDERDALE
ACTIVE 99

December 5-9, FORT LAUDERDALE
INTER-NOISE 99
Details: INCE, PO Box 3206 Arlington Branch, Poughkeepsie, NY 12603, USA, Fax: +1 914 4624006, inceusa@aol.com
http://ince.org

December 3-5, AUCKLAND
Taking OH+S into 21st Century.
Details: F. Lamm, Dept Management & Employment Relations, University Auckland, Private Bag, 92019 Auckland, New Zealand, Fax: +64 9373 7402, f.lamm@auckland.ac.nz

2000

*** February 7-9, SYDNEY**
Pacific 2000
Undersea Defence Technology
Details: http://www.udtnet.com

May 17-19, AALBORG
9th Int Meet Low Frequency Noise & Vibration
Details: W. Tempest, Multi-Science Publishing Co. Ltd., 5 Wates Way, Brentwood, Essex CM15 9TB, UK Fax: +44 1277 223453

May 30 - June 3, ATLANTA
139th Meeting of ASA.
Details: Fax: +1 516 5762377, Web: asa.aip.org

June 5-9, INSTANBUL
Int Conf On Acoustics, Speech & Sig Proc
Details: Tülay Adali, University of Maryland Baltimore County, Department of Computer Science and Electrical Engineering, 1000 Hilltop Circle, Baltimore, MD 21250 USA; Fax: +1 410 455 3969;
http://icassp2000.sdsu.edu/

June 6-9, ST.PETERSBURG
5th Int Symp Transport Noise & Vibration
Details: EEAA, Moskovskoe Shosse 44, 196158 St.Petersburg, Russia; Fax: +7 812 127 9323; noise@mail.rcom.ru

July 4-7, GERMANY
7th Int. Cong. on Sound and Vibration
Details: ICSV7, Congress & Seminar Management, Industriestrasse 35, D-82194 Groebenzell, Germany. Fax: +49 8142 54735 info@csm-congress.de, http://www.iiav.org

August 23 - 25, NANJING
ACSIM 2000, 2nd Asia-Pacific Conf Systems Integrity & Maint.
Details: Anna Maltezos, Dept Mech Eng, Monash Uni, Caulfield East, VIC 3145, Australia. Tel: +61 3 9903 2335 Fax: +61 3 9903 1084; anna.maltezos@eng.monash.edu.au, http://www-mech.eng.monash.edu.au/

August 28-30, NICE
INTER-NOISE 2000
Details: SFA, 23 avenue Brunetière, 75017 Paris, France; Fax: +33 1 4788 9060; http://inter-noise2000.loa.espci.fr/

Aug 31 - Sep 2, LYON
Int Conf Noise & Vib Pre-Design & Charact. Using Energy (NOVEM)
Details:LVA, INSA de Lyon, Bldg. 303, 20 avenue Albert Einstein, 69621 Villeurbanne, France; Fax: +33 4 7243 8712 lva@insa.insa-lyon.fr http://lva.insa-lyon.fr/novem2000/

Sep 13-15, LEUVEN
Int Conf Noise & Vib Eng (ISMA 25)
Also short courses on Modal Analysis and Numerical Acoustics
Details: ISMA 25, K.U.Leuven Dept Mech Eng, PMA, Celestijnenlaan 300B, B-3001 Leuven, BELGIUM Fax (+32) 16 32 29 87, lieve.notre@mech.kuleuven.ac.be
http://www.mech.kuleuven.ac.be/pma/events

Sept 17 - 21, VILNIUS
1st Int Conf (10th Anniversary).
Details: Acoustical Soc Lithuania, Kriviu 15-2, 2005 Vilnius, Lithuania; Fax: +370 2 223451; daumantas.ciblys@ff.vu.lt

October 3-5 KUMAMOTO
WESTPRAC VII
Details: Dept Computer Science, Kumamoto Uni. 2-39-1 Kurokami, Kumamoto, 860-0862. Tel: +81 96 3423622 Fax: +81 96 3423630 westprac7@cogfni.eecs.kumamoto-u.ac.jp
http://cogni.eecs.kumamotou.ac.jp/others/westprac7

October 16-20 BEIJING
6th Int. Conf. on Spoken Language Processing
Details: ICSLP 2000 Secretariat, Institute of Acoustics, PO Box 2712, 17 Zhong Guan Cun Rd, Beijing 100 080, China, Fax: +86 10 6256 9079, mchu@plum.ioa.ac.cn

December 4-8, NEWPORT BEACH
Meeting of the ASA
Details: ASA, 500 Sunnyside Blvd., Woodbury, NY 11797 USA. Fax +1 516 576 2377, web: asa.aip.org

2001

June 4-8, CHICAGO
141th Meeting of the Acoustical Society of America
Details: ASA, 500 Sunnyside Blvd, Woodbury, NY 11797-2999, USA, Fax: +1 516 576 2377, Web: asa.aip.org

Aug28 - 30, THE HAGUE
INTER-NOISE 2001
Details: secretary@internoise2001.tudelft.nl;
Web: internoise2001.tudelft.nl

September 2-7, ROME
17th Int. Cong. on Acoustics
Details: A. Alippi, 17th ICA Secretariat, Dipartimento di Energetica, Universitá di Roma "La Sapienza", Via A. Scarpa 14, 00161 Roma, Italy, Fax: +39 6 4424 0183, www.uniroma1.it/energ/ica/html

September 10-13 , PERUGIA
ISMA 2001 ,
CIARM & Catgut Acoust Soc
Details: c/o "Perugia Classico" - Comune di Perugia, Via Eburnea,9, I-06100 Perugia, Italy, Fax: +39 75 577 2255, perusia@classico.it

WWW LISTING

The ICA meetings Calendar is available on http://gold.sao.nrc.ca/ims/ica/calendar.html

COURSES

October, All cities
Sound Intensity
Modal Analysis
Details: Bruel & Kjaer, Tel (02) 9450 2066 Fax (02) 9450 2379 bk@spectris.com.au

Distance Education Course

The School of Mechanical and Manufacturing Engineering at the University of New South Wales will be offering its Master of Engineering Science (MEngSc) course in Noise and Vibration in distance mode from first session, 2000.

This has been running as an internal course for a number of years, and some details of this course can be found on the School's website at: www.mech.unsw.edu.au under the headings Postgraduate Studies/ Coursework degrees.

The degree involves taking six subjects and carrying out a project. All five core subjects will be available in distance mode as well as a number of alternative subjects such as Environmental Noise, Building Acoustics and Machine Condition Monitoring.

Details: Assoc. Prof. R.B. Randall
tel (02) 9385 5697 or (02) 9385 4085
b.randall@unsw.edu.au

AUSTRALIAN ACOUSTICAL SOCIETY ENQUIRIES

NATIONAL MATTERS

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

General Secretary
AAS– Professional Centre of Australia
Private Bag 1, Darlinghurst 2010
Tel/Fax (03) 9887 9400
email: watkinsd@melbpc.org.au
http://www.users.bigpond.com/Acoustics

SOCIETY SUBSCRIPTION RATES

From 1 APRIL 1999 membership subscriptions are:

Fellow and Member	$94
Associate and Subscriber	$75
Retired	$31
Student	$21

DIVISIONAL MATTERS

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

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

AAS - Queensland Division
PO Box 1528,
MILTON 4064
Sec: Ms R. Carter
Tel (07) 3364 7444
Fax (07) 3364 7477
rachel_carter@usrcorp.com

AAS - SA Division
C/–Department of Mech Eng
University of Adelaide
SOUTH AUSTRALIA 5005
Sec: Carl Howard
Tel (08) 8303 3156
Fax (08) 8303 4367
cqhoward@mecheng.
adelaide.edu.au

AAS - Victoria Division
PO Box 417 Collins St. West PO
MELBOURNE 8007
Sec: A/Prof C. Don
Tel (03) 9905 3695
Fax (03) 9905 3637
charles.don@sci.monash.edu.au

AAS–W A Division
PO Box 1090
WEST PERTH 6872
Sec: Mr J Macpherson
Tel (08) 9222 7119
Fax (08) 9222 7157
john_macpherson@environ.gov.au

ACOUSTICS AUSTRALIA INFORMATION

GENERAL BUSINESS

Advertising Subscriptions

Mrs Leigh Wallbank
PO Box 579, CRONULLA 2230
Tel (02) 9528 4362
Fax (02) 9523 9637
wallbank@zipworld.com.au

PRINTING, ARTWORK

Scott Williams
16 Cronulla Plaza
CRONULLA 2230
Tel (02) 9523 5954 Fax (02) 9523 9637
email: print@cronullaprint.com.au

ADVERTISING RATES

B&W	Non-members	Sus Mem
1/1 Page	$550	$500
1/2 Page	360	325
1/3 Page	275	250
1/4 Page	235	220

Spot colour: $100 per colour
Prepared insert: $250 (additional postage may apply)
Column rate: $18 per cm (1/3 p 5.5cm width)

Discounted rates for 3 consecutive ads in advance

Special rates available for 4-colour printing

All enquiries to: Mrs Leigh Wallbank
Tel (02) 9528 4362 Fax (02) 9523 9637
wallbank@zipworld.com.au

ARTICLES & REPORTS NEWS, BOOK REVIEWS NEW PRODUCTS

The Editor
Acoustics Australia
Acoustics & Vibration Centre, ADFA
CANBERRA ACT 2600
Tel (02) 6268 8241
Fax (02) 6268 8276
email: acoust-aust@adfa.edu.au

SUBSCRIPTION RATES 1999

	Aust	Overseas
1 year	A$ 52	A$ 64
2 year	A$ 88	A$112
3 year	A$125	A$161

Overseas subscriptions go by airmail

Discounted for new subscriptions

20% Discount for extra copies

Agents discount 15% of surface (Aust) rate

ACOUSTICS AUSTRALIA ADVERTISER INDEX - VOL 27 No 2