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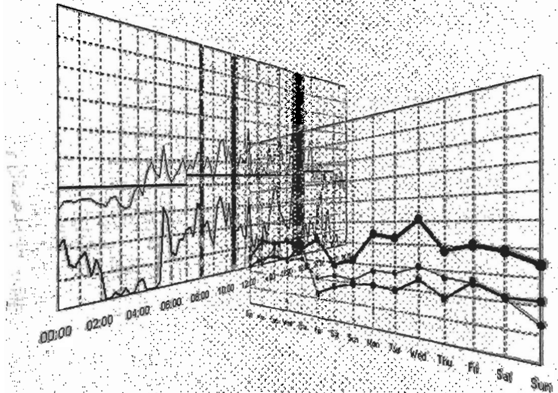

SPECIAL ISSUE: ENVIRONMENTAL NOISE

- *Overview of Environmental Noise Policies*
- *Long-term Environmental Monitoring*
- *Road Traffic Noise in Capital Cities*
- *Effects of Environmental Noise on Children*

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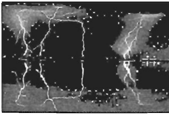

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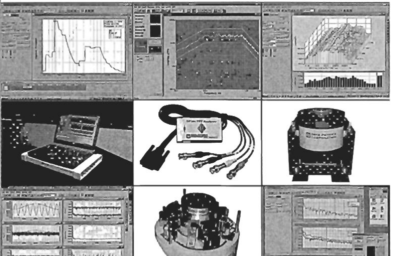

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Mrs Leigh Wallbank
P O Box 579
CRONULLA NSW 2230
Tel (02) 9528 4362
Fax (02) 9523 9637
wallbank@zipworld.com.au

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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
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Cover illustration: Environmental noise — see paper by Bullen.

From Wepac8, Melbourne, April 2003

Charles and Sheena Don, David and Carolyn Watkins at the conference dinner receiving thanks for their efforts in organising the conference.

Joe Wolfe receiving the Inaugural Excellence in Acoustics Award from Neville Taylor (CSR Bradford Insulation)

See News section for report on the conference. Proceedings available from www.wespac8.com.

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Editorial

The study of acoustics, as readers of this journal will know, has two primary practical aims. On one hand we examine the production, recording and reproduction of sound with the aim of evoking in the listener sensations that are pleasurable, informative or beautiful. To this end we examine the functioning of musical instruments, the design of concert halls, the construction of microphones and loudspeakers, and the psychophysics of sound perception. On the other hand we recognise that much of the sound produced in the world today is annoying, destructive of information transfer, and far from beautiful by any criteria. To protect people from the influences of this type of sound, generically called noise, we examine the ways in which machines produce sound, practical means of reducing such sound and vibration, the isolation of listening and living spaces from intrusive outdoor sound, and the effects that noise can have on our hearing and on our mental functions. It is this second aim of our science that concerns us in the present issue.

A general precept in any conflict is the adage "Know your enemy!" and this must be our initial approach to noise. What are its properties? How is it produced? How can it be controlled, if elimination is impossible? How can we keep ourselves safe from its influences? All these questions are addressed to some extent in the papers that follow. Since unfortunately noise, like the poor in another adage, is always with us, it is also important to know as much as we can of its effects, both physical and psychological, and these questions are also asked and some of them are partially answered. We will never know our enemy completely, and it keeps appearing in new guises with new and different technology. The price of liberty, whether from noise or from other enemies, is "eternal vigilance".

The Australian Acoustical Society is dedicated to enhancing our abilities in both aspects of the science of acoustics, and we see the role of our journal as being to keep members informed about what is happening, both in Australia and, often more importantly, in the world outside. To this end, we publish, from time to time, special issues such as the present one, devoted to a group of papers on a particular topic. But we must keep the broader aspects of the subject in view at all times and recognise both the practical utility and the formal beauty of our science. We are therefore happy to publish interesting papers, written for a general scientifically informed readership, on any aspect of acoustics, and would welcome your contributions. While our journal itself has not yet succumbed to the electronic revolution, you will find details of our submission guidelines on the Society's web site www.acoustics.asn.au.

Neville Fletcher

From the President

Future Directions

Your Council will be meeting to plan for the Future Directions for the Australian Acoustical Society at the Quarantine Station North Head Sydney, 30th May – 1 June 2003.

The form of the agenda will be:

Part 1 – Brainstorming and external presentations,

Part 2 – Plan priorities and prepare timeframes for a practical plan,

Part 3 – Council meeting to enact the plan, budget and attend to other council matters.

Key objectives

The 'Vision thing' Overview, planning preparation interaction and brainstorming.

Identify common problems and barriers to managing Societies.

Identify and agree on techniques to prioritise the activities of a Society and draw up a plan of action.

Professional recognition: Status of members, Environmental, Industrial, Architectural, standing as expert witness and references in legislation.

Provision of continuing education and accreditation. How can we provide these?

Bringing in new acousticians.

How to handle complaints against members?

How to provide a planning framework to maximise membership benefits?

Public Liability, how does it affect us?

What do members want? How to frame and carry out a "member survey"?

Establish the Societies Top 10 issues

Tools for making the Society more efficient.

Tools for delivering membership benefits with regard to (a) peers, (b) obtaining a political profile, and (c) establishing a public profile.

Identify issues the society must face and rank the top 10.

Procedural matters

Is the current structure most beneficial?

Insurance; members, conferences, public liability directors, What do we need and how much will it cost in future, is it affordable and are there other ways?

Demonstrate the benefits and provide tips on electronic communication, professional development, conference management, political lobbying and media communication.

Tips and techniques for more effective management of Societies.

Case-studies to discuss implementation of the plan, including resourcing and evaluation of activities.

Identify the most cost-effective ways of managing membership databases and finances

How to entrain and reward volunteers

If you have any input you want to make into this process, now is your first chance. Call up your State Committee or State Councilor and make your view known or e-mail/mail your thoughts to the General Secretary, watkinsd@castlemaine.net.

Ken Mikl

OVERVIEW OF ENVIRONMENTAL NOISE POLICIES IN AUSTRALIA*

Marion Burgess
Acoustics & Vibration Unit, School of Aerospace & Mechanical Engineering, UNSW at Australian Defence Force Academy, Canberra

Warren Renew
Environmental Protection Agency, PO Box 155, Albert Street, Brisbane

Abstract: Across Australia, legislation for environmental noise is largely the responsibility of each of the six States and two Territories. The Federal government has the responsibility for national issues such as aircraft noise and also to encourage harmonisation of the legislation and regulations among the States and Territories. Even though there has been an Australian Standard (AS 1055) on environmental noise for some decades, the assessment methods in this Standard are not necessarily followed in each jurisdiction. In some cases the assessment of the noise is on a different basis, such as comparison with background noise level or with a zone noise standard. In other cases the differences are minor, such as differences in the times for day and night. This paper will summarise and discuss the implications of the differences in the legislation and regulations.

1. INTRODUCTION

Australia is a federation of six States and two Territories (referred to as States throughout the paper). There are three levels of government: Federal, State and Local.

At the Federal level, the Department of Environment and Heritage includes Environment Australia. This organisation aims to achieve three major outcomes for the Commonwealth Government: the protection and conservation of the environment, especially those aspects that are matters of national environmental significance; benefit to Australia from meteorological and related science and services; and advancement of Australia's interests in Antarctica. There are divisions within Environment Australia with specific responsibility for aspects of the environment such as air and water but there is none specifically addressing noise. The predecessor to the current organisation (the Australian Environment Council) did take an active role in overseeing noise issues. In 1987 it produced a document summarising the approaches to legislation employed by governments throughout Australia for controlling various types of noise [1]. Unfortunately there is no such strong direction for harmonisation of noise legislation from Environment Australia. The Intergovernmental Agreement on the Environment (IGAE) [2] sets out the 'ground rules' under which the Commonwealth, State/Territory and Local Governments interact on the environment. It includes a broad set of principles to guide the development of environment policies and, in a series of schedules, sets out cooperative arrangements on a wide range of specific issues. The National Environmental Protection Act [3] allows for measures related to noise but only if differences would have an 'adverse effect on national markets for goods and services'.

The only noise sources that are controlled at the Federal level are aircraft and motor vehicles. Type approval noise testing is provided for prior to approval for registration. Each State has a department or agency responsible for development and implementation of environmental legislation and policy. Most of these are currently named Environment Protection Agency or some similar title. Local government is responsible for the implementation of many of the policies developed by State governments, particularly those dealing with noise from residential premises.

2. FEDERAL NOISE LEGISLATION

The Federal noise legislation for motor vehicles relates to the maximum noise emission for approval for registration in Australia. This legislation is based on the International Standard 'drive by' test and the limits are in general agreement with international best practice [4]. The need to update the Australian Design Rules as more stringent criteria are established (usually in Europe) is carefully considered by the appropriate authorities. It is the responsibility of State governments to control the noise of in-service vehicles. Compliance with noise limits for certification of new aircraft types is in accordance with international specifications [ICAO]. Environmental Protection Regulations for Airports [5] include noise criteria which specifically address airport activities and do not apply to aircraft when in flight, landing, taking off or taxiing. An Australian Standard, AS2021 [6], provides guidelines for land use planning in the vicinity of airports with criteria based on the Australian Noise Exposure Forecast (ANEF). Compliance with these guidelines is not mandatory but is strongly supported by Air Services Australia and the Federal Department of Transport and Regional Services (DOTARS). This Department has a management role over any works to minimise the noise impact of major airport developments, such as the Sydney Airport Noise Insulation Program following the construction of a new runway.

* The views expressed in this paper are not necessarily those of the authors' organisations

3. STATE NOISE LEGISLATION

While there had been some means of controlling clearly excessive noise, it was not until the 1970s that comprehensive noise legislation was introduced by most of the Australian States. This legislation was usually specific to noise, with names such as 'Noise Control Act'. Subsequent revisions and changes in approaches to policy throughout most of Australia led to the introduction of integrated environmental legislation to cover all aspects of the environment. Environment protection policies, regulations or guidelines were then introduced to address specific aspects of the environment. A major advantage of this approach is that it allows changes to be made more rapidly than would be the case should the Act need to be changed.

It is acknowledged that changes in the views of the States on the appropriate approach for controlling environmental noise impact are brought about by many factors. These include experience with the implementation of the current policy, changes in community expectations, changes in government, dissemination of research information, technological improvements in noise measurement, international experience, etc. Revision of policy documents generally occurs around every 7 to 10 years. As the different State agencies do not revise their policies at the same time, there will inevitably be differences in approach. However, as long as the States justify to themselves the need for different criteria, there will be an impact on companies and suppliers operating on an Australia-wide basis. Noise assessments may need to be repeated because of the different State legislation. Plant designed to meet the requirements in one State may need modification to operate in another State. Cooperation between State authorities will be required to deal with noise issues arising from any activities operating close to adjoining State boundaries.

3.1 Industrial Noise

In each of the States, the basic method for assessing excessive noise involves measurement or prediction of the noise level in terms of dB(A). A correction for the nature of the noise is applied and comparison is made with the criteria considered to be acceptable for the time of day and the nature of the area. However, there are important differences between the States in the implementation of this basic procedure.

An Australian Standard specifying measurement and assessment methods for environmental noise was first published in 1973 and has been revised and expanded on a regular basis [7]. The standard (AS 1055) includes inter alia an assessment method based on measurement of the background noise level. It also gives estimated average background levels based on six types of areas and three time periods; 0700 to1800, 1800 to 2200 and 2200 to 0700 hrs. For Sundays and public holidays 0700 hr is changed to 0900 hr to allow for additional sleep. It is important to note that an Australian Standard has no legislative power itself. It is up to each State to decide if it wants to refer to all or part of the

Table 1. General Methods of Assessing the Extent of Noise Impact

State	Assessment	Descriptor	Time Zones*	Web based information
Queensland	Background	L_{Aeq}, L_{A10}	0700-1800 1800-2200 2200-0700	www.epa.qld.gov.au/environment/misc/publications/
New South Wales	Zone and Background	L_{Aeq}	0700-1800 1800-2200 2200-0700	www.epa.nsw.gov.au/publications/noise.htm
Victoria	Zone and Background	L_{Aeq}	0700-1800 1800-2200[1] 2200-0700	www.epa.vic.gov.au/publications/legislation/sepps.asp#noise
Tasmania	Background	L_{Aeq}	0700-1800 1800-2200 2200-0700	www.dpiwe.tas.gov.au
South Australia	Zone and Background	L_{A10}	0700-2200 2200-0700	www.environment.sa.gov.au/epa/pub.html
Western Australia	Zone	L_{A1},L_{A10}, L_{Amax}	0700-1900[2] 1900-2200 2200-0700	www.epa.wa.gov.au/
A.C.T.	Zone	L_{A10}	0700-2200 2200-0700	www.environment.act.gov.au
Northern Territory	Zone	L_{Aeq}	0700-2200 2200-0700	www.lpe.nt.gov.au

* Night-time for Sundays and public holidays is extended in most States
[1] Saturdays 1300 – 1800 and Sundays and public holidays 0700 – 1800 treated as evening
[2] Sundays and public holidays: 0700 – 0900 treated as night and 0900 – 1900 as evening.

standard in legislation.

There are some parts of the Standard that have been adopted by the States. For example, there is general agreement that the measurement location for the assessment of annoyance should be at the nearest affected residence. For those States that base the criteria for assessment on limits for noise zones, there may be additional measurement locations required at the zone boundary. All States require the assessment to be in terms of A-weighted decibels. Formerly, the percentile level (L_{A10}) or the average-maximum value (L_{Amax}) was the descriptor used for assessment of the noise from a source, but now there is a general trend towards the use of the equivalent energy level (L_{Aeq}) and recent changes in legislation have incorporated its use [8]. The minimum time period for monitoring is normally 15 minutes. However, the availability of automatic data loggers enables the noise monitoring to be commonly undertaken for longer time periods, with shorter attended measurements used to verify the actual sources of the noise. The methods for applying corrections for the nature of the noise are generally similar and based on the procedures in AS 1055, but there are some differences in applying multiple corrections, such as for a noise which is both tonal and intermittent.

Table 1 summarises the general method of assessing the extent of noise impact for each of the States. It is clear from this table that assessment procedures used by the States differ. Earlier versions of AS 1055 essentially recommended comparison with background noise as the primary method of assessment and most States adopted this approach in earlier legislation with the criterion being an excess of +5 dB(A). The current move away from this method of assessment reflects the difficulties that were encountered in practice, in particular the difficulties experienced in basing the assessment on a noise level descriptor which itself varied from day to day and from week to week. An interesting approach is the recent NSW Industrial Noise Policy [8] which allows for assessment based on intrusiveness using comparison with background noise levels and/or amenity using comparison with criteria specific to the land use.

3.2 Specific Noise Sources

In addition to a policy for controlling noise from industry, each of the States has introduced policies or guidelines for dealing with other types of community noise sources, such as outdoor concerts, motor sports, shooting ranges, standby generators, chain saws, etc. These specific policies establish environmental noise criteria to meet the needs of the surrounding communities whilst accepting the rights of other members of the community to participate in various activities. Considerable negotiation is often required between the representatives from the organisations involved with the noisy activity and the surrounding community. Different approaches have been found to be more effective for different types of noise source.

Permitted hours of operation

This method has been found to be an effective approach for controlling general community noise. For example, the use of lawn mowers has been restricted to daytime hours, while amplified music/parties are allowed until late at night. Of course the policies allow for further investigation if the noise is excessive even during normally permitted hours. This control method is easy to enforce by administering authorities such as the police or council officers since noise measurements are not required. In addition, the complainants have a clear statement of their rights. This approach is also used for activities such as construction, which are known to be noisy but are generally short-term. Usually such activities are permitted only during daytime, Monday to Saturday, thus providing for a quiet Sunday.

Maximum noise levels

For other types of noise sources in community areas a maximum allowable noise level is specified. Some examples of this type of control are noise limits for mobile street vendors, residential pool pumps and domestic air conditioners. This approach requires measurement and so needs investigation by the local government noise inspector.

Combination of controls

Some community activities can be controlled by a combination of methods. Typical examples are outdoor recreational activities such as concerts and motor sports, which occur on an irregular basis. There is a need to establish a balance between the rights of the nearby residents and the rights of those who enjoy the activity. The goal of most of the State policies for this type of noise is to encourage good management of the facility and minimisation of the environmental noise impact. Another approach is to set an upper limit for the noise but also use incentives to encourage the proponents to further limit noise levels. Such a policy is that developed in one of the States for motor sports [9]. The venue receives an annual allowance of event credits, each having a value of 5 dB(A). Thus more events can be held if there is simultaneous use of the venue by less noisy activities.

There is as yet no environmental legislation specifically addressing vibration. However, vibration is accepted as an issue and some agencies are currently drafting guidelines for its control. Most States have policies and guidelines for vibration associated with blasting and mining and these are generally in accord with the Guidelines to minimise annoyance due to blasting overpressure and ground vibration published by the Australian and New Zealand Environment Council [10]. The guidelines specify limits at the nearest affected residences for blast overpressure and ground vibration. Incentives for blasting during the day are provided by having lower limits specified at other times. Guidelines for vibration in buildings where occupants could be affected can be based on whole body vibration limits in accordance with the Australian Standard [11]. The British Standard, BS 7385 Part 2 [12], is commonly used for evaluating effects of vibration on structures.

3.3 Transportation Noise

Over recent decades there has been a growing community reaction to noise from all forms of transportation (road, rail, air and water). Noise has been an important issue to be resolved in the environmental impact assessment of new and upgraded transportation links. When the issue has not been resolved adequately, considerable community reaction to developments considered to produce unacceptable noise has continued and ultimately resulted in the installation of mitigation measures. This result has emphasised the importance of resolution of potential problems at the approval stage and the demonstration that best management practices are being used.

Setting noise limits for aircraft as part of certification is the responsibility of the Federal government. In relation to planning guidelines, criteria are given in Australian Standard AS2021 [6] in terms of ANEFs (Australian Noise Exposure Forecasts). Compliance with these criteria is not mandatory for State and Local governments.

The control of noise from road traffic is the responsibility of State and local governments. Most States have maximum noise levels specified in guidelines or expressed as environmental goals. These levels may be specified in policies or codes of practice prepared by the agency involved, which could be a transport and/or environmental authority. Many of the guideline criteria have been based on an $L_{A10(18hr)}$ value measured at 1 m from a building facade. Typically the criteria for residential areas near existing roads vary from 65 to 68 dB(A) with a lower criterion of 63 dB(A) for new or upgraded roads. There is a trend towards the use of L_{Aeq} and a general lowering of the criteria for new developments. The recently adopted criteria in New South Wales [13] are in terms of daytime, $L_{Aeq(15hr)}$, and night time $L_{Aeq(9hr)}$ levels. The majority of the criteria are based on measurements taken from the front of an affected building facing a busy road. The ACT Government acknowledges that a lower criterion is applicable to the private open space in a garden and uses a guideline $L_{A10(18hr)}$ value of 58 dB(A).

The criteria are usually applied on the basis that the responsibility for any change lies with the proponent. Thus it is the authority that is building a new road or upgrading an existing road that needs to ensure compliance with the criteria by including mitigation measures where necessary. For new developments near existing roads it is the responsibility of the developer to incorporate mitigation measures to ensure compliance with the criteria.

The States also have the responsibility for controlling noise from rail traffic. Most specify maximum noise levels in guidelines or express them as environmental goals in policies or codes of practice. The greater demand for public transport has led to a growth in rail travel in the major cities, with duplication of portions of the existing network, the installation of new sections of line and proposals for faster trains. The noise impact of these upgrades has been of concern to nearby residents and a number of the agencies are developing more comprehensive policies to address these concerns.

4. FUTURE DIRECTIONS

In general, the various environmental agencies in Australia can best be described as reactive rather than proactive. However, there is a growing recognition, the result of an increasing number of complaints, that more emphasis should be placed on prevention of noise problems. Unfortunately, there is very little research undertaken in Australia to assess the effects of noise on people. There is also little formal assessment of the effectiveness of noise policies and procedures. Any statistics that are collected are related to the number of complaints received and processed and the number of environmental impact assessments evaluated.

Thus the Australian environmental agencies tend to look to international initiatives when assessing the need for new or changed policies. For this reason the recent European Parliament Directive on Environmental Noise 2002/49/EC [14] may, in due course, have some impact on environmental noise in Australia. This directive aims to provide a common basis for tackling the noise problem across the European Union. A key feature is the production of "strategic noise maps" for towns with more than 250,000 inhabitants. The Australian agencies should be able to learn from the experience that will be gained by this large European undertaking and decide if such mapping would be worthwhile. The European Directive also requires assessment in terms of L_{den} (day-evening-night equivalent level) and L_{night} (night equivalent level). The L_{den} has a weighting of +5 dB(A) for evening hours (1900 to 2300) and +10 dB(A) for night (2300 to 0700). There is already a tendency in Australia to move towards the use of L_{Aeq} for noise assessment, so again the vast experience gained with the use of these units in Europe may influence future Australian criteria.

5. CONCLUSION

Most of the environmental legislation in Australia is developed, implemented and enforced by State governments and there are still important differences between the States on approaches to noise assessment and setting criteria. There is a move toward harmonisation of policy approaches. Until harmonisation has been achieved, the differences will continue to cause problems for companies and product distributors operating in more than one State in areas close to adjoining State boundaries.

Industrial noise is assessed by comparison of measured levels with either background noise levels or zone noise standards. Criteria have been established by most States for road and rail noise. The approaches to noise control for other types of noise source take into account the nature of the noise source with the most common control measures based on permitted hours of operation and maximum allowable noise levels. As the various agencies are mainly reactive, any assessment of the effectiveness of a policy is usually based only on a reduction in the number of complaints.

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ROAD TRAFFIC NOISE EXPOSURE IN AUSTRALIAN CAPITAL CITIES

A. L. Brown[1] and Rob B. Bullen[2]
[1]School of Environmental Planning, Griffith University, Nathan 4111
[2]Wilkinson Murray P/L, 123 Willoughby Rd Crows Nest 2065

ABSTRACT: This paper reports the exposure of dwellings, in Australian mainland capital cities, to road traffic noise. The exposure of Australian dwellings has been reported previously, but the current study, based on a sample of 200 dwellings per city, provides estimates of exposure in each city. Estimates were based on rigorous sample selection and on predicted levels using measured traffic and geometric data. Some 8-20% of dwellings are exposed to $L_{A,10,18h}$ levels above 63dB, and 5-11% above 68 dB. The results suggest that efforts to date to ensure that Australian urban populations are not exposed to high levels of road traffic noise have had little success. An analysis of jurisdictional responsibility for the roadway sources confirms that management of this problem must be accepted by both local and State authorities.

1. INTRODUCTION

Reliable quantitative information on the extent and intensity of exposure to pollutants is essential for their proper consideration as policy matters and in determination of the appropriate level of resources that should be devoted to the pollutant's management.

Road traffic noise is largely an urban problem and in highly urbanised Australia the population exposed to noise is concentrated in metropolitan areas. As most effects of traffic noise are on people in their own homes, the problem of estimating the community's exposure to road traffic noise is effectively a problem of estimating the levels of road traffic noise incident on the facades of the population of dwellings in Australian cities. Different methodologies can be used to obtain estimates of road traffic noise exposure of populations (Brown and Cliff, 1988) but any methodology must be based on rigorous sampling of the specific population of interest to provide a measure of exposure that has known sampling errors.

Brown (1994) reported the exposure of the population of Australian dwellings to road traffic noise. That national study, based on a random sample of Australian dwellings located in Urban Centres with a population greater than 100,000, provided a definitive estimate of the exposure to road traffic noise of the Australian urban population as a whole. Confidence limits were provided for these exposure estimates and this distinguishes these estimates from those of previous studies of road traffic noise exposure in Australia. The national study used a sample size of 264 dwellings selected randomly across eleven of the country's largest cities. The national sample included sub-sample sizes of 80 dwellings in Sydney, 72 dwellings in Melbourne, and 112 dwellings across the remaining nine urban centres. That study was designed to estimate the exposure of the Australian population in order to be able to compare Australian exposure with exposure of other OECD countries and as a result, the small sub-sample size for any particular city meant that estimates of the exposure to road traffic noise within Australian cities, and comparisons between them, were not possible.

This current paper reports the results of a similar, but much larger, study designed to provide adequate estimates of road traffic noise exposure in each of Australia's mainland state capital cities.

A two-stage methodology was used. It drew a random sample of dwellings from each of five state capital Urban Centres with subsequent estimation of road traffic noise exposure at each dwelling in the sample. As in the 1994 work, this study used traffic noise calculation at individual dwellings, rather than traffic noise measurement.

The choice of calculation over measurement was one of economy and efficiency. As Brown (1994) points out, errors on studies that estimate traffic noise exposure of a population arise from two sources: sampling error and errors in noise estimation. Considerable tolerances are acceptable in the latter because error in noise estimates obtained by measurement or prediction should be largely random, not systematic, (providing adjustment is made for any systematic error in the prediction model) and this has little effect on the estimated levels of exposure of the *population* (of course, it does affect the estimate of exposure at any *individual* site, but individual site exposure is of no interest for current purposes). Thus limited study resources are better expended in reducing the sampling error by increasing the sample size and by reducing bias through rigid enforcement of a random sampling regime, rather than in reduction in the magnitude of the error in the noise estimate. Noise levels were calculated using the best available methodology, including the inclusion of corrections based on validations conducted under Australian conditions. To further reduce error in the noise estimate it would have been necessary to replace prediction by expensive noise measurement procedures. Within the constraints of resources available to this study this would have been possible only with a large reduction in the size of the sample of dwellings in the cities for which noise level exposures were to be estimated, with consequent increase in sampling error of the estimates.

2. SAMPLE SELECTION AND FIELD PROCEDURES

Determination of Sample Size in Each City

The area to be covered by the sample in the present study comprised the Urban Centres (as defined by the Australian Bureau of Statistics) for each of the five cities of Sydney, Melbourne, Brisbane, Perth and Adelaide.

To ensure that different city results were comparable (in terms of sampling error in the proportion of dwellings exposed to various levels of traffic noise) the same sample size was required for each city. Within each city, the study rigorously selected a random sample of dwellings within the boundaries of the Urban Centre, and predicted the level of traffic noise at the facade of each sampled dwelling.

The expected sampling error was estimated by using data from Brown (1994). If it is assumed that in a particular city the true proportion of dwellings exposed to various levels of traffic noise is equal to the proportion found in the national study, then the error in estimating that proportion for samples of various sizes can be estimated. Of course, the true proportion would differ between cities, and could not be known ahead of time, but errors calculated in this way gave the best estimate of prediction errors for different sample sizes, and could therefore be used to determine a sample size that provided a compromise between study costs and sampling error.

Table 1 shows 95% confidence limits (two-tailed) for the proportion of dwellings in a city with noise levels above specified values, for various city sample sizes.

Table 1 illustrates the trade-off between sampling error and sample size. It was believed that for the survey results to be valuable in detecting future changes in noise levels, and differences between cities, the percentage of dwellings with noise levels greater than 60dB $L_{Aeq,24h}$ should be able to be specified to within better than five percentage points in each city. Based on the results from Brown (1994), an overall change of 3dBA in noise level would result in a change of about five percentage points in percentage of dwellings exceeding 60dB $L_{Aeq,24h}$, and this is the magnitude of change which it was considered important to detect. From Table 1, this dictates a sample size of 200 (confidence limits for the percentage of dwellings then range from 4.9 points below the estimated value to 5.0 points above it.) Expanding the sample size to 250 per city provides only small gains in terms of sampling errors. For this reason, it was determined that the appropriate sample size for this project was 200 dwellings per city.

Selection of Dwellings

The acquisition of a truly random sample of dwellings within each of Australia's five largest urban centres was a difficult task, and required a large part of the resources of this study.

Addresses of dwellings in each Urban Centre were randomly selected from lists based on electoral rolls. In these lists, multiple entries for the same dwelling had been deleted. The available electoral roll data were current to 1994 for Sydney and 1993 for Brisbane, Melbourne, Perth and Adelaide.

Data based on electoral rolls are available by postcode area only, and postcodes boundaries are not necessarily contiguous with the boundaries of Urban Centres. To overcome this 300 dwellings were randomly selected from each city from a list of all postcodes that were either wholly or partially within the Urban Centre. Addresses in postcodes which lay only partially within the Urban Centre were then individually checked and deleted if they fell outside the Urban Centre boundaries.

Of these 300, the first 200 were given to field operatives as the primary sample, while the remaining addresses (in randomised order) were used for possible replacement dwellings.

The use of electoral roll data was preferable to alternatives such as telephone connections since it provides a more comprehensive coverage of dwellings. Even so, it was known that this sampling procedure would result in some non-representation of the city population of dwellings. Dwellings constructed since the preparation of the rolls would not be included in the sample, and dwellings demolished since roll preparation (without constructing a replacement at the same address) would result in "non-response" at that address. In

Table 1 CONFIDENCE LIMITS FOR THE PROPORTION OF DWELLINGS EXPOSED TO NOISE LEVELS GREATER THAN A SPECIFIED VALUE

Noise Level, $L_{Aeq,24}$	Assumed True Proportion of Dwellings (based on Brown, 1994)	Lower and Upper 95% Confidence Limits for the True Proportion, Based on a Sample Sizes of 100 to 250 Dwellings			
		100	150	200	250
70 dB	1.5%	0 – 3.8	0 – 3.3	0 – 3.0	0 – 2.9
65 dB	8.3%	2.6 – 13.5	3.6 – 12.8	4.3 – 12.0	4.9 – 11.8
60 dB	16.7%	9.5 – 24.1	11.0 – 22.6	11.8 – 21.7	12.2 – 21.3
55 dB	31.1%	22.1 – 39.7	23.7 – 38.4	24.7 – 37.5	25.2 – 36.7

addition, the sample based on electoral rolls would not include dwellings where no resident was on the roll. This would include: unoccupied dwellings, dwellings where all residents were either not Australian citizens or were under 18 years of age, and dwellings containing Australian citizens over 18 who were, illegally, not on the electoral roll. The proportion of dwellings in the first two of these categories can be estimated from census data and Table 2 shows the proportion of dwellings in each of these categories for each city. To the extent that unoccupied dwellings, and dwellings occupied solely by non-Australian citizens or people under 18 years of age, could have exposure to traffic noise which differs from the rest of the population, this non-representation could represent possible bias in the sample, though the effect of such bias could not be quantified without further study.

Field assessments on a total of 996 dwellings were conducted, approximately 200 in each of the five cities. The sampling procedures ensured that, irrespective of type, every dwelling unit had an equal chance of inclusion in this sample (whether the structure of the dwelling unit was a detached dwelling, a duplex, terrace house, unit, flat, apartment or part of a high-rise building complex).

Survey Procedures

Operatives trained in survey work were used to conduct the field study. A one-day training course was conducted in each city, including field trials, to ensure that the operatives were familiar with the techniques required.

On arrival at a site, operatives selected the window on the dwelling facade that was exposed to the highest level of traffic noise. This could be at the front, back or side of the residence. The name of the road causing the greatest traffic noise at this location was noted, together with any other roads if they also were the source of noticeable road traffic. The distance to the road(s) was measured, as well as the angle of view from the dwelling to the roadway, or if the road was not visible, the approximate location and height of barriers. The road gradient, speed limit and road surface material were noted. A plan and cross-section to the most important road(s) were sketched.

In addition, a 15 minute L_{Aeq} check noise measurement was made, one metre from the most exposed facade of the dwellings. The purpose of the short-term noise measurements was to identify those dwellings in the sample where it was unlikely that even moderate (>55 dB L_{Aeq}) road traffic noise levels would exist, obviating the need to collect the expensive traffic parameter data for these sites, and hence reducing the resource requirements of the study. All field work was conducted over 1997/1998.

3. NOISE LEVEL CALCULATION

Road traffic noise levels were calculated at all dwellings where the measured 15-minute level (from road traffic) exceeded 55 dBA. The measured $L_{Aeq,15min}$ noise level provides a conservatively high estimate of the $L_{Aeq,24h}$ value, so that locations excluded by this procedure will almost certainly have $L_{Aeq,24h}$ levels below 55 dB. At sites with measured 15-minute noise levels exceeding 55 dBA it was necessary to obtain information on the traffic flows and percentage of heavy vehicles for the road(s) identified as generating traffic noise at the residence. These traffic data were obtained by the relevant road authority, either from existing records or by purpose-made counts.

Based on the road traffic flow information, together with the geometric and other site-specific information recorded for each dwelling, the CORTN prediction method was used to calculate the noise level exposure at the site (Great Britain 1988). The following assumptions were made in the calculations:

- 18 hour traffic volumes were scaled as 0.94 times the Annual Average Daily Traffic;
- traffic speed was estimated as the speed limit for the roadway;
- for sites with more than 50% soft ground between source and receiver, a ground effect mid-way between the CORTN hard and soft ground calculations was used;
- standard corrections to the CORTN calculations, derived from validation under Australian conditions were applied. A uniform correction of −1.7 dB (Saunders et al, 1983) was applied to all calculated levels (to remove the known systematic error in the prediction estimates);
- the CORTN procedure was used to predict $L_{A10,18h}$ levels.

In addition to reporting exposure in terms of this noise scale, results are also reported in the $L_{Aeq,24h}$ scale obtained by applying linear translation of $L_{Aeq,24h} = L_{A10,18h} - 3.5$ dB (Brown 1989).

Table 2 ESTIMATED PERCENTAGES OF DWELLINGS IN URBAN CENTRES NOT INCLUDED IN THE ELECTORAL ROLL SAMPLING FRAME

Urban Centre	Proportion of Dwellings Unoccupied	Proportion of Dwellings occupied only by Non-Australian Citizens or People Under 18
Sydney	6.3%	10.7%
Melbourne	8.2%	9.2%
Brisbane	5.7%	7.7%
Adelaide	5.8%	7.7%
Perth	6.7%	10.7%

4. RESULTS

The study estimates the proportion of the population of each city exposed to road traffic noise in excess of any nominated level of noise exposure above about 55 dB L_{Aeq24h}.

Based on the sample of dwellings in each city, Figure 1 provides an estimate of the proportion of dwellings within the Urban Centres of Sydney, Melbourne, Brisbane, Adelaide and Perth for which the calculated traffic noise level exceeds various values of $L_{A10,18h}$. Figure 2 shows the same results, but using the L_{Aeq24h} scale.

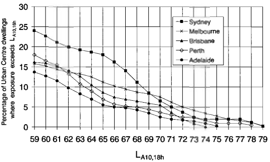

Figure 1. Cumulative noise exposure of dwellings in Australian capital cities, $L_{A10,18h}$

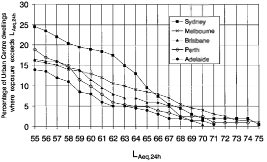

Figure 2. Cumulative noise exposure of dwellings in Australian capital cities, L_{Aeq24h}.

For Sydney, over 11% of the population are exposed to $L_{A10,18h}$ of 68dB or above and 19% of the population are exposed to $L_{A10,18h}$ of 63 dB or above. Confidence limits can be calculated for the estimated proportions (Zar, 1984). The confidence limits are not symmetrical. For example, the confidence band for the percentage of dwellings in Sydney exposed to 68dB or above is 7.7% to 15.5%, and for the percentage of dwellings exposed to 63 dB or above is 14.6% to 24.3% ($p < 0.05$). For Adelaide, over 4% of the population are exposed to $L_{A10,18h}$ of 68dB or above and 8% of the population are exposed to $L_{A10,18h}$ of 63 dB or above. The confidence band for the percentage of dwellings in Adelaide exposed to 68dB or above is 2.2% to 7.2% and for the percentage of dwellings exposed to 63 dB or above is 5.2% to 12.0% ($p < 0.05$). The exposures for the other cities lie generally between the exposures for these two cities.

The results can also be compared to the estimates from the national sample obtained in 1994. Figure 3 replicates the data from Figure 1, but adds to it the previously estimated exposure of the Australian urban population. The results are reasonably consistent. Note that the Australian urban population data, representing exposure of dwellings in all urban centres greater than 100,000 across the country, drew near 60% of its sample from the two cities of Sydney and Melbourne alone. This is apparent in Figure 3 at the lower noise exposures, but the Australian urban population results are somewhat lower than the results from the current study at the higher noise exposures. There is no obvious explanation for this, and in fact the differences are small relative to the confidence limits to the estimates of the proportions. It should be noted that the national results, as published in Brown (1994), did not include the -1.7 dB(A) Australian correction to the CORTN model. This correction has been applied to all results in Figure 3.

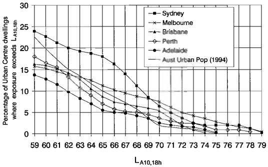

Figure 3. Comparison of the noise exposure of dwellings in Australian capital cities estimated in the current study with that of the noise exposure of the Australian urban population of dwellings estimated in 1994 (Brown, 1994).

In Figure 1, there is quite remarkable consistency across all cities in the proportions of the population exposed to levels above about 70 dB and across all cities, other than Sydney, to levels below 70dB. Most of the apparent (small) differences between the sample proportions for the cities are not significant for the population proportions when the confidence limits of each of the city estimates are taken into account. However, in the sample data, there is a trend for some correlation between city size and exposure, with Sydney and Melbourne recording a higher proportion of dwellings exposed to moderate to high levels of road traffic noise, with Brisbane, Perth and Adelaide generally having lower exposures. The Melbourne sample has a marginally higher proportion of dwellings exposed to levels above 70 dB than do other cities. The proportion of dwellings in Sydney exposed to levels of 60 – 70 dB is somewhat higher than any of the other cities. Such differences presumably result from a different pattern of road location and use in Sydney, with its road system constrained by topography.

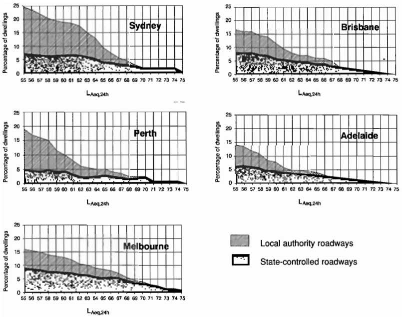

Figure 4. Jurisdictional responsibility for the roadways generating noise exposure at dwellings in Australian capital cities. The lower line shows the cumulative noise exposure of dwellings where the noise is generated from State-controlled roadways alone. The upper line shows the cumulative noise exposure where the noise is generated from either local authority roadways or State-controlled roadways.

In this respect it is unfortunate that Canberra, a planned city in which there has been considerable effort in design of a hierarchical road system and separation of residential land uses adjacent to the upper end of the road hierarchy, was not included in the study. It would be hoped that Canberra results would have shown a significantly lower level of traffic noise exposure than all of the other cities where there has not been similar opportunities to achieve noise control through land use planning .

Road Traffic Noise Exposure generated by State-Controlled or Local Authority-Controlled Roadways

While it is a matter of little interest to any resident exposed to high levels of road traffic noise, there is an important jurisdictional distinction regarding roads in Australian urban areas. In each city, a certain number of roads are designated as state-controlled roadways, or "declared" roadways, which are the responsibility of the respective State road authority. The rest of the city's road system is the responsibility of the local government or municipality. Such jurisdictional differences can become very important in terms of action with respect to road traffic noise control. For example, Queensland has different planning noise levels for these different categories of roadway (Queensland Government, 1997). To date, in any data on urban road traffic noise exposure, quantitative information on jurisdiction has not been available.

In the current study the jurisdictional control of the roadways generating noise exposure of the sample was identified. The results, shown in Figure 4, distinguish the proportion of dwelling in each city exposed to noise generated from State-controlled roads from the proportion exposed to noise generated from local authority-controlled roads. Figure 4 shows, as would be expected, that the very highest noise exposures in each city are generated from State-controlled roadways but, at all other exposure levels, the source of noise exposure is shared between State-controlled and local authority-controlled roadways.

5. CONCLUSIONS

This study has provided a definitive estimate of the exposure of the population of dwellings in Australian capital cities to road traffic noise. The results demonstrate that the situation in all capital cities is poor. Some 8-20% of dwellings are exposed to levels above 63 dB, and 5-11% of dwellings above 68 dB. These are unacceptably high proportions subject to these levels of noise, particularly given that the above levels, variously adopted as criteria in Australian states, are considerably higher than those recommended by a WHO expert task force (WHO, 2000), as necessary to protect against annoyance and sleep disturbance. The results suggest that efforts to date have had little success in ensuring that Australian urban populations are not exposed to high levels of road traffic noise. The jurisdictional analysis confirms that the responsibility for management of this problem must be accepted by both local and State authorities responsible for roadways, land use controls and building controls. There would be little doubt that most expenditure and effort in the control of noise from roadways has been directed at limited-access controlled roadways such as freeways. While road traffic noise from these sources warrants attention, they represent only the tip of the iceberg in terms of the number of urban dwellings exposed to high noise levels. A concerted effort in management of the road traffic noise problem, not only the road traffic noise problem from newly constructed roadways, needs to be an area of national, State, and local authority priority.

ACKNOWLEDGEMENT

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THE EFFECTS OF ENVIRONMENTAL NOISE ON CHILD HEALTH AND LEARNING — A REVIEW OF INTERNATIONAL RESEARCH

M.M.Haines[1,2] and S.A.Stansfeld[2]

[1] **Health Risk Management Practice, PricewaterhouseCoopers, Sydney, Australia**
[2] **Department of Psychiatry, Barts and the London Queen Mary s School of Medicine, University of London**

Abstract: Impairments of early childhood development and education by environmental pollutants such as noise, may have life long effects on achieving academic potential and health. In this article the non-auditory health effects of noise on children will be reviewed with a focus on current research evidence from international studies. In studies examining the effects of chronic aircraft, rail and road traffic noise on children there is consistent evidence that noise exposure adversely affects child cognitive performance. Noise exposure has also been consistently associated with noise annoyance and impaired well-being. There is moderate evidence that chronic noise exposure affects motivation, blood pressure and catecholamine hormone secretion. There is equivocal evidence that chronic noise exposure affects child mental health and sleep disturbance. Intervention studies should be a research priority area, because they can provide an evidence base to inform policies and measures to protect children from the adverse effects of noise. In addition, future studies are required to provide a more precise insight into the mechanisms that underlie child noise effects and the identification of vulnerable subgroups.

1. INTRODUCTION

There is consistent research evidence that chronic exposure to environmental noise leads to impaired cognitive function and health in children.[1,2] In the last 20 years there has been increased empirical research investigating the effects of noise on children, with the Los Angeles Airport Study,[3,4] the Munich Airport Study[5,6], the Schools Environment and Health Study[7,8] and the West London Schools Study[9] around Heathrow Airport in London, in New York City,[10] and the Sydney Airport Health Study.[11] Children may be more susceptible to environmental stress than adults for a variety of reasons including: less cognitive capacity to understand environmental issues and anticipate stressors and a lack of well-developed coping repertoires.[12], [13] Impairments of early childhood development and education by environmental pollutants such as noise, may have life long effects on achieving academic potential and health.[13] In this review article we will summarise the international literature on non-auditory health effects of noise on children. We will conclude with a summary of the main effects and the requirements for future research.

2. NON-AUDITORY HEALTH EFFECTS OF NOISE ON CHILDREN

Cognitive performance

The most widespread effects of noise found in children are cognitive impairments, though these effects are not uniform across all cognitive tasks.[1,12] There is empirical evidence from laboratory[14–18] and field studies[5,6] suggesting that complex tasks that involve central processing demands and language comprehension, such as reading, attention, problem solving and memory are more affected by noise exposure than simple tasks. This effect of environmental stress on cognitive tasks with high processing demands is widely accepted in the environmental stress literature examining the general sources of environmental stress on cognition.[12,19]

These are the specific effects that have been found in relation to noise exposure and child performance:

1) poorer reading ability and school performance on national standardised tests[5,10,20–27]
2) poorer memory that requires high processing demands of semantic material [5,6,15,28–31]
3) deficits in sustained attention and visual attention[8,31–38]
4) poorer auditory discrimination and speech perception[3,5,10,12,22,37]

Some of the earlier research examining noise effects in children has methodological flaws limiting the conclusions that can be drawn from the data. These flaws include: data were not provided to indicate how well socio-economically matched the noise exposed children were to the control sample,[35–37] the sample size was not large enough (most of the studies); not enough schools to rule out a school effect confounding the results,[3,4,7[illegible]] statistical methods were not sensitive enough,[38] and most studies were cross-sectional. The results from field studies that control for socio-economic factors, show that chronic noise exposure is consistently and reliably associated with cognitive impairments in school children.[3–5,7–9,22]

In the 1970s, the first well-designed naturalistic field study was conducted by Cohen et al.[22] who studied elementary school children living in four 32-floor apartment buildings that were located on an expressway. The sample of 73 children were tested for auditory discrimination and reading level. Children living on lower floors of the 32-story buildings (i.e. higher noise levels) showed greater impairment of auditory discrimination and reading achievement than children living in higher-floor apartments. Bronzaft and McCarthy[21] compared reading scores of elementary school children who were taught in classes on a noisy side of a school near a railway line with the scores of the school children in classes on the quiet side of the same school. They found that children on the noisy side of the school building had poorer performance on the school achievement tests than those in classes on the quiet side of the school. The mean reading age of children in the classes on the noisy side of the school was three to four months behind the children in the quiet classes. A strength of these results is that they cannot be attributed to self-selection, a methodological problem found in many field studies, because the noise effects were found in the same school. Children were not assigned in any systematic manner to classrooms on the noisy or quiet side of the school.

In the 1980s, impaired performance on a difficult cognitive task was found in primary school children aged 8-9 years in a systematic well-controlled naturalistic field study around Los Angeles Airport (cross sectional results[3] longitudinal results[4]). Cohen and colleagues [3] concluded that their results were strikingly similar to those reported in the laboratory setting, but that replication was required before definitive conclusions could be reached. In the 1990s, these effects were confirmed around Heathrow Airport in a repeated measures field study comparing the cognitive performance and stress responses of children aged 9-10 attending four schools exposed to high levels of aircraft noise (>66 dB(A) 16hr Leq) with children attending four matched control schools exposed to lower levels of aircraft noise (<57 dB(A) 16hr Leq). Children tested at baseline were re-tested a year later at follow-up. The results indicated that chronic exposure to aircraft noise was associated with impaired reading comprehension and sustained attention after adjustment for age, main language spoken at home and household deprivation.[7] The within subjects analyses adjusting follow-up performance for baseline performance indicate that children's development in reading comprehension may be adversely affected by chronic aircraft noise exposure[8].

The results of a multi-level modelling study analysing pre-existing national standardised scores of school performance in relation to aircraft noise around Heathrow airport for 11,000 scores of children aged 11 suggest that aircraft noise is associated with school performance in reading and mathematics in a dose-response function but that this association is influenced by socio-economic factors.[24] These results replicate an earlier study examining standardised school performance scores conducted around New York City airports.[23]

Intervention Studies

Stronger evidence to suggest the existence of noise effects comes from intervention studies and natural experiments where changes in noise exposure are shown to be accompanied by changes in health and cognitive performance. To date, there have been three studies examining the effects of noise reduction on children's cognition: two intervention studies[4,20] with methodological flaws that limit their generalisability and one well-designed natural experiment; The Munich Airport Study.[5,6,29] The most convincing evidence for noise related cognitive effects came from the prospective longitudinal natural experimental field research around Munich Airport in older children with a mean age of 10.8 years (cross-sectional results[5] and longitudinal results[5,8,29]). In 1992 the old Munich airport closed and a new airport was opened. The cross-sectional results indicate an association between high noise exposure and poor long term memory and reading comprehension[5]. Longitudinal analyses, after three waves of testing, indicate improvements in long term memory and reading after closure of the old airport. Strikingly, these effects were paralleled by impairment of the same cognitive skills after the new airport opened.[29] The Munich Airport Study, designed as a prospective longitudinal natural experiment with a change in noise exposure, provides very strong evidence for the effects of aircraft noise on child health and cognition.

Chronic exposure to aircraft noise has also been associated with decreased motivation in school children[3-5,12] although the results are not consistent.[7] This motivation effect may either be independent or secondary to noise related cognitive impairments.

Noise annoyance

Children have been found to be annoyed by chronic environmental noise exposure.[5,7-9,21] In Munich, it was found that children living in noisier areas were significantly more annoyed by noise in their community as indexed by a calibrated community measure that adjusts for individual differences in rating criteria for annoyance judgements.[5] In London, noise annoyance was measured with child adapted standard self-report questions.[7-9,39] The repeated measures analyses from the Heathrow study indicate that children's annoyance remains constant over a period of a year with no strong evidence of habituation[8]. It is important to recognise that even young children report disturbance by environmental noise. In many ways child noise annoyance may be less subject to bias because children are less affected by other factors that influence annoyance in adult samples, namely: political and environmental attitudes.

Child Mental Health and Well-being

Noise exposure has consistently been associated with lower psychological well-being[5,6,8] in children. However, noise exposure does not seem to be associated with anxiety, depression and psychological morbidity or sleep disturbance.[7]

Previous research suggests that noise does not influence child mental health, however it may affect child stress responses and sense of well-being. Generally there are very few studies that have examined the effects of noise on child mental health. In one British study, the depression (Child Depression inventory) and anxiety (Child Manifest Anxiety Scale) scores of 169 children attending four schools exposed to high levels of aircraft noise (>66 dB(A) 16hr outdoor Leq) were compared with 171 children attending four matched control schools exposed to lower levels of aircraft noise (<57 dB(A) 16hr outdoor Leq) around Heathrow Airport in West London.[7] Mirroring the results from the adult studies, no associations were found between chronic aircraft noise exposure and anxiety and depression in school children. These results suggest that chronic aircraft noise exposure does not directly affect anxiety and depression. However, it is possible that noise might affect other more stress-related aspects of mental health such as self-reported stress, social functioning, behavioural adjustment and well-being in children. This possibility is supported by evidence from the Munich Airport Study where it was found that aircraft noise was associated with reduced quality of life (measured by the Kindl) in children aged 9–11 years.[6]

'Quality of life' impairment is a different, less severe impairment than mental ill-health. In the West London Schools Study chronic aircraft noise exposure was weakly associated with overall psychological morbidity and specifically hyperactivity measured by the Strengths and Difficulties Questionnaire.[8] As this was an isolated finding, not found in the earlier Schools Health and Environment Study, it needs further research to confirm or refute this finding. A recent Austrian study has found that exposure to road and rail traffic noise was associated with poorer classroom behaviour and poor self reported child mental health derived from the Kindl Quality of Life Scale.[40] However, ambient noise was only associated with poorer mental health in children with low birth weight or pre-term birth and these conditions may have an effect independently from noise on mental health. These studies suggest that overall noise is probably not associated with serious disturbance of child mental health, however it may affect child stress responses and sense of well-being and there is a need for further research.

Physiological stress responses

There is evidence that children are not only susceptible to cognitive impairment in noisy environments but may also react physiologically to noise. Previous research has demonstrated a pattern of physiological and psychological stress responses associated with chronic noise exposure in children. Catecholamine (adrenaline and noradrenaline) secretion is commonly measured in noise studies as a physiological marke of chronic stress[5,6,9] There is moderate evidence that chronic noise exposure affects blood pressure and catecholamine hormone secretion. Chronic high levels of noise exposure have been associated with: higher levels of systolic and diastolic blood pressure[3,5,6,41,42] raised catecholamine secretion.[5,6] The effects on blood pressure[11] and catecholamine secretion[9,41] have not always been consistently demonstrated.

Summary

Table 1 below contains a summary of the strength of the effects of noise on child health. The categories of evidence have been classified into:

1) Sufficient evidence, that is consistent strong associations from high quality studies
2) Limited or weak evidence but it is possible there is an effect (e.g weak association in a few studies)
3) Inconclusive evidence where there are conflicting results.
4) No effect (that is negative association found in a few studies)
5) Inadequate evidence — that is it has not been thoroughly tested if at all

Table 1 Strength of the evidence for effects of environmental noise on children

Health Outcome	Strength of Evidence
Annoyance	Sufficient
Cognitive performance	Sufficient
Motivation	Sufficient/Limited
Wellbeing/Perceived stress	Sufficient/Limited
Catecholamine secretion	Limited/Inconclusive
Hypertension	Limited (weak associations)
Psychiatric disorder	Inconclusive/No effect
Sleep disturbance	Inadequate/No effect
Birth weight	Inadequate
Immune effects	Inadequate

* Cognitive performance has been measured as: reading, memory, auditory discrimination, speech perception, academic performance and attention.

3. KEY ISSUES TO BE CONSIDERED

Three key issues need to be taken into consideration when making suggestions for future research.

Possible Mechanisms of Noise Effects

The research evidence outlined above leaves us with the critical question of how does one explain the link between chronic exposure to noise and these adverse effects on child cognition and health? The theoretical understanding of child noise effects is very limited. The 'cognitive coping strategies' is the major theoretical psychological model of environmental stress that has been applied to explain the effects of noise on child performance and health.[12] Noise in the home or school environment is an environmental stressor that causes increased distraction, which may overburden developing cognitive systems. Children may adapt to noise interference during activities by filtering out the unwanted noise stimuli. This tuning out strategy may over-generalise to all situations when noise is not present, such that children tune out stimuli indiscriminately. Under some circumstances, these strategies may be detrimental and it is possible that the impairments in attention, auditory discrimination and/or speech perception may mediate the association between noise and child cognitive performance. Only four studies[7,8,10,22] have actually tested the mediating role of a hypothesised factor. The results from these studies provide empirical evidence that the effects of noise on child reading are more likely to be mediated by psycholinguistic processes such as auditory discrimination or speech perception. However, this is yet to be confirmed because the most recently published results suggest that the poorer reading was not mediated by speech perception and that impaired recall was in part mediated by reading.[29] There is evidence that noise related reading effects are not mediated by either annoyance[7] or sustained attention[8] or sound perception.[10]

Teacher frustration and communication difficulties could also be mechanism for cognitive and motivation effects.[13] Learned Helplessness has been proposed as a mechanism to account for the motivation effects.[1,3,5] The mechanism to account for the effects of noise exposure on children's blood pressure, endocrine disturbance and annoyance is considered to be the same stress mechanism proposed to account for the adult noise effects.[43]

Dose response relationships

Without robust dose-response curves the current state of knowledge can only provide a suggestive evidence base for guidance on the noise threshold level before effects become manifest. In the absence of these data it is difficult to give precise figures on how many children are taught in schools with noise levels that may adversely affect their health or set limits for noise exposure levels. This question will be addressed in the RANCH project (Road traffic and aircraft noise exposure and children's cognition and health: exposure-effect relationships and combined effects) funded by the European Commission (**www.ranchproject.org**). One of the main aims of the RANCH study is to determine exposure-effect relationships in children between chronic exposure to noise and impaired cognitive function, health, noise annoyance and sleep quality for aircraft, road traffic and combined sources. The RANCH study involves four epidemiological field studies on chronic noise exposure, including two smaller quasi-experimental psychological field studies on a limited sample of children, and two biomedical laboratory studies on acute noise exposure conducted within four countries across Europe. RANCH began in January 2001 and is planned to take three years to complete at the end of 2003.

Vulnerable Child Groups and Individual Differences

Although there are overall trends showing that chronic exposure to noise is associated with impaired cognition over a range of functions, there may be individual differences in these effects. Some children in the population may be more vulnerable to noise effects than others. There is limited evidence that children who have lower aptitude[12,44,27] or other difficulties such as learning difficulties[45,46] may be more vulnerable to the harmful effects of noise on cognitive performance. There may also be individual differences according to age and gender.

4. SUMMARY AND CONCLUSIONS

To conclude, there is sufficient evidence to suggest that chronic noise exposure at schools affects child health and performance. Since research results are consistent, it may be wise to apply the precautionary principle of environmental law for improving the school environment around airports and transport developments using the recommended WHO noise levels as guidelines.[47] To date, the potential negative and positive effects of interventions have not been thoroughly researched enough to provide policy makers with clear guidance. The development of future interventions and policies must be concurrent with a thorough research evaluation to determine the efficacy of the intervention to reduce exposure and reduce the adverse health effects of noise on children.

There is a need to evaluate a) sound insulation programmes and b) policies to reduce noise exposure in a well controlled large scale study to determine the impact of these programmes on a range of performance and health effects associated with child noise exposure. Future studies need to evaluate the protective and restorative effects of accessibility to quiet zones (or options for protection of such quiet zones i.e. natural areas, parks, etc.) on child health. Studies are required to provide a more precise insight into the mechanisms that underlie child noise effects. The identification of vulnerable subgroups within the child population should also be a research priority.

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LONG-TERM ENVIRONMENTAL MONITORING AND NOISE SOURCE IDENTIFICATION

Robert Bullen
Wilkinson Murray Pty Ltd
123 Willoughby Rd
Crows Nest NSW 2065

Abstract: To control noise emission from any source, regulating bodies can adopt one of two strategies – physical controls specifying equipment types, silencers, barriers, etc. or performance-based controls specifying noise levels to be met at sensitive locations. The performance-based approach is generally preferred by both noise-makers (because it allows flexibility in designing noise controls) and affected communities (because it guarantees a noise level outcome). A major problem, however, is monitoring compliance confidently. The performance-based strategy generally requires accurate detection of the noise level due to a particular source, automatic monitoring of this level over a long period (often months or years), and fast (preferably real-time) access to monitored data. Techniques are becoming available to perform all these tasks, making performance-based noise conditions practical for a much larger class of noise sources. This article describes some recent developments in this field, and demonstrates the capabilities of a large noise monitoring system with source-detection capabilities.

1. INTRODUCTION

"It s ridiculous. Look at your meter — the BIRDS make more noise than my factory/road/mine/wind turbine." A very familiar comment which encapsulates one of the most difficult issues in the control of environmental noise.

There is, of course, nothing irrational about residents showing different levels of reaction to different noise sources (as the noise-maker above seems to imply). Nevertheless, it does present a problem for regulators. If limits for industrial and similar noise are set low enough to protect residents adequately, then almost invariably noise which meets or almost meets those limits will be very difficult to measure in the presence of other less annoying noises such as rustling leaves, distant traffic, lawn mowers and (yes) birds. Residents can easily tell the two types of noise apart, but until recently acoustic measurement equipment has not generally been up to the task.

In Australia, noise limits for industrial and similar sources are becoming increasingly more stringent and more detailed, as evidenced by the NSW Government's recently-released Industrial Noise Policy [1]. As the theoretical criteria become more strict, monitoring of compliance with these criteria becomes more difficult.

This paper describes some current approaches to the control of environmental noise, concentrating on noise from industrial and similar sources where the problem of compliance monitoring tends to be most acute. In particular, recent developments in noise monitoring technology bring the goal of real-time monitoring of noise from a specified source closer to reality, and one example of the use of these techniques is described in detail.

2. NOISE CRITERIA AND COMPLIANCE MONITORING

Standards for the control of general environmental noise in Australia are summarised by Burgess and Macalpine [2]. These standards are generally invoked at the point of approval of a project, at which time the proponent is required to demonstrate that the level of noise due to the project will be within the criteria. In most States, the requirements are broadly similar to the "intrusiveness" and/or the "amenity" criteria in the NSW Industrial Noise Policy :

$L_{Aeq,15min}$ <= Rating Background Level + 5 ("intrusiveness") and

$L_{Aeq,Period}$ <= Acceptable Noise Level ("amenity")

where:

- $L_{Aeq,15min}$ represents noise emitted by the source under consideration;
- the "Rating Background Level" is a measure of background noise in the absence of noise from the source;
- $L_{Aeq,Period}$ represents noise due to all industrial sources (but excluding transportation and natural sources); and
- the "Acceptable Noise Level" is a fixed value depending on the type of area and time of day.

Once it has been accepted that noise levels due to the project can meet the relevant criteria, the consent authority will then set down binding conditions intended to guarantee that the criteria are met in practice. There are two general approaches to setting these conditions.

First, the authority may simply require that all noise control measures such as barriers, silencers, etc. which were included in the proposal be installed. Under this approach, verification of compliance is very simple. It does, however, rely on (usually) theoretical calculations in the proponent's statement to ensure that these measures are adequate. The accuracy of such calculations is typically ± 5 dBA [3], so this procedure is adequate where compliance issues are not critical and/or where conservative assumptions have been made in calculations. In critical cases however, residents often demand that the assumptions be confirmed by actual noise measurements. Plant operators also prefer measurement-based conditions, because it allows flexibility in cases where, for example, actual operations may be less noisy than predicted, or new noise control technology may become available after consent is granted.

Alternatively (or in addition), a consent authority may require a regime of noise monitoring designed to determine whether the criteria are being met. Once again, monitoring traditionally takes one of two forms.

- Long-term unattended monitoring uses automatic data loggers, which are relatively inexpensive and easy to deploy. These may record only noise level index, or they may include methods for recording short sections of audio signal, to allow later identification of the most important noise source(s) by an operator. Some monitors can be interrogated remotely via a modem, and thereby for a semi-permanent system. Unless permanent power (mains or solar) is available their batteries need to be changed regularly. Aircraft noise monitors generally incorporate some form of event discrimination, based typically on rise time and duration, to assist in separating aircraft noise from other events. For other types of noise, such discrimination is much more difficult, so unless very large sections of audio signal are recorded, it is generally not possible to be sure that recorded noise actually emanates from the source of interest.
- Attended monitoring allows more positive source identification by an operator, although it may still not permit a confident measurement of the level of noise from a specific source, unless that source is dominant (over other noise sources) for at least short periods during the monitoring. This form of monitoring is necessarily short-term, and hence may miss periods of high noise emission. It can also be quite expensive, particularly if multiple monitoring sites are involved.

Neither of the above forms of monitoring can necessarily provide an unambiguous answer as to whether or not noise from the source of interest exceeds a specified criterion. This explains the reluctance of consent authorities to rely solely on monitoring as a tool for enforcement of noise conditions.

3. NOISE SOURCE IDENTIFICATION

Separating a complex signal into its independent, uncorrelated component sources is termed the "blind source separation" problem. It is in principle soluble, and considerable work has been performed recently on finding computationally efficient methods to perform this task.

For acoustic applications, techniques have been investigated which allow recovery of the complete time waveform of each source. Approaches which provide an unambiguous solution for spatially-separated sources, such as that described by Choi [4], generally require at least as many microphones as there are possible sources. Alternative techniques such as that described by Pearlmutter and Parra [5] require only one microphone, but detect different components of a sound (such as tonal and non-tonal components) rather than different spatially-separated sources. Both these techniques require "training" of the system to converge on an optimal source decomposition, and both involve computing requirements which would preclude real-time use with current-technology systems. Nevertheless, they offer significant scope for future developments which would allow separation and actual "listening" to specific component sources, as well as measurement of properties such as the level and time-variation of the signals.

Another approach relies on detecting a "noise signature" for particular sources. Some progress has been made in identifying particular types of vehicle in a traffic stream [6,7]. Variations on these procedures involve simple filtering of a signal to remove a known source such as insects, and detection of the noise signature from, for example, an aircraft in order to exclude this noise from monitoring results. These and similar systems however, depend on prior knowledge of the temporal and/or spectral characteristics of all sources to be detected or excluded, and assume that sources of interest will differ significantly from others in these characteristics.

A technique developed by the author [8] allows real-time detection of the direction of noise sources and assessment of the level of those sources, using a three-microphone array. The system requires prior knowledge of the direction of a source of interest, but this is generally known in environmental noise monitoring. Each measurement includes all noise in the specified range of directions, including any extraneous sources which happen to be in that direction. Nevertheless, because the technique can be implemented continuously and in real time, it offers the possibility of significantly improving the specificity of unattended noise monitoring systems.

The following section describes the implementation of a large, permanent system for monitoring noise from an open-cut coal mine. The system incorporates directional monitors, storing of audio signals, and the possibility of obtaining real-time audio and directional information from any monitor, as well as validation using traditional attended and unattended monitoring. It is believed to represent the current "state of the art" in environmental noise monitoring, and points toward future directions and possibilities.

4. NOISE MONITORING AT MOUNT ARTHUR NORTH COAL MINE

Noise Requirements

The Mount Arthur North coal project is located south-west of Muswellbrook, NSW. It includes an open-cut coal mine producing up to 15Mt of run-of-mine coal per year, together with associated processing facilities and a rail loading point. There are isolated residences within approximately 2km of the mining areas, and relatively dense development within approximately 4km (Figure 1). There are also a number of other existing coal mines in the area which are audible at many of the residences potentially affected by Mount Arthur North.

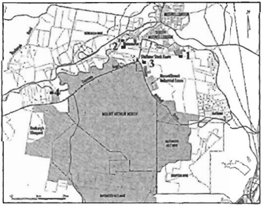

Figure 1 Location of Mount Arthur North mine and directional noise monitors

Figure 2 A directional noise monitor

The project received development approval in May 2001. As anticipated, environmental noise was a major issue during the assessment process. The relevant approval conditions are framed fundamentally in terms of compliance with criteria, rather than simply noise control measures to be carried out, although some specific measures are also required. The criteria are expressed as:

- an $L_{Aeq,15min}$ noise level not to be exceeded for more than 10% of monitoring periods in any season. This criterion applies to noise from the Mount Arthur North project alone; and
- a long-term $L_{Aeq,Period}$ noise level (where "period" represents day, evening or night) not to be exceeded by the cumulative noise from all industrial sources in the area. (The relevant sources are largely mines.)

A noise monitoring program designed to test compliance with these criteria was approved by the NSW EPA.

The Monitoring System

The Mount Arthur North noise monitoring system serves three functions:

- provision of data to demonstrate compliance with the above criteria, for inclusion in quarterly and annual reports;
- continuous updates of recorded noise levels over any selectable period, available on-line at any time, to provide "early warning" of possible problems; and
- a real-time display and listening function to provide operators with immediate feedback on current noise levels, allowing site operations to be altered to avoid potential exceedances of criteria.

The major part of the system consists of four directional noise monitors, installed at locations shown in Figure 1. Each monitor consists of three microphones located at a height of approximately 4.5m from the ground (Figure 2). The microphone outputs are connected to a computer located in a small shed adjacent to the monitor, which performs the following functions:

- detects the direction and level of noise sources once per second, based on processing of the three microphone signals;
- accumulates the L_{Aeq} noise level arriving from each five-degree increment of angle, and saves the accumulated levels every five minutes;
- accumulates non-directional statistical noise levels as for a standard unattended noise logger, and saves every five minutes;
- saves audio data in WAV-format files of any specified length, at specified time intervals and/or when the total noise exceeds a trigger level for a specified length of time;
- on request, provides real-time streaming audio to another connected computer; and
- performs an automatic test of the microphone functions once per day.

Each of the monitors is connected through an 8Mbps microwave link to the site's computer network. Two separate programs, which may run on any computer on the network, can interrogate the monitors.

First, a real-time inspection program can display the noise level and direction of sources being detected at any monitor, the total L_{Aeq} noise level since the last logging interval and the L_{Aeq} noise level from sources within a specified range of angles. Figure 3 shows a typical display from this program. Simultaneously, audio signal from the selected monitor is fed to the computer's sound card. This allows an operator to listen to noise at any monitor, while tracking both the noise level and the direction from which it is arriving. If a source is identified as being associated with the mine, and is creating

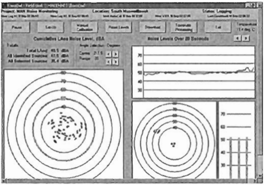

Figure 3 Typical real-time display showing noise level vs time (upper right), instantaneous sources detected (lower right) and cumulative noise level by five-degree segments (lower left)

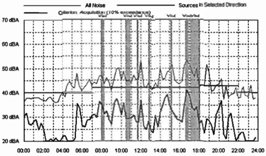

Figure 4 Noise levels for a single day, showing total noise and noise from a specified range of angles. Wind-affected data are shaded.

unacceptably high noise levels, corrective action can be taken immediately.

Second, an automatic downloading program retrieves data from each monitor every five minutes, and updates a database of stored noise levels. This database contains a record of L_{Aeq} noise levels from each of 72 five-degree angle increments from each monitor every five minutes, as well as statistical noise levels, calibration readings and other information. Stored WAV files are also downloaded, and may be compressed to MP3 or similar format and saved to disk. At present the database contains information from over a year's measurements. Information from meteorological measurement stations at each of the monitoring locations is stored in the same database, to allow exclusion of data affected by high wind or rain.

A third program generates reports from the database, oriented toward demonstrating compliance or otherwise with the mine's noise criteria. Figure 4 shows information from a particular day, while Figure 5 shows results over a two-week period.

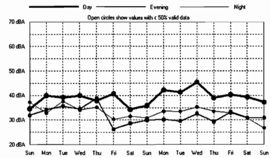

Figure 5 Recorded noise levels over 14 days, showing the noise level from a specified range of directions which is exceeded for 10% of 15-minute time periods during the day, evening and night periods on each day

At the time of writing this report the monitoring system has been installed and running for over a year, during which time extensive testing and development has been carried out. Mine operations during that time have been largely construction-oriented. The effectiveness of the system in monitoring and controlling noise from full-scale mining operations will be tested over the first six months of 2003.

5. FUTURE DIRECTIONS

The Mount Arthur North noise monitoring system represents a complex, "high end" system designed to support performance-based noise conditions of approval in a large project where noise implications are critical. Identification of the source of monitored noise is crucial to its function, and the use of directional monitors represents a large step forward in this regard. Equally important is the integration of noise monitoring data into the site's computer systems, to take advantage of on-site distributed processing and information dissemination.

Based on this experience, two future trends can be predicted. First, "high end" systems will develop even more capabilities for automatic source detection. These would combine directionality with noise signature profiling, and eventually "blind source separation" programs to automatically recover the full audio signal of each independent source. Wilkinson Murray is already undertaking some work on such combined systems.

Second, source-detection capabilities will become available in less expensive "low-end" monitoring systems designed for short-term use. At present the major hurdle to this development is the power requirements of computer systems necessary for real-time data processing. While a standard noise logger can operate for several weeks from a battery power source, systems capable of complex number-crunching can only operate without mains power for less than a day. Nevertheless, where mains power is available, directional monitors have been used successfully in temporary installations. Recent advances in low-power computing may extend the possibilities for battery-powered operation.

The advent of reliable noise monitoring systems with source-detection capability should give regulators and residents more confidence that the noise criteria specified in consent conditions can and will be met. It should also allow operators to demonstrate unambiguously that they are meeting their noise requirements. Both these developments represent a significant step forward in environmental noise control.

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AUSTRALIAN ENVIRONMENTAL NOISE ISSUES

Each of the State Environmental Agencies was invited to provide a short report on recent activities in relation to noise policies and emerging issues.

ACT

Sergei de Bray

The ACT government finalized the **Motor Sports Noise Environment Protection Policy** late 2002. The policy was developed under the *Environment Protection Act 1997* (the Act) to balance the need to provide adequate protection to neighbouring residents from noise with the rights of motor sports enthusiasts to participate in their sport. A number of motor sports venues exist in the ACT that impact to varying degrees on nearby residents and it is not economically practicable to relocate existing venues in the foreseeable future. Having been through a relatively long gestation period, the policy also reflects the need to balance the social, political and environmental aspects in particular 'catchments' affected by motor sport noise.

The policy includes several measures to manage adverse noise impacts including limiting the level of noise, number of events per year, the time when events can take place and spread of events during the year. The policy facilitates the flow of various types of motor sport noise information between Environment ACT (as the regulator), motor sport enthusiasts and those affected by motor sports noise. As well as encouraging better scheduling of noisy motor sport events at regularly used venues, prior notification allows affected residents to better plan their home activities.

A key challenge in the development of the policy has been the incorporation of an event credit system with a feedback loop for the purpose of limiting the total noise load emanating from particular venues each year. Some motor sport organisations have an allocation of event credits that enable them to generate noise exceeding a set limit at a compliance location. For example, one event credit allows an additional 5 dB(A) over the limit on a day and at the maximum end of the scale, four credits allow up to 20 dB(A) over the limit. It should be noted where noise is below the limit the amount of motor sport is not restricted by the Act. With the system having its fair share of complications, regular meetings were convened to assist stakeholders learn from each other to achieve continued improvements implementing the trial policy. The policy will be reviewed within three years to ensure adequate noise management is occurring at the more contentious venues.

A policy for **Outdoor Concert Noise** preceded the motor sports noise policy and similar concepts were used. The policy also includes an event credit system as a mechanism to ensure a balance between community expectations and the protection of environmental noise standards.

Policies on environmental noise may be found via www.environment.act.gov.au

NEW SOUTH WALES

Chris Beasley

The New South Wales EPA shares responsibility for enforcing noise control regulations with local government, the NSW Police and the Waterways Authority. During 2002 we have concentrated on implementing the Government's Environmental Criteria for **Road Traffic Noise** and NSW **Industrial Noise Policy**; continuing development of a policy on rail noise; and providing support for the work of local councils in noise control.

As part of our support for councils, we developed the draft **Noise Management Guide for Local Government**. This guide outlines the legislative framework, field procedures and management strategies for avoiding, minimising and regulating the noise problems commonly encountered by council officers. Selected councils with experience in managing a wide range of noise control issues reviewed the draft in June 2002. We expect to consult all councils before finalising the guide.

In December 2001, we distributed a video called **Managing Rural Noise** to all rural councils. This video examines a range of noise problems commonly experienced by council officers in rural areas.

The EPA also assisted the Roads and Traffic Authority (RTA) to develop its **Environmental Noise Management Manual**, which outlines how to implement the road traffic noise policy. During the year, we participated in enforcement operations with the RTA and NSW Police to reduce excessive noise from vehicle engines and sound systems.

The EPA continued its development of a policy to manage noise from the NSW **rail network**. The policy will provide detailed guidance for assessing and controlling the impact of rail noise. During the year we contacted more than 70 stakeholders from the rail industry, government, councils and environment groups to identify rail noise issues. We also reviewed over 130 technical and policy-related papers to identify world best practice for managing railway noise.

On the national front we contributed to the National Road Transport Commission's review of the Australian Design Rules for motor vehicle noise. Mechanisms for dealing with noise from the brakes of heavy vehicles were also reviewed. We promoted a more effective and practical solution for use by the police and councils to address this problem. The EPA was also a member of a steering committee, commissioned by the Commonwealth organisation EnHealth, to research the effects of environmental noise on public health. The report has not yet been released.

In 2003 we will strengthen noise control by completing a rail noise policy and a guide on neighbourhood noise, and initiating a policy on construction noise. Policies on environmental noise may be found via http://www.epa.nsw.gov.au

SOUTH AUSTRALIA

Jason Turner

The **Environment Protection (Noise) Policy** (draft Noise EPP) will replace the two current Environment Protection Policies (EPPs) relating to noise in South Australia, the Environment Protection (Industrial Noise) Policy 1994, and the Environment Protection (Machine Noise) Policy 1994. This new EPP will provide an up to date response to noise issues and will provide clarity and transparency for industry, local government, planners, authorised officers and the residential portion of the community in securing of compliance with the Environment Protection Act 1993 (the EP Act). A 3-month public consultation period commences at the end of March 2003.

Draft guidelines on **Audible Bird Scaring Devices** are to be released for public comment in conjunction with the draft noise EPP. Managing orchards and vineyards, bird populations, and efforts to scare birds from sensitive production; while not unreasonably impacting upon the quality of life of nearby residents is not a simple matter. Specific guidelines are required for audible bird scaring devices to recognise the unique noise generating characteristics of these devices and the adverse impacts these devices can have on the community.

Guidelines on **Wind Farms Environmental Noise** aim to help developers, planning and enforcement authorities, other government agencies and the broader community assess environmental noise impacts from wind farms.

During 2003, the EPA will be undertaking a number of new projects which will include guidelines for Music Noise, Rural Noise and Rail Noise.

Policies on environmental noise may be found via www.environment.sa.gov.au/epa

TASMANIA

Bill Wilson

Initial legislative control of environmental noise sources was established under the *Environment Protection Act 1973* and the associated *Environment Protection (Noise) Regulations 1977*. The 1973 Act was replaced by a package of planning and resource management legislation in 1993 and 1994. The 1977 regulations are still in force but are currently under review. This review is coupled to the development of an Environmental Protection Policy (Noise). The following legislation is in force: The *Land Use Planning and Appeals Act 1993*; The *Environmental Management and Pollution Control Act 1994*, The *Dog Control Act 2000*; and the *Environment Protection (Noise) Regulations 1977* which provide maximum dB(A) levels for certain types of machinery such as off-road vehicles, heat pumps and chainsaws, permissible distances and hours of operation

The Tasmanian Government is currently developing an **Environment Protection Policy on Noise** in response to the need to improve protection of the acoustic environment. The policy will further the objectives of the Resource Management and Planning System, in particular the objectives of the *Environmental Management and Pollution Control Act 1994*. A Draft Policy has been released for public comment and it is expected that the assessment will be completed by the end of 2003.

This draft policy includes noise emission standards for industry, transport and neighbourhood noise sources and standards for noise sensitive developments such as residences, schools and hospitals. It defines a range of acoustic environmental quality objectives that should, ideally, not be exceeded at specified receptor types. They are not intended to be used directly by regulatory authorities as noise limits for activities or sources. Achievement of the acoustic environmental quality objectives is a long-term goal for all situations, and the objectives serve as an indicator for judging the effectiveness of this policy and other noise control instruments. Planning authorities should take the objectives into account when making planning decisions. The acoustic environmental quality objectives and noise emission standards are based on the most sensitive receptor in the area under consideration and are not dependent on land use zoning.

Current information on ambient noise levels in Tasmania is limited and further analysis and reporting is required to appropriately understand and manage noise. The Tasmanian acoustic environment is not well studied and further research is required.

Directions for management of the acoustic environment include: finalising the Environment Protection Policy (Noise); establishing a program of monitoring of the acoustic environment to support better identification of objectives; and updating monitoring and recording systems to permit greater sharing of noise data among agencies.

Policies on environmental noise may be found via www.dpiwe.tas.gov.au

WESTERN AUSTRALIA

John Macpherson

Environmental noise legislation in Western Australia is primarily administered by the Department of Environmental Protection (DEP) under provisions of the *Environmental Protection Act 1986*. The *Environmental Protection (Noise) Regulations 1997* provide the main regulatory instrument for noise under the Act.

The DEP noise section has three permanent specialist staff, all within its Environmental Regulation Division. The main tasks of the group fall into four areas *Policy development* – noise regulation amendment, transport noise policy, etc; *Environmental impact assessment* – provision of advice to the Environmental Protection Authority (EPA) on noise impacts of new proposals, including town planning proposals involving rezoning of land; *Support* – training, authorisation and technical support for the local government Environmental Health Officers (EHO's), DEP Inspectors and police who deal with day-to-day noise issues around the State; Regulation – preparing approvals and exemptions and advice on appeals.

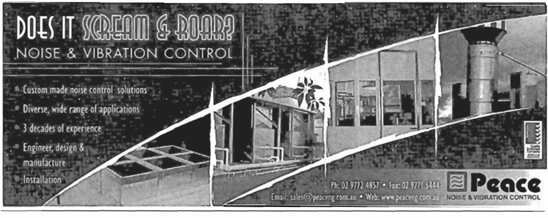
The local government noise complaints **survey results** from 2001/2002 indicated that noise from barking dogs was the most common source of complaints, accounting for over 40% of the total of over 10,000 complaints. Noise from barking dogs is dealt with by local government rangers under the *Dog Act 1975*, which is currently undergoing a major review. Of the non-canine noise sources, radios and stereos were the most common, followed by alarms and sirens, construction noise, power tools/workshops, caged birds, musical instruments and airconditioners. The DEP has produced a brochure for airconditioner installers in a bid to achieve greater compliance at the time of installation.

The **noise regulations** have been in force for 5 years. They regulate noise emitted from premises and received at another premises, by means of assigned noise levels based on the land use zoning. Special provisions are included for agricultural noise, blasting, construction noise, specified equipment on residential premises, bellringing/calls to worship, certain community activities, outdoor events, and an approvals process for persons who believe they cannot reasonably and practicably comply with the assigned levels. A 2-year review of the regulations in 1999 found that, while the regulations were working quite well, some amendments were needed. The issues currently under review include local government essential services such as garbage collection; motor sports; entertainment precincts and priority venues; and the assigned levels for noise received on industrial premises.

In 2002 the WA Planning Commission (WAPC) released a draft Statement of Planning Policy with regard to **aircraft noise** for land use planning around Perth Airport and a final version is expected to be released this year.

Road and rail transportation noise has for several years been the subject of a working group project under the WAPC's Infrastructure Coordinating Committee, aiming to develop a whole-of-government policy to deal mainly with new infrastructure proposals and land use planning adjacent to transport corridors. After engaging an acoustical consultant to review other policies, recommend a policy framework and evaluate the framework under various transport scenarios, the working group is about to commence drafting a policy document for wider discussion.

Policies on environmental noise may be found via www.epa.wa.gov.au



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THE 'A' FREQUENCY WEIGHTING

Ken Scannell

Noise and Sound Services,

Spectrum House, 1 Elegans Avenue, St Ives NSW 2075

1. INTRODUCTION

The 'A' frequency weighting is used extensively in many acoustical noise measurements. Although almost exclusively used, it is often misunderstood or incorrectly defined even by those who would be expected to have a better knowledge. It is commonly stated in glossaries, even in official documents or textbooks on acoustics or noise, as *"a scale that simulates the response of the human ear"* or similar erroneous nonsense.

2. ORIGINS OF THE A-WEIGHTING CURVE

The human hearing system is not as sensitive to all sounds if they vary in pitch or frequency. Generally, the low frequency bass tones (i.e. 50 to 250 Hz) sound slightly quieter than the tones in the mid-audio frequency range (i.e. 1 to 4 kHz). Experiments were carried out by Harvey Fletcher [1] at the Bell Telephone Laboratories in New York, in the early 1930s to determine how loud tones of different frequencies sounded subjectively. A series of curves on a graph were drawn from these experimental results. These become flatter in frequency with higher sound pressure levels and are known as equal loudness contours. From these contours, three curves known as A, B, and C frequency weightings were developed for use in sound level meters. These frequency weightings were specified in an American Standard for sound level meters in 1936 [2]. The 'A' frequency weighting is shown in Figure 1, this approximately follows the inverted Fletcher and Munson 40-phon curve (± 3 dB). The 40-phon curve is based on the subjectively reported equal loudness magnitudes at various frequencies relative to 40 dB at 1 kHz.

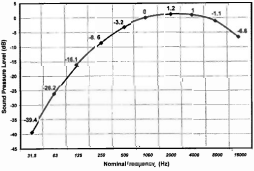

Figure 1. The 'A' Weighted frequency filter relative to 0 dB at 1 kHz.

The symbol for the 'A' frequency weighted sound pressure level, measured in decibels is 'L_{PA}' [3] although the common abbreviation is dBA or dB(A). Either of the two abbreviations could be used but the symbol is preferred as this places the 'A' with the level and not with the decibel, which incorrectly implies there are different types of decibels.

3. LIMITATIONS OF 'A' WEIGHTING

Due to its simplicity and convenience, the 'A' frequency weighting has become popular and it is an often-used frequency weighting for many different noise sources. It is used for all types of noise assessments from occupational noise, building acoustics, loudness assessments and noise annoyance assessments.

The World Health Organization (WHO) [4] has recognised that the 'A' frequency weighting is an overall value which may simulate neither the spectral selectivity of human hearing nor its non-linear relation to sound intensity. Quite wrong and totally misleading statements in glossaries are commonly given for the 'A' frequency weighting such as *"The 'A' frequency weighting adjusts the noise level to the subjective response of the human ear"* or reference is made to *'A-weighted decibels'*, which, of course do not exist and should be expressed as 'A' frequency weighted sound levels in decibels.

Fletcher and Munson derived the original equal loudness curves using only eleven observers who listened to pure tones through headphones. In their paper Fletcher and Munson (1933) stated *"...it would be necessary to increase the size of the group if values more representative of the average normal ear were desired"*.

The equal loudness contours were re-determined under more stringent conditions in 1955 using ninety subjects. The re-determined equal loudness contour curves are similar to the original curves on first impressions but can vary by up to 11 dB in the low frequency (e.g. 100 Hz) range.

Even if the 'A' frequency weighting could be used as a good universal predictor of loudness it is not a good predictor of noise annoyance, particularly for sounds which differ from those which are medium level, broadband mid-audio frequency, and have constant temporal characteristics.

It is often stated that the 'A' frequency weighting follows the 40-phon equal loudness contour. The confusion comes from the fact that there are two sets of equal loudness contours – one from Fletcher and Munson and another from Robinson and Dadson (1956) [5]. The 'A' weighting frequency filter is close to the Fletcher and Munson 40-phon curve but varies by up to 8 dB at low frequencies from the *'more representative'* Robinson and Dadson 40-phon curve. This is a significant difference as it represents close to a 50% change in the perception of subjective loudness. The two 40-phon curves, at the low frequency end of the spectrum are compared to the 'A' frequency weighting in Figure 2.

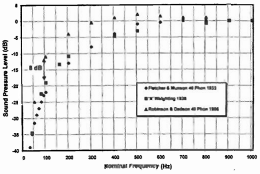

Figure 2. The 'A' Frequency Weighting and the Equal Loudness Contours from Fletcher and Munson and Robinson and Dadson.

Many noise sources in the environment are low frequency. When assessing these noise sources the 'A' weighting frequency filter can be regarded as a high-pass filter with a cut-off frequency (10 dB down point) at about 250 Hz. Hence, where a noise source is dominated by low frequency, the use of the 'A' frequency weighting gives a poor indication of loudness and an abysmal indication of noise annoyance.

Annoyance is multi-dimensional, in fact, at low sound pressure levels the character of the noise (e.g. temporal structure and frequency content) can become, by far, the dominant factor in the annoyance perception. This was clearly shown in research carried out by Scannell [6] where subjects compared a low frequency repetitive impulse noise to pink noise for both loudness and annoyance. Here a character correction of up to 15 dB was found to be required where audible sounds were at a very low sound pressure level but were unpleasant in character.

Scannell found that for annoyance, any penalty added to the objective measurement for a source with unpleasant character must be level dependant with a higher penalty for lower sound pressure levels. The fact that character is more important than the sound pressure level can be realised by considering the simple case of a 'dripping tap' noise when trying to sleep.

The 'A' frequency weighting should be used for occupational noise assessments (except peak noise assessments) because there are *'known'* relationships between the statistical risks of hearing damage and the overall long term 'A' frequency weighted noise exposure level [7].

The 'A' frequency weighting has, unfortunately, never been changed from the 1936 American Standard even though it was based on results where Fletcher and Munson indicated that they were not necessarily representative of the average normal ear. This was later proved to be the case by Robinson and Dadson. Hence the 'A' frequency weighting is not even a rough approximation (i.e. about 50% error) to the response of the human ear at 40-phon.

4. SUMMARY AND CONCLUSIONS

The 'A' frequency weighting is not a scale, it cannot be used to *'establish a human dose response relationship'* and it does not simulate the response of the human ear. The 'A-weighting' should always be described in a glossary as the 'A' frequency weighting to distinguish it from a time weighting. The 'A' frequency weighting must be used for occupational noise assessments but should be utilized with extreme care when an indication of loudness or noise annoyance is required.

A possible improved description of the 'A' frequency weighting is: *the 'A' frequency weighting is used as a rudimentary approximation to the subjective human perception of loudness at low sound pressure levels. There is a known relationship between the statistical risk of occupational hearing damage and the A' frequency weighted exposure to noise. It is however not a good frequency weighting to use when assessing annoyance from noise which is predominantly low frequency (i.e. below about 250 Hz).*

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Book Reviews

Meantone is Beautiful

Reinhart Frosch

Peter Lang AG, Berne, Switzerland 2002. 254 pp. ISBN 3-906769-92-5 (soft cover). Distributor DA Information Services, 648 Whitehorse Rd, Mitcham 3132, Australia, tel 03 9210 7777, fax 03 9210 7788, Price A$100.85 or www.peterlang.net

Because sustained-tone instruments have overtones that are exact harmonics of the fundamental, several musical notes played together produce a "beautiful" sound if their fundamental frequencies are in the ratio of small integers. Thus the ratio for an octave is 2:1, for a perfect fifth 3:2, a fourth 4:3, a major third 5:4, a minor third 6:5, and so on. Unfortunately basic mathematics defeats us if we want to tune the black notes on a keyboard as well as the white notes so that we can play in a variety of keys. Suppose we go for perfect fifths and octaves, then the cycle of fifths C,G,D, ... ultimately appears to get us back to C with all twelve notes tuned, but there is no way in which a sequence of factors (3/2)12 can equal 7 octaves or 27. If it did, then 312 would have to equal 219, but this is impossible since the first is an odd number and the second an even number. Added to this, the major and minor thirds come out wrong by a factor 81/80 or about a fifth of a semitone. The modern solution of equal temperament closes the "cycle of fifths" by flattening each of them by about 0.1% or 1/60 of a semitone, which is hardly noticeable, but this leaves the thirds very little changed and still sounding a bit rough.

The puzzle of finding an optimal solution to this tuning problem has occupied musicians for several hundred years. The most successful tunings were those called "meantone" in which most of the fifths were flattened several times more than in equal temperament so that the thirds were now in tune again. The best of these tunings worked extremely well for keys up to three sharps or three flats and gave beautifully concordant sounding major and minor chords except for just one, usually involving G-sharp or A-flat, which contained the accumulated errors. While such tunings fell out of favour during the nineteenth and twentieth centuries, and were replaced by equal temperament, they are now making a comeback in instruments as diverse as organs, harpsichords, and electronic synthesisers.

This book, subtitled "Studies on Tunings of Musical Instruments", is based on an earlier German edition, which in turn was based upon a lecture series given at the Swiss Federal Institute of Technology. The English version is replete with numerous numerical examples and exercises (with answers) and explores in detail many possible "diatonic", "chromatic" and "meantone" tunings and temperaments and their relation to standard equal temperament. As one may guess from the title, meantone wins the beauty contest, and some psycho-physical reasons are given for this.

While one can learn a lot by reading quickly through the book, it is really designed for more careful study with a pencil and paper at hand, and the large number of numerical tables and examples in the text does not make things easy for the casual reader who might prefer just to be told about general principles. The maths is not at all demanding, just involving simple arithmetic of powers and ratios, and does have the advantage that you will really understand the subject after working through the examples. It would be a good text upon which to base a course for musicology students, if such courses exist.

The purpose of precise tunings is, as the title proclaims, to make the music sound "beautiful". It is therefore a pity that the book is not accompanied with a CD giving examples. For those having access to an appropriate Korg or Yamaha synthesiser, however, details are given of the various just and meantone tunings built into those instruments.

Neville Fletcher

Neville Fletcher is a Visiting Fellow in the Research School of Physical Sciences and Engineering of the Australian National University. He has written widely on many aspects of musical acoustics.

Acoustics of Long Spaces

Jian Kang

Thomas Telford Publishing, London 2002. 251 pp. ISBN 0 7277 30134 (hard cover). Distributor DA Information Services, 648 Whitehorse Rd, Mitcham 3132, Australia, tel 03 9210 7777, fax 03 9210 7788, Price A$175.67 or www.t-telford.co.uk.

This is a comprehensive study of what initially appears to be a narrow topic area, long spaces, in fact covers a wide range of applications. Long spaces include road and railway tunnels, transportation stations, corridors, concourses, urban streets etc. For some of these the goal of the acoustician is to control the 'room' acoustics to provide an environment suitable for communication. For others it is to control the 'pollution' which can be generated in the space. A key feature of long spaces is that the conventional assumption of a diffuse sound field does not apply because of the extreme dimensions.

The first third of the book deals with basic acoustic theories and modelling techniques and the development of acoustic theories for long spaces. The second third comprises design guidance for long enclosures and urban streets and in particular public address systems. The final sections of the book are described as case studies. The detailed findings from a wide range of acoustic treatments on models of a railway station and a railway tunnel are presented. Comparative analysis is detailed from speech intelligibility tests in a long space and in a conventional room. One interesting outcome from this was a difference in speech intelligibility for English, Cantonese and Mandarin with the latter requiring a higher Speech Transmission Index (STI).

While this book goes into considerable detail it is easy to read and very well illustrated. At the end of each chapter is a summary which provides the key outcomes. The book would be of value to acousticians and other professionals involved with the design and construction of long spaces. It is certainly a worthwhile addition to a library.

Marion Burgess

Marion Burgess is a Research Officer in the Acoustics and Vibration Unit of UNSW at ADFA, Canberra. She has a wide experience of many aspects of acoustics.

Dictionary of Noise Pollution and Acoustics Terminology

David Bruce Eager

University of Technology Sydney, 2003, 87 pp. ISBN 1-86365 707 X (soft cover). Distributor Co-operative Bookshops throughout Australia, Price A$12.95

This dictionary is based on a Dictionary of Acoustics, Noise and Vibration published by Eager in 1997 and reviewed in Acoustics Australia 25(3) that year. Eager had noted during his studies the difficulties in finding one comprehensive source of explanations of the terms he came across, and this publication meets that need for today's students. Putting together a dictionary is surely a challenge for one person. Eager should be congratulated on the efforts that have gone into this document and that he has chosen a low-cost publication format, targeting the student market for which the dictionary is particularly suited.

The change in the title better reflects the content of the dictionary as it is focussed on terms related to environmental and occupational noise and deals in only a minor way with the terms associated with architectural and building acoustics and vibration. One feature that will be appreciated by those just getting started is that the explanations are in simple English and with few mathematical symbols and equations. A quick scan through the Dictionary discloses only a few things that could have been better expressed, and it is interesting to skip past the usual terms with which we have become familiar to the ones that are quite specialist. We wonder how many of the readers know (or need to know!) what a Saphe is or what an Incudectomy involves (answers at end of review)!

The new content of the dictionary comprises substantially terms used for environmental noise and there is considerable emphasis on NSW terminology, e.g. Protection of the Environment Act NSW 1997 is included but with no reference to similar legislation in other states; "most affected locations" is included but not "compliance location". An indication should be given that a term is included because it is used in NSW legislation or policy and that other states may use other terms.

This dictionary is certainly a worthwhile purchase for students in the areas of environmental noise, occupational noise and engineering noise control and would also be a useful quick reference for workers in these fields.

[Saphe is phase in the cepstrum domain and Incudectomy is the surgical removal of the incus, or anvil, bone.]

Neville Fletcher and Marion Burgess

Neville Fletcher and Marion Burgess are editors of Acoustics Australia and so read many documents from a range of areas of acoustics.

New Members

Member: Christopher Field (NSW)
Tracey Gowen (NSW)
Richard Haydon (NSW)
Darren Liu (Vic)

Associate: John Channon (NSW)
John Hunter (NSW)
Graham Wilcox (NSW)

Graduate: Mark Novakovic (NSW)

New Products

RION
Vibration Measurement

New to the range of vibration measurement equipment from Rion are the VA-20 machinery fault checker and the VM-52/52A vibration level meters. The VA-20 is a small easy to use meter and is used to diagnose rotating machine faults. The VM-52 and VM-52A meters are used to measure the vibration level and vibration acceleration level of ground or floor simultaneously in all three directions. The VM-52A accepts a memory card for data storage however both models can be connected to a PC via an RS232 connection.

While these new additions to the Rion range fill particular niche needs, other vibration meters such as the VM-63A and VM-82 continue to fill more general needs. The VA-11 vibration analyser is also now available in VA-11C configuration to provide a machine condition monitoring system. This complements the VA-11 and VA-11K vibration analysers.

Further information: Acoustic Research Laboratories. Tel 02 9484 0800, www.acousticresearch.com.au.

BRUEL & KJAER
Sound Level Meter Exchange

We are pleased to announce that for a limited period you can part-exchange your old sound level meter including microphone & calibrator for a new state-of-the-art, real-time noise analyzer and calibrator from Brüel & Kjær. Trade in a calibrator & your old Sound Level Meter for a favourable discount when you purchase your new, state-of-the-art Bruel & Kjaer hand-held, Sound Level Meter.

Measuring Room Acoustics

Brüel & Kjær is the sole worldwide distributor of DIRAC, an acoustics measurement software tool, developed by Acoustics Engineering. DIRAC Room Acoustics Software Type 7841 is used for measuring a wide range of room acoustical parameters. Based on the measurement and analysis of impulse responses, DIRAC supports a variety of measurement configurations.

For accurate measurements according to the ISO 3382 standard, you can use the internally generated MLS (maximum-length sequence) or sweep signals through a loudspeaker sound source. Survey measurements are easily carried out using a small impulsive sound source, such as a blank pistol or even a balloon. Speech measurements can be carried out in compliance with the IEC 60268-16 standard, for male and female voices, through an artificial mouth-directional loudspeaker sound source or through direct injection into a sound system, taking into account the impact of background noise.

Endevco Accelerometer

The new Model 65HT-10, triaxial, High-temperature ISOTRON® Accelerometer uses the latest technology in high-temperature components and processes. The unit's microelectronic circuits are designed specifically for continuous operation at an extended temperature up to +175°C (347°F). Welded in a 10mm cube of titanium, the unit weighs 5 grams. Model 65HT-10 is shockproof, overload protected and has excellent amplitude and phase frequency responses, making it ideal for structural and component testing in automotive test cells, environmental test chambers, and general laboratory applications. The reduced size of this accelerometer enables the test engineer or technician to measure the accelerations of three orthogonal axes of vibration simultaneously on lightweight structures.

Model 65HT-10 provides a high-resolution, low-impedance output. Its dynamic range is 500g. High-temperature cable assemblies are supplied as a standard accessory. Interface to the accelerometer is via a hermetically sealed 4-pin connector.

Noise Calculation Software

ENPro™ is a PC-based software package for the easy modelling, precise prediction, and cost-effective simulation and design of indoor and outdoor environmental noise. It is ISO 9613 compliant and its advanced 3D graphic user-interface tools allow you to quickly model complex noise environments such as directional noise sources, multi-sloped barriers and cylindrical towers.

It can provide cross-sectional and 3D visualisation of a noise map in a geographical area to show noise population exposure and to identify noise problems. ENPro can also quickly calculate future scenarios by identifying their differences from the results of the current scenario. "Scenario comparison" and "source rank" maps intuitively inform you how to effectively reduce noise in both existing multi-source areas and future land development.

For further information please contact your local Brüel & Kjær sales representative.

KINGDOM
Mobilyzer-II Analyser

MOBILYZER-II is a new, superbly engineered, highly sensitive dynamic signal analyser for FFT analysis and applications in vibration and acoustic analysis. It incorporates a new architecture and application of the very successful Sigma Delta A to D Conversion technique to achieve a dynamic range, typically better than 120 dB for either a 40 KHz or 80 KHz band width across 8 to 32 channels depending on the configuration and with a spectral resolution of from 3200 to 25600 lines.

The physical design of the analyser includes a processor case which houses 4 DSP processing modules and a Pentium computer module complete with hard disk. Each of the DSP modules provides 8 input channels (BNC connectors), two wave form output channels (1 BNC & 1 SMB) and two Tachometer input channels (SMB). The SMB (small mini bayonet) connectors are a novel though not new introduction to the vibration and acoustic industry. Fitted with a carrying handle the unit is a very comfortably portable 8 to 32 channel instrument and can be daisy chained in almost unlimited numbers providing in practical terms, an unlimited expansion of the channel count. The DSP processor case connects to a normal Notebook or Desktop computer which runs the application software under all current variations of Microsoft Windows operating system, via 10/100 Ethernet cable through the onboard Pentium computer.

Abacus Analyser

ABACUS - the first DSPcentric signal analysis engine provides precise real time measurements and the ability to create over a thousand channel systems for both noise and vibration analysis. Finally, a single platform that runs all applications through a simple user interface.

ABACUS builds on the new 32 channel Mobilyzer-II and provides the same exceedingly low noise floor. Under some circumstances in the low frequency range, it is possible to configure Mobilyzer-II and ABACUS with a noise floor (Dynamic Range) of better than 150 dB down. ABACUS can be configured nominally up to 1024 channels or more, with separate DSP units inter linked by 100/1000 Ethernet communication and synchronisation.

These new analysers are based on 24 bit processors and will have a very wide appeal for all sorts of Sound and Vibration analyses especially when there is a need to extract sounds or vibrations with very tiny variations or fluctuations or between two noise sources which are widely different in magnitude. The range of instruments provides not only an excellent dynamic range (and other specs) simultaneously for the full bandwidth of 40 KHz, but they also provide high channel-count with synchronized sampling, built-in recording to an onboard hard disk and a comprehensive analysis suite.

Information: Kingdom Pty Ltd
on 02 9975 3272

ACU-VIB
ORCHESTRA Data Acquisition

Orchestra consists of one or several modular multichannel hardware units and dBFA software suite dedicated to real time data recording and frequency analysis. It is a configurable modular system with separate independent modules. Three kinds of modules can be implemented together:

Interface module allowing connection to PC through Firewire interface (IEEE 1394)

Input modules for 4 transducers with direct conditioning and 16 or 24 bits A/D conversion.

Function module adding features like output module for signal out or generator

One Interface unit can manage up to 24 channels and different input modules are available for direct voltage/ICP: Transducers, Microphones, Charge accelerometers, Thermocouple, Strain gage, Tacho sensors etc. Multichannel real-time analysis can be done while recording to a PC Hard Disk. Network and distributed measurements can be performed with several Orchestra systems.

Information ACU-VIB Electronics
Tel: 02 9680 8133, info@acu-vib.com.au, www.acu-vib.com.au

MSC
Actran Vibro Acoustic Software

MSC.Actran is acoustics and vibro-acoustics software currently under a common technological umbrella provided by the finite and infinite element method. Actran provides a rich library of elements, materials, boundary conditions, solution schemes and solvers. Actran is used to solve challenging acoustics, vibro-acoustics and aero-acoustics problems.

Actran has many capabilities including prediction of the sound radiated by complex sound sources and the propagation of sound in ducts, modelling of enclosed sound fields, calculation of the sound transmission through simple or composite partitions. Actran combines all features found in other computational acoustics software programs but offers a wealth of unique features. It is both internally consistent and easy to connect, combine or compare with other major CAE tools. It offers a unique solver for quickly calculating the frequency response function of a damped or undamped system over a large frequency range with an arbitrary frequency resolution. Actran is directly and seamlessly integrated with two major finite element pre- and post-processing software tools: MSC.Patran and IDEAS Master Series.

Information MSC.Software Australia ,
Tel02 9260 2222, Fax 02 9260 2299,
chris.dandre@mscsoftware.com.au
www.mscsoftware.com.au

Letter

Acoustic Tests a Waste of Time and Money or a Valuable Investment?

Some companies manufacturing acoustic products have independent acoustic tests carried out. Is this a valuable investment or are these companies wasting time and money? I pose this question because Pyrotek/Soundguard has undertaken many such tests yet we have a number of competitors who tell acoustic consultants that their product is the same as Pyrotek's without any acoustic tests to support this statement. What could the consultant do?

The consultant could accept this but go no further.

The consultant could accept this and then specify the competitor's product.

The consultant could have specified Pyrotek's products but accept our competitors' product when it is installed and sign off on it to say it complies.

The consultant could accept this and publish opinions that our competitor's product is the equivalent of Pyrotek's.

On what information could consultants make a decision or publish an opinion? If our competitors' products are the same then should they not have to prove it with an independent test? Should we stop investing in testing to prove our products and just say our product complies or is the same as competitors? If this is so then a valuable technical resource for acoustic consultants would dry up as manufacturers invest their resources into other areas. This would then put at risk reputations and businesses. Litigation could result if the end user does not get what was specified and what was paid for. Do acoustic consultants want tested proven products specified for projects? Or is price the only consideration?

Philip Cadwallen, Sales Manager Pyrotek

Meeting Reports

Wespac8 Conference

The Wespac8 Conference, held in Melbourne, 7 to 9 April 9, 2003 has been most successful, with an attendance of over 250 from 22 countries. This was in spite of the difficulties of the timing with respect to International events like the war in Iraq and the concerns about the spread of SARS which led to around 40 last minute withdrawals. An indicator that WESPAC is truly an international event is that the range of countries of the participants extended well beyond the Western Pacific region.

After the three plenary speakers on the first morning there were five parallel sessions for the three days of the conference. Included in these sessions were 6 distinguished papers and 10 keynote presentations each 40 minutes plus over 200 invited and contributed papers each of 20 minutes. It can be said that the papers covered the full range of topics in acoustics including environmental, architectural, psychological, speech, underwater, instrumentation, ultrasonics, sound quality etc. The high standard of the papers and the presentations was a feature of the conference commented on by many of the participants. The full papers are included on the proceedings CD which is available for purchase from the Australian Acoustical Society at www.acoustics.asn.au.

The conference program provided plenty of opportunities for viewing of the technical exhibition, discussion with colleagues and eating – the catering for the tea breaks and lunches was a well appreciated aspect of the conference. The evening function of a visit to experience a country Australian BBQ was included in the registration and a great social event on the first night. The conference dinner was held at the venue on the Tuesday with yet more wonderful food complemented by the wonderful musical performance of the Australian Girls Choir. During this dinner the presentations of the elevation to the grade of Fellow for Marion Burgess, Joseph Lai and Stephen Samuels and of the Inaugural Excellence in Acoustics award, sponsored by CSR Bradford Insulation, to the Musical Acoustics group at the University of NSW (details below) were made.

The success of the conference resulted from the achievement of an ideal balance between the technical content in the formal sessions and the opportunities for informal discussions during the social events. The success is due to the sterling work over the long time of preparation by Conference Chairman Charles Don who was ably assisted by the AAS General Secretary David Watkins and the local organizing committee. The superb preparation by this core team and their spouses (in particular Sheena Don and Carolyn Watkins who, in addition to all the other support manned the registration desk for the duration of the conference) meant that the conference itself went smoothly and was enjoyed by all the participants. At the closing ceremony the challenge to organise Wepac9 in Seoul in 2006 was handed over to the Acoustical Society of Korea.

NSW

Noise from Railway Rollingstock

On 19 February 2003 approximately 45 attended a NSW Divisional Meeting on noise source identification and noise control of railway rollingstock presented by Ross Emslie of Sinclair Knight Merz at National Acoustic Laboratories in Chatswood.

Measurement methods described included sound intensity to discriminate between various noise sources on the locomotive and sound pressure measurements with specific elements (such as the exhaust) isolated with simple building materials. Once the significant noise sources have been identified, noise control methods can be applied to these items including:

- A reactive muffler on the loco exhaust;
- Lined intake plenum and absorptive discharge louvers on the dynamic brake fans;
- Absorptive side panel on the radiator fan;
- Damping and absorptive lining on the engine cab;
- A lined plenum on the TM blower;
- Intake and discharge mufflers on the compressor.

Ross said that a major limitation to be aware of was the Rail Infrastructure Corporation (RIC) requirement that all noise mitigation measures must remain within an identified 'envelope' surrounding the locomotive. Based on the above treatments, noise reductions of approximately 8 dB(A) have been realised at a distance of 15 m from the locomotive. A large amount of locomotive noise emissions is due to structure-borne noise from the locomotive body and attempts to address this include isolating the body from the mounted engine via isolation mounts. Ross briefly discussed some detailed analysis techniques for determining the effectiveness of the isolation, such as mobility tests. Questions related to the amount of further noise reduction that may be achievable and the effectiveness of some of the more abstract measurement techniques (such as the interesting "sound box" technique).

Chris Schulten

Victoria

ISIS Demonstration

At the first meeting of the Victorian Division on Mar 5, George Lazenka and David Cohney from Airplan described and demonstrated Interactive Sound Information System (ISIS). This System was originally designed to simulate various types and level of aircraft noise and now can simulate the noise in a residential street, from very fast and other trains, or from large or small flows of road traffic, etc. Because the demonstration sounds are recorded in stereo, their playback can simulate movement of the sound source and can be calibrated to suit each listening location or room. This System also allows for the realistic simulation of numerous noise-reducing devices and effects and a visual display to illustrate what is being heard.

Louis Fouvy

Future Meetings

ACOUSTICS 2004

The AAS Annual Conference, Acoustics 2004, will be held on Queensland's Gold Coast, November 3rd to 5th. The conference will provide a forum for the presentation of a wide range of papers on all aspects of fundamental and applied Acoustics and Vibrations.

Papers from all areas of acoustics are welcomed. Submitted papers will be peer reviewed, where requested, under the coordination of a scientific advisory panel. A series of workshops will focus on aspects of transportation noise.

The conference will be held at the five star Gold Coast International Hotel in the heart of Surfers Paradise and is just 30km from Coolangatta Airport and 90km from Brisbane Airport. The Gold Coast area offers a diverse range of accommodation options that should suit all styles and budgets.

Information: aas2004@acran.com.au, www.acoustics.asn.au

News Items

EU Noise Directive

The Noise Directive has now been published in the Official Journal of the EC. It is dated 15 February 2003, which means that it will have to be transposed into law by the European countries by 15 February 2006. The text can be found at http://europa.eu.int/eurlex/en/dat/2003/l_042/l_04220030215en00380044.pdf.

VIPAC Acquires ADI Facility

Vipac Engineers and Scientist Ltd (Vipac) recently announced the acquisition of the ADI Environmental Test Facility (ETF) at St Marys NSW, a leading provider of a range of environmental, mechanical test and engineering services. The St Marys ETF complements the test capabilities of Vipac's Melbourne laboratories. The St Marys ETF will continue under the stewardship of John Duffett, former ADI St Marys Test and Evaluation Manager, and Peter Matthews, Vipac's Sydney Operations Manager. The facility will continue, with the same staff, to provide quality services with which clients are familiar.

For more information on the ADI Acquisition, contact Peter Matthews on peterm@vipac.com.au or John Duffet on johnd@vipac.com.au

QLD Occupational Noise law changed

New laws for measuring peak sound pressure associated with occupational noise came into force in Queensland on February 1 2003. The scale has changed from a linear to a C-weighted one which results in more accurate and consistent measurements due in part to better-defined frequency responses. The change ensures consistency with the National Noise Standard, developed by the National Occupational Health and Safety Commission. The amended regulation can be viewed on via www.whs.qld.gov.au.

INCE Membership Offer

INCE/USA has established a special first year bonus to encourage individuals to become new Members or Associates. The fee will only be US$40, less than half the regular annual fee. The supplement applicable to non US residents for air mail of the journal will be reduced to only US$15. The details and the application forms are available on www.inceusa.org.

ISMA 2002 Proceedings Available

The Department of Mechanical Engineering of the Katholieke Universiteit Leuven in Belgium organised ISMA2002 from September 16th till 18th 2002. It was the 27th edition in a series of two-yearly International Conferences on Noise and Vibration Engineering. The technical program included 2 keynote lectures, 10 tutorial lectures and about 270 technical papers and five plenary poster sessions. The full program and the book of abstracts are available on the ISMA website from http://www.isma-isaac.be/publications

Aviation Noise Discussion Groups

The Acoustics Group of Wyle Laboratories, Inc. is hosting several e-mail/online discussion groups focused on the many aspects of aviation noise. The goal of the discussion groups is to provide the aviation community an easy-to-use resource and a system for sharing useful information between airports, communities, consultants, government policy makers, and other professionals involved in the world of aviation noise.

There are currently two separate discussion groups - (1) "Aviation-Noise-Issues," a list focused on the general needs, policies, and studies that relate to aviation noise and, (2) "Sound-Insulation-Issues," a list focused on sharing information focused on planning and implementing sound insulation programs. Participants can opt to receive individual messages as they are posted or they can receive a daily or periodic digest in a single message at the interval they select.

In addition to the two discussion groups, Wyle currently hosts two additional "announcement" mailing lists "Aviation-Noise-Issues-Announcement" and "International-Aviation-Noise-Announcement." These lists are intended for professionals in the aviation community who only want to receive occasional mailings and stay informed on current issues and trends in the field of aviation noise. Note that these lists are "announcement only" lists - they don't provide a mechanism for members to get involved in online or e-mail discussions. "Aviation-Noise-Issues-Announcement" is intended to focus on the particular issues related to U.S. airports, while "International-Aviation-Noise-Announcement." focuses on the needs, policies, and requirements of non US. airports.

To signup go to www.wyleacoustics.com and follow the links to Noise Bulletins - Newsletters - Discussion Groups.

Excellence in Acoustics Award

The winner of the inaugural Excellence in Acoustics Award was announced at Wespac8 in Melbourne by Neville Taylor, State Manager for the sponsor CSR Bradford Insulation. The award aims to foster and reward excellence in acoustics and entries are judged on demonstrated innovation from within any field of acoustics. Two finalists were selected from the first round of submissions. The judging panel of representatives from the Australian Acoustical Society and CSR Bradford Insulation were presented with a massive challenge to select the winner. "Both projects were of extremely high quality and it was a difficult decision to make," Guy McGrath, Group Marketing Manager, CSR Bradford Insulation said "The winning project exhibited a very high standard of overall excellence and clearly demonstrated innovation and creativity in acoustics. It also has a breadth of future applications".

First prize was awarded to the Music Acoustics Group from the School of Physics at the University of New South Wales for their project 'Flute Acoustics: New Understanding And New Tools For Musicians'. This project led from the discovery of a novel technique for the measurement of acoustic transfer functions with high accuracy, broad dynamic range and high speed. An expert system to rank all possible notes on the flute, according to their degree of difficulty. A flexible 'musician friendly' web service was then developed to provide easier, better ways of playing difficult passages and chords. This has achieved great success already, with constant hits from both local and international musicians.

Accepting the major prize of a plaque and $2,500 Joe Wolfe announced that the money would be used to create a one-off vacation scholarship to assist a final year honours student in research for their science degree. The plaque is of clear acrylic contemporary design, with a frosted angled side and the AAS logo engraved on the back. Joe said that it would be mounted in a prominent position in the Group's working area.

CSR Bradford Insulation has advised that it will continue to support an award for Excellence in Acoustics and the application details will soon be available from www.acoustics.asn.au.

Diary...

2003

18-23 May, CAIRNS
21st ARRB and 11th REAAA Conference
Transport - our highway to a sustainable future
http://www.arrb.com.au/conf21

19 - 21 May, NAPLES
(Euronoise 2003).
DETEC, University of Naples Federico II, P. le Tecchio 80, 80125 Napoli, Italy, Fax +39 81 239 0364, http://www.euronoise2003.it

16 - 18 June, CADIZ
ACOUSTICS 2003
Third International Conference on Modelling and Experimental Measurements in Acoustics
http://www.wessex.ac.uk/conferences/2003/acoustics03/index.html, rgreen@wessex.ac.uk

18-20 June, BRISBANE
2003 National Environment Conference
Environmental Engineering Society (IEAust)
www.eesq.com.au, dgaudie@ieaust.org.au

23-25 June, CLEVELAND
NoiseCon 03.
INCE Business Office, Iowa State University, 212 Marston Hall, Ames, IA 50011-2153, USA, Fax +1 515294 3528, www.inceusa.org, ibo@ince.org

29 June — 3 July, ROTTERDAM
8th ICBEN Congress – Noise as a public health problem
www.icben.org

7-10 July, STOCKHOLM
ICSV 10
Fax:+46 8 661 91 25, icsv10@congrex.se
www.congrex.com/icsv10

14-16 July, SOUTHAMPTON
8th Int Conf Recent Advances in Structural Dynamics
http://www.isvr.soton.ac.uk/sd2003/

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

1-4 September, GENEVA
Eurospeech 2003.
SYMPORG SA, Avenue Krieg 7, 1208 Geneva, Switzerland, Fax: +41 22 839 8485, http://www.symporg/eurospeech2003

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

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

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

2004

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

04 - 09 April, KYOTO,
18th International Congress on Acoustics (ICA2004).
http://ica2004.or.jp

03 - 07 August, EVANSTON
8th Int Conf of Music Perception and Cognition.
School of Music, Northwestern University, Evanston, IL 60201, USA, http://www.icmpc.org/conferences.html

24 - 27 September, PRAGUE
Inter-Noise 2004.
I-INCE, Herrick Laboratories, Purdue University, West Lafayette, IN, USA, Fax: +1 765 494 0787, www.i-ince.org

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

WWW Listing
The ICA meetings Calendar is available on http://www.icacommission.org/calendar.html

FASTS

The AAS is a member society of the Federation of Scientific and Technological Societies (FASTS). The following items are extracted from the March Newsletter which can be accessed from the www.FASTS.org.

The President, Chris Fell and Executive Director, Toss Gascoigne met with Minister Ian Macfarlane to discuss the FASTS' proposal to establish 100 postdoc positions in industry. Australian industry has been very slow to invest in R&D, and an incentive program similar to that offered by the government of Singapore might demonstrate the value of research to industry. FASTS' proposal is for the Government to support the employment in private industry of new PhD graduates over the first two years of their employment. After the two years, the company would be free to offer continuing employment to the graduates. FASTS discussed the idea with people from industry and that helped tighten up aspects of the proposal. The meeting with Industry Minister Ian Macfarlane was encouraging. He showed healthy scepticism about the benefits of our proposal but he could see the benefits of breaking down the cultural barriers between research and industry, and encouraging industry to make use of research to improve existing products and create new ones. It may result in changes to existing support programs or the creation of a new program. But an important component in the arguments we put to the Minister was the fact that FASTS had sought the views of people in industry.

Professor Snow Barlow has been elected President-elect of FASTS. He will join the Executive immediately, and begin his two-year term as President in November 2003. Associate Professor John O'Connor of the University of Newcastle is the other new member of the FASTS Executive. He was elected to the position of Secretary.

In January, FASTS launched a campaign to end the use of the word 'boffin' in media headlines. Professor Chris Fell said that 'boffin" was a jaded word which bordered on the offensive for many scientists. "It conjures up images of weird old men in flapping lab coats, pouring strange chemicals into test-tubes, like Doc Brown in the 'Back to the Future' movies. The term reinforces a negative perception which stops people seeing the value of science. It inhibits young students looking at science as a possible career." "The true picture is vastly different. Science is lively, useful and generates wealth. It's about finding solutions to problems and creating new industries and new jobs. Every new industry created in Australia this century will have a basis in science and technology. Every environmental problem we have in Australia - water, global warming, rampant weeds, salinity - has a solution that begins with science."

TOP TEN ISSUES: FASTS

1. Australia needs a plan for science and technology?
2. Boost funding for university science
3. Enhance industry - meet half the cost of employing new PhD graduates
4. Bring on "backing Australia's ability"
5. Universities to pursue individual excellence in teaching and research
6. Encourage industry to be inventive - give tax breaks for research,
7. Scientists in parliament
8. Equal HECS for science and mathematics teachers
9. Venture capital for new industries
10. Implementing national research priorities.

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* Payment of annual subscription
* Proceedings of annual conferences

General Secretary
AAS– Professional Centre of Australia
Private Bag 1, Darlinghurst 2010
Tel/Fax (03) 5470 6381
email: watkinsd@castlemaine.net
www.acoustics.asn.au

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AAS - NSW Division
Professional Centre of Australia
Private Bag 1,
DARLINGHURST 2010
Sec: Ken Scannell
Tel (02) 9449 6499
Fax (02) 9402 5849
scannell@rivernet.com.au

AAS - Queensland Division
PO Box 760
Spring Hill Qld 4004
Sec: Rebecca Donovan
Tel: (07) 3367 3131
Fax: (07) 3367 3121
rebecca@ronrumble.com.au

AAS - SA Division
C/–Department of Mech Eng
University of Adelaide
SOUTH AUSTRALIA 5005
Sec: Simon Hill
Tel: (08) 8303 5469
Fax: (08) 8303 4367
simon.hill@mecheng.adelaide.edu.au

AAS - Victoria Division
PO Box 417
Collins St. West
PO MELBOURNE 8007
Sec: Elizabeth Lindqvist
Tel (03) 9925 2144
Fax (03) 9925 5290
elindqvist.gharding@projectx.com.au

AAS–WA 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

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

PRINTING, ARTWORK

Scott Williams
16 Cronulla Plaza
CRONULLA 2230
Tel (02) 9523 5954 Fax (02) 9523 9637
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