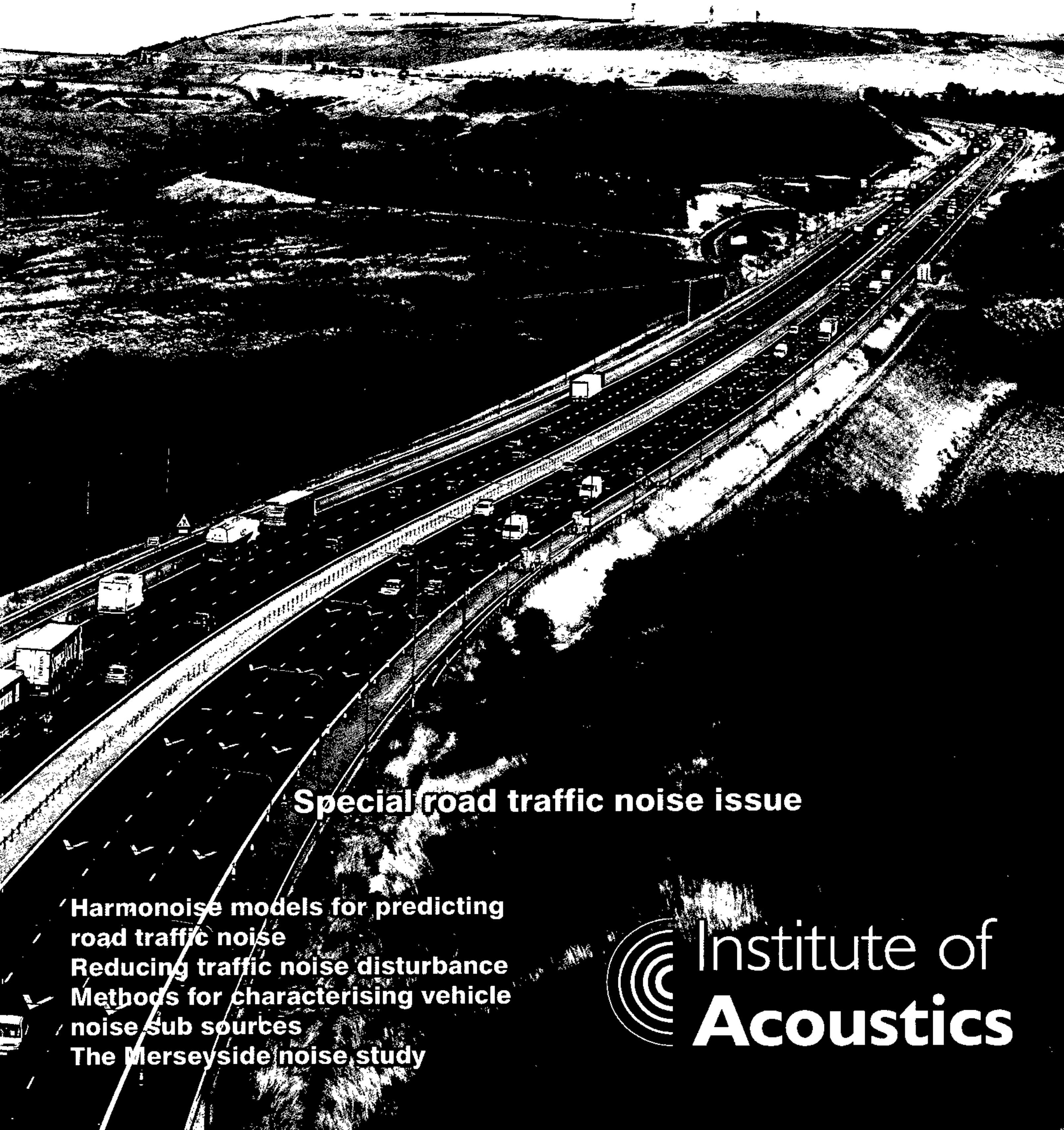
Acoustics BULLETIN

VOL 30 No5 Sept/Oct 2005



Special road traffic noise issue

- Harmonoise models for predicting road traffic noise
- Reducing traffic noise disturbance
- Methods for characterising vehicle noise sub sources
- The Merseyside noise study

Institute of Acoustics

Acoustics BULLETIN

Vol 30 No 5 Sept/Oct 2005

CONTACTS

Editor:
I F Bennett BSc CEng MIOA

Associate Editor
J W Tyler FIOA

Contributions, letters and information on new products to:
Ian Bennett, Editor, 39 Garners Lane, Stockport SK3 8SD
Tel 0161 487 2225 Fax 0871 994 1778
e-mail ian@acia-acoustics.co.uk

Books for review to:
S R Peliza MIOA, Institute of Acoustics, 77A St Peter's Street, St Albans, Herts AL1 3BN

Advertising:
Advertising enquiries to
Dennis Baylis MIOA, Peypouquet, 32320 Montesquiou, France
Tel/Fax 00 33 (0)5 62 70 99 25
e-mail dbioa@hotmail.com

Published and produced by:
The Institute of Acoustics, 77A St Peter's Street, St Albans, Herts AL1 3BN
Tel 01727 848195 Fax 01727 850553
e-mail ioa@ioa.org.uk
Web site http://www.ioa.org.uk

Designed and printed by:
Russell Purvis, Designs for You, Oak Court, Sandridge Business Park, Porters Wood, St Albans, Herts AL3 6PH

Production Editor:
Ann Satchell CamDipPR

Origination:
Norman Simpson

Annual subscription (6 issues) £110.00
Single copy £20.00

Contents

Institute of Acoustics

The Institute of Acoustics was formed in 1974 through the amalgamation of the Acoustics Group of the Institute of Physics and the British Acoustical Society and is the premier organisation in the United Kingdom concerned with acoustics. The present membership is in excess of two thousand and since 1977 it has been a fully professional Institute. The Institute has representation in many major research, educational, planning and industrial establishments covering all aspects of acoustics including aerodynamic noise, environmental, industrial and architectural acoustics, audiology, building acoustics, hearing, electroacoustics, infrasonics, ultrasonics, noise, physical acoustics, speech, transportation noise, underwater acoustics and vibration. The Institute is a Registered Charity no 267026.

Dear Members

The Institute's conference programme resumes after the summer interlude with the Autumn Conference 'What noise annoys' and Reproduced Sound 21 'Feedback to the future'. Both are confidently expected to maintain the high standards and popularity of the Institute's conferences, so book early to avoid disappointment. Looking further ahead, our next Spring Conference 'Futures in Acoustics, Today's research – Tomorrow's careers' places emphasis on contributions from students and young practitioners. Have you been thinking about offering a paper for an Institute conference but haven't quite got round to it? If so, this might be your ideal opportunity, but you will need to get your abstract to Linda Canty before the deadline of 7 November 2005.

At its July meeting, Council returned to discussing means of improving the Institute's engagement with our younger members and benefited from a constructive critique from Anne Carey in her first report as our Young Members' Representative for 2005/6. Among Anne's suggestions was the creation of a student group that could be responsible for arranging its own meetings, act as a point of contact for students wanting to learn more about the Institute and to participate in our activities, and that could be directly represented on Council. Anne also provided some interesting perspectives on other issues affecting young members, such as recognising that some young members feel nervous about participating at meetings, the advantages to be gained from a support and discussion network involving interaction between younger and older members, and the benefits of having more young members on our committees. We hope this autumn's fresh drive to attract new student members, together with the theme of the 2006 Spring Conference, will enable us soon to make significant progress in some of these areas. If you would like to communicate your views directly to this discussion, please don't hesitate to contact me at tonyjonesioa@hotmail.com or Anne at annecarey@hotmail.com or by correspondence via the Institute's office.

In November, we will be convening the biennial meeting of the Chairs and Secretaries of our Regional Branch and Specialist Group committees. One of the new subjects we will discuss is the use of our Specialist Group network to improve the co-ordination of Institute representation on BSI and other external committees. If you have fresh ideas for your Branch or Group activities, then please communicate them to your representatives. Of course, by doing so, there is a risk that you'll be invited to join the committee – young members will be particularly welcomed!

Tony Jones

Tony Jones
President

Developments in Noise Research

National Motorcycle Museum, Birmingham

***Bernadette McKell* and *Colin Grimwood* report on this meeting, which was held on 24 May 2005 and arranged by the Environmental Noise Group in conjunction with Defra. It was held in support of Noise Action Week, organised by NSCA**

The morning session was chaired by **Bernadette McKell** (Hamilton & McGregor). In the first presentation, **Paul Bassett** (Hepworth Acoustics) looked at producing an up-to-date database of noise emissions from equipment used on construction and open sites. An existing construction plant noise database is contained in Annex C, Part 1 of British Standard 5228, *Noise and vibration control on construction and open sites*.

The project's objective was to obtain measurements of noise from plant and equipment currently used on construction and open sites in the UK, and to prepare a database of the information. As well as obtaining data for equipment put into operation since the publication of BS 5228 in 1977, the database has been extended by including octave band noise levels, and also data for plant used on waste disposal (landfill) sites.

The data were obtained by field measurement for items of plant in actual use on construction and open sites in the UK. During his presentation, Paul showed some interesting pictures of various items of plant in operations while noise measurements were being taken.

This database is presented with the intention that it may be useful to the practitioner, as it represents a recent inventory of construction noise sources. The full report is available from the Defra website at *http://www.defra.gov.uk/environment/noise/research/construct-noise/constructnoise-database.pdf*

Andy Moorhouse (University of Salford) followed with a presentation on the research to develop a methodology for assessment of low frequency noise (LFN) complaints. Andy explained that the problem was recognised in many countries, caused severe suffering and complainants often described the noise as sounding like 'idling diesel engine', or 'rumbling'.

He went on to say that the investigation of low frequency noise complaints often leads to prolonged contact with EHOs, but unfortunately there was a low success rate in resolving cases with often no cause being found. The research aimed to recommend a method for assessing low frequency noise suitable for use by Environmental Health Officers in the UK.

Andy then went on to provide a project overview, full details of which are provided on the Defra website *http://www.defra.gov.uk/environment/noise/research/lowfrequency/index.htm*

In summary, the research concludes with a proposed criteria and procedure for assessing LFN and also provides a methodology through which local authorities can assess LFN complaints.

The proposed criteria require that measurements should be taken with the microphone in an unoccupied room where the complainant says the noise is present (even although the person taking the measurements may not be able to hear the sound). The L_{eq}, L_{10} and L_{90} in the third octave bands between 10Hz and 160Hz should be recorded. If the L_{eq}, taken over a time when the noise is said to be present, exceeds the reference values identified in the research, it may indicate a source of LFN that could cause disturbance.

The character of the sound should be checked if possible by playing back an audio recording at amplified level. If the noise occurs only during the day then 5dB relaxation may be applied to all third octave bands. If the noise is steady then a 5dB relaxation may be applied to all third octave bands. Further information on what is considered to be steady noise is provided in the full report published on the Defra website.

Developing coping strategies

Following on the theme of low frequency noise **Geoff Leventhall** (consultant) discussed his research in developing coping strategies for LFN. He explained that, as already described in the previous presentation, LFN investigations are very often unsuccessful. So what then happens to sufferers? Leave them to get on with poor quality of life? Suggest alternative help?

Geoff explained that the nine subjects who took part in the research (two working, seven retired) were asked to complete an LFN reaction questionnaire (adapted from a tinnitus reaction questionnaire). This comprised 27 questions related to what the noise does to the recipient, and the responses were assessed on the basis of a five point scale from 'not at all' to 'most of the time'. Personality types were also assessed. Geoff explained the use of psychotherapy techniques such as reassurance, explanation, and support, relaxation therapy techniques, general stress management advice and exercises (coping skills), and relaxation techniques.

The work to date has concluded that the subjects were helped by talking to each other, learning relaxation techniques, learning to defocus and reducing anger/resentment, all of which assisted the sufferer in taking greater control. It was hoped that this research would also result in strategies for management of LFN problems, the development of a training programme for EHOs, and personal advice for sufferers. A review of published research on LFN and its effects can be found at *http://www.defra.gov.uk/environment/noise/research/lowfrequency/pdf/lowfreqnoise.pdf*

The last presentation of the morning session, by **Stuart Dryden** (Rupert Taylor), looked at the review of existing codes of practice, *ie* Noise from Ice-Cream Van Chimes etc; Noise from Model Aircraft; and Noise from Audible Intruder Alarms.

The research set out to review the 1982 codes of practice to assess their usage by LAs, LPAs, and other organisations in terms of effectiveness in their current form and currency. It also set out to investigate the 'adopted' status in respect of the effectiveness, if any, that this accords the codes and the extent to which a code of practice has to be adopted for it to be useful.

Stuart outlined the project research strategy and reported that, in summary, the Noise from Ice Cream Van Chimes Code was widely used and regarded as effective, with its Code of Practice status regarded as of value. The updates required are confined to references and best practice. Some 45% of respondents use the Noise from Model Aircraft code, and 60% of them think it effective, and that its Code of Practice status helps. The main substantive change would be to address gas-turbine powered models. Updates and additions are needed to existing references, 'best practice' needed updating, and an Appendix summarising the key points was urged.

Finally, in relation to the Code of Practice on Noise from Audible Intruder Alarms 1982, Stuart discussed implications of the

Clean Neighbourhoods and Environment Act 2005 (CNAE) and further explained that policy decisions are required in respect of compulsory alarm maintenance contracts for homes, establishing database for current non-registered alarms and compulsory registration for all or some classes of premises. He also reported other matters for review, including clarification of requirements for warrants (although some questions as to whether or not still required post CNAE) and bringing provisions of NSNA into force. It is possible that this COP will become less important as the CNAE Act is adopted.

Defra research plans

The afternoon session, chaired by **Colin Grimwood** (Casella Stanger), opened with an overview of *Defra: Current Research Plans,* presented by **Richard Perkins** (Defra Contract Research Manager). He explained how Defra research is intended to provide support in two policy areas, environmental noise and neighbourhood noise. Every paper presented during this one-day meeting was in fact the result of Defra or devolved government funded research.

Richard discussed the research procurement process and reminded delegates that the Defra research list can be found on the Defra website which is regularly updated. For those wishing to express an interest in undertaking research for Defra the latest research list can be found at: *http://www.defra.gov.uk/environment/research/2005/eprn0506.pdf*

The second paper, on *The development and production of a guide for noise control from laminate and wooden flooring*, was given by **Tim Waters-Fuller** (Napier University), who explained the extent of the problem of impact sound transmission. He highlighted results from a series of sound transmission tests showing the performance of timber and concrete floors with and without a laminate surface finish. Further results were presented showing the improvements obtained using underlays and carpet.

The main outcome from the research were recommendations for the content of a Good Practice Guide as well as the need for further research on what might constitute an excessive level of impact noise. There was a need to engage the manufacturers of laminate flooring in the search for a solution to a growing problem. More details are available at: *http://www.defra.gov.uk/environment/noise/research/hardfloors*

The next paper, given by **Bill Davies** (Salford University), concerned *A review of methods for assessing noise from pubs and clubs*. The project had been carried out in conjunction with Hepworth Acoustics and Bill's presentation engaged delegates with tempting pictures of the outside and inside of pubs as well as references to the infamous 'volume setting 11' of Spinal Tap. This research produced a shortlist of possible approaches that could be used to develop a robust assessment method for entertainment noise. It is hoped that Defra will fund a second phase of this work where laboratory and field investigation could be combined to develop a preferred assessment method. The Clean Neighbourhoods and Environment Act 2005 extended the Noise Act 1996 so that local authorities will have wider powers to control night-time noise from licensed premises. It is possible that this research could help develop a suitable method of assessment for excessive noise at night.

Industrial noise mapping

The final paper of the afternoon session was given by **Bernadette McKell** (Hamilton & McGregor) on the topic of industrial noise mapping. Bernadette explained how, under Scottish executive funded research into *The Facilitation of Strategic Noise Mapping For The Environmental Noise Directive,* an automated methodology for the identification of industrial noise sources had been developed. She explained that, in the absence of a strategically workable prediction methodology for measurement or prediction of industrial noise, it will be necessary for the foreseeable future to undertake END assessment of industrial noise based on recommendations contained within the WG-AEN Good Practice Guide.

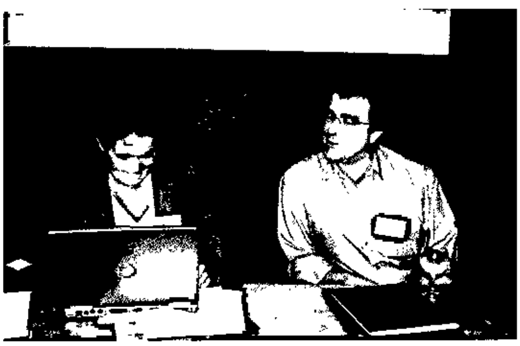
http://europa.eu.int/comm/environment/noise/best_practice_guide.pdf

To assist in the automation of the mapping process an enhanced approach making use of existing, nationally available GIS datasets has been adopted. It involves creating a database of all buildings extracted from the OS MasterMap dataset. Building use is then inferred using a variety of other datasets in an automated way.

As a result it will be possible to identify buildings where there is a high probability of commercial/industrial use (and as a by-product, buildings which will be receptors of noise). These building uses are then further refined, using standardised (national) land use datasets, business directories and other sources, to identify noise-producing uses. The strength of this alternative approach is that it makes use of existing datasets to infer building use at a level of detail that is required for acoustic modelling, while not requiring the high level of intervention required for a detailed study.

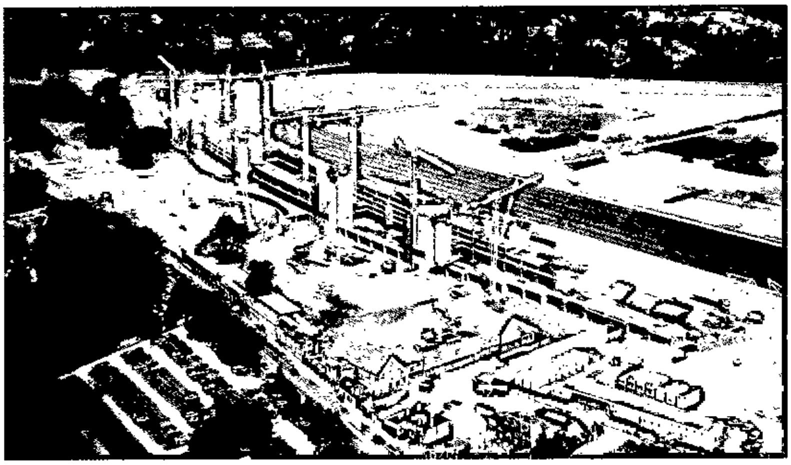
Although all uses are inferred it is believed that the overall result would be more than adequate for the purposes of strategic mapping. Furthermore, the process will be consistent across the whole country and can therefore be relied upon to give a comprehensive overview of all areas to be mapped. The production of a detailed and comprehensive database of building uses will also be much easier for competent authorities to check, where the alternative is to tell them to create a dataset from scratch. The full report should be available on the Scottish Executive website in the near future.

Planning and Noise: PPS24



The meeting report from this one-day workshop, held in London on 1 July 2005, has been held over owing to lack of space. However, the photographs give a quick impression of this very well attended event, and serve to prove to certain members that your Editor, pictured here with Sarah Radcliffe from consultants Peter Brett Associates, does actually get 'in front' of the camera sometimes!

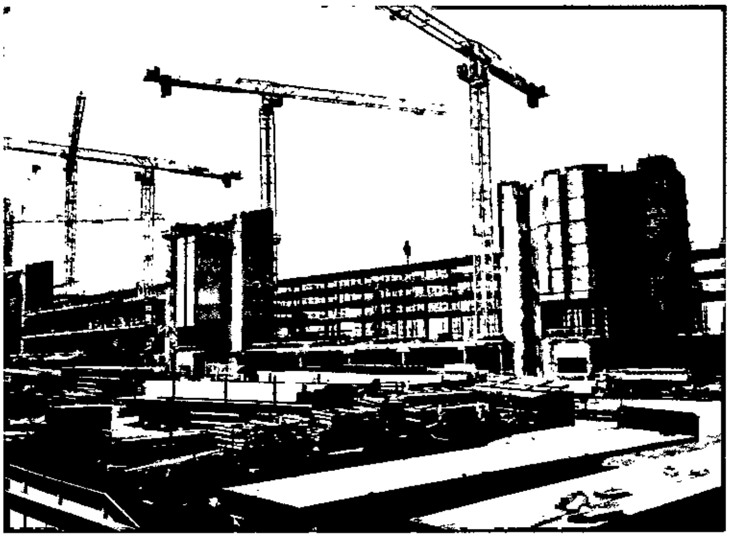
London Branch reports



Above: informative presentations covered environmental noise and planning; architectural acoustics and sound system design
Left: an aerial view of Ascot Racecourse, under redevelopment

£185m revamp for Ascot Racecourse

Development priorities include environmental noise and acoustic issues



From the start of this £185 million project, which incorporates a stunning contemporary grandstand, acoustics have been an architectural and design priority

The London branch's final meeting prior to our two month summer break was a half-day visit in late June to Ascot Racecourse. The site is currently being re-developed and when completed will include a stunning contemporary grandstand blended with listed buildings, greatly improved back of house facilities and access tunnels, a centrally located 9000 seat Parade ring and a re-aligned track with new underpasses providing the horses with a means of getting round the track without crossing the road! The £185m project will be completed within 14 months, so that the venue is open in time for the return of the Queen to Royal Ascot in June 2006.

Our day started with a walking tour of the site, conducted by Steve Jones (Capita Symonds), taking in the 'South lands' which covers the Royal Enclosure Lodge, Gilly's Yard and the (unfortunately empty) Stables. The tour then continued on the other side of the busy high street on the site proper where the construction of the main grandstand, parade ring and new track could be viewed. A few very pleasant minutes were spent standing in the sun while Steve gave a brief overview of the layout of the site and typical race day facts and figures.

Meeting complex acoustic and accommodation needs

We were then treated to two sets of very informative presentations, the first covering environmental noise and planning and the second concentrating on architectural acoustics and sound system design.

Steve began by running through artist's impressions of the new buildings etc. and explained some of the complications and solutions for dealing with accommodation and acoustics at a venue with such hugely varying populations on any one day.

He then passed over to Simon Kahn (Capita Symonds) who took us through the environmental noise design. Stuart Dryden (Rupert Taylor Associates) concluded the session with a description of the environmental noise requirements and planning process issues.

Acoustic design - an architect's perspective

After tea and biscuits, the baton passed to Alex York (HOK Sport+Venue+Event), senior architect for the project, who showed us the final designs of the new grandstand and parade circle and provided an architect's view on the importance of good acoustic design from the start of a project. Some time was then spent focussing on the materials being used to treat surfaces in different areas of the grandstand and the audience had the opportunity to study samples for themselves in more detail.

Alex was followed by the operations director, Ronnie Wilkie, who officially welcomed the IoA to Ascot and provided us with an interesting insight into its workings with an overview of operations.

Finally, Simon showed a small sample of the many acoustic models which have been made of the site (internal and external) and described the design variations in the sound system across the site and within the buildings.

The meeting attracted 30 attendees of whom approximately two-thirds were acoustic consultants or retired consultants and one-third were from local authorities. The London branch would like to thank Ascot Racecourse Ltd for its warm welcome and hospitality and all the people who gave up their time to organise the day and make presentations.

Anne Carey
Secretary, London Branch

Human Response to Vibration
measure, assess and regulate

Our May evening meeting drew an exceptionally large crowd for a presentation by Dr Gurmail Paddan from the Royal Navy Institute of Naval Medicine. The subject was clearly topical, no doubt due to the imminent publication of the Control of Vibration at Work Regulations 2005 (note that these regulations have since been passed in Parliament and came into force on 6 July 05).

The scale of the problems associated with vibration exposure was introduced by providing figures of those estimated by the HSE to be at risk from either excessive exposure to Hand-Arm or Whole-Body vibration. This was followed by a summary of equipment known to be sources of exposure and the potential effects if left unmanaged. Typical sources of Whole-Body vibration included the well-known examples of tractors and military tanks. Those for Hand-Arm vibration included the less well-known examples of mortuary hand tools used to saw through bones during post-mortems!

Characterising vibration

Whilst we were still wondering whether vibration was the greatest hazard you needed to worry about in such a place, Gurmail proceeded to explain how to characterise vibration (magnitude, frequency, direction and duration) and how to carry out an assessment of the risk. For Whole-Body, this included a summary of the Comfort Rating Scale and examples of suitable monitoring equipment were shown. For Hand-Arm exposure, diagnosis techniques for health surveillance were introduced, followed by some good tips for management techniques to control any hazards identified.

The last section of the presentation was concerned with the standards and guidelines available, both in the UK and internationally. A brief history was presented, before Gurmail turned his attention to the Physical Agents (Vibration) Directive 2002/44/EC (PA(V)D). Finally, the draft Control of Vibration at Work Regulations 2005 (which have since been passed in Parliament and came into force on 6 July 05) were explained, along with a comparison of the changes compared to the relevant British Standards and the PA(V)D.

After an extended questioning session, most of us decamped to the local hostelry as is traditional to test Gurmail's theory that alcohol consumption can lead to an altered blood flow rate! Our appreciation is extended to Gurmail for agreeing to address the London Branch on this most topical of topics.

Anne Carey
Secretary, London Branch

North-West Branch
Procedure for assessing low frequency noise complaints

On 24 May 2005 Defra (Department for Environment Food and Rural Affairs) published three reports prepared by the University of Salford on the assessment of low frequency noise complaints. During a topical and well attended July meeting, Dr Andy Moorhouse (University of Salford) presented the contents of the reports, carried out by him together with colleagues, Dr David Waddington and Dr Mags Adams.

The most significant outcome is a set of guidelines, published on the Defra and CIEH websites, giving comprehensive guidelines to local authorities for assessing complaints about low frequency noise (LFN). Andy outlined this procedure and also reported on the results of case studies and laboratory tests from which the procedure was derived, and the results of field trials in which the procedure was 'road tested' by a number of local authorities on 'live' LFN cases. There was also a chance to listen to some real low frequency sounds.

Most local authorities in the UK have experienced complaints about LFN and, in the past, such cases have been notoriously difficult for Environmental Health Officers to deal with, so as expected there was considerable interest from EHOs with many questions afterwards.

http://www.defra.gov.uk/environment/noise/research/lowfrequency/pdf/nanr45-procedure.pdf

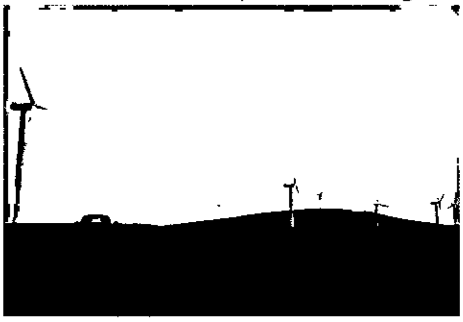
Forthcoming Institute meetings

Wind farm noise

20 September 2005

Many countries are facing energy problems. The introduction of wind turbines is one of the solutions to reducing dependence on fossil fuels. However, there continues to be much debate, especially in areas where wind farms are planned close to housing, with regard to the possibility of noise problems generated by these installations.

At the present time there are 200 wind farms in the UK in the process of being



applied for or under appeal, of which about three-quarters are in Scotland or northern England.

The Institute of Acoustics' meeting in Edinburgh will discuss the background to wind energy developments, how noise is generated by wind turbines, background noise and planning conditions.

There will be a mock public enquiry involving views from a reporter/inspector, a developer, the local authority and witnesses. The essential debate is about what methods should be used to assess Wind Farm noise.

The meeting will conclude with a workshop discussion on topics including wind shear and 'the van den Berg effect', vibration and frequency noise.

Autumn Conference to ask 'What noise annoys?'

18 and 19 October 2005

In an increasingly noisy society, we are all affected by noise, whether it be at home, in our place of work or at play.

The 2005 Autumn Conference will be held at the Oxford Hotel, Wolvercote and organised by the Institute's Measurement and Instrumentation Group. The theme concerns any form of noise which needs reduction or alteration in order to achieve a quieter local environment.

Topics including current and pending environmental legislation, methods involving prediction and measurement, and an improved understanding of sound propagation will be covered in four sessions. The conference will have an international flavour with leading experts from France, Greece, Germany and Denmark. There will also be an audience-participation workshop on the first evening dealing with the perception of tonal sounds.

Hear Ye, Hear Ye

26 October 2005

Noise at work will be a hot topic for the next few years. New regulations will be implemented in 2006 with reduced action levels and the focus will be very much on reducing noise at source.

Those eager to find out the latest news on good practice in reducing noise will therefore not want to miss the Institute of Acoustics' one-day meeting, also to be held in Oxford. The event is organised by the Institute's Noise and Vibration Engineering Group in support of European Week for Safety and Health at Work which this year has a noise theme.

The best way to protect individuals is by engineering noise out, but how can the principles be applied in any particular industry? When an inspector calls, how can an employer show that enough has been done? The meeting will address these issues.

The day will include a speaker line-up from HSE, industry, consultancies and academia. It will also include a discussion of HSE benchmarks for good practice in noise control, practical examples and demonstrations and some case studies from industry.

Reproduced Sound 21: Feeding back to the future

4 and 5 November 2005

Following the technical and social success of last year's meeting, the Electroacoustics Group is organising a special *Reproduced Sound 21* conference which will again take place in Oxford.

This 'coming of age' meeting promises to be a landmark in *Reproduced Sound's* history and will be an opportunity to look back - and forward .

Those who have ever attended a *Reproduced Sound* conference will know that the cutting edge of modern audio and acoustics is presented in an informal and convivial environment that allows consultants, manufacturers, contractors and end users to mingle and share insights and information.

This year, as would be expected from such an important milestone, there are many key ingredients. There will be a menu of impeccably served papers from the world's leading academics, consultants, suppliers and manufacturers in the field who will speak on the practical and theoretical aspects of a range of topics including: room acoustics; studios; surround sound; intelligibility; acoustic enhancement; loudspeakers; microphones; system optimisation; measurement and modelling; perceptual domain.

For the evenings, an audio *Antiques Roadshow* and a *University Challenge* are planned. *Reproduced Sound 21* has its own web site at www.reproducedsound.co.uk

For further information regarding any of these events, please contact Linda Canty, Institute of Acoustics, tel: 01727 848195, or e-mail linda.canty@ioa.org.uk The institute's web site is at www.ioa.org.uk

ADVANCE NOTICE

Spring Conference 2006

Date and venue to be announced

Futures in Acoustics: Today's research - Tomorrow's careers

The title of next year's Spring Conference is '*Futures in Acoustics: Today's research - Tomorrow's careers*'.

As this implies, the conference will have as its themes the dual topics of recent and current research in acoustics and career opportunities in acoustics. It is hoped that the conference will attract students and young people, both to present papers and as delegates.

The technical sessions will cover all areas, including physical, medical, building, engineering and environmental acoustics, hearing and speech, plus novel and innovative applications of acoustics.

A feature of the conference will be a special session on careers, during which people working in many different areas of acoustics will describe their work and experience.

Employers, including consultants, local authorities, industry, academic institutions and government departments, will be invited to participate in an *Employment Forum*, when they will have an opportunity to describe their work and talk to young people who are interested in a career and/or further training in acoustics. Similarly students and young people attending the conference will be able to discover the type of work opportunities available with different companies, and to talk in an informal setting to potential employers and training bodies.

A *Call for Papers* is to be issued shortly. In addition to the regular IOA contributors, it is hoped that academics and employers will encourage students and young people to present papers on their research projects, and to attend the conference.

Employers and institutions who would like to take part in the Employment Forum should contact Linda Canty at the IOA office (telephone: 01727 848195 or e-mail: linda.canty@ioa.org.uk).

The deadline for abstracts is 7 November 2005

Editor's Notes

Ian F Bennett BSc CEng MIOA

Articles for the *Bulletin* are rather like buses - you wait for ages, then three come along all at once. The issue you now hold in your hands is a special 'road traffic noise' number: there is a great deal of interest in vehicle and road noise at present, both in the UK and Europe-wide, so we took the opportunity to group together a number of articles on the subject. My thanks go to TRL, and especially Greg Watts, whose name appears more than once in the following pages, both as author and co-author.

Road traffic noise strikes a particular chord with me, not so much professionally, but at a personal level. Although I live on a reasonably busy suburban road, the traffic noise does not bother me, and the nearby railway is a familiar background noise rather than any kind of nuisance. However, I have recently returned from a week's holiday on a narrowboat in Staffordshire, where I rediscovered that the presence of a main road near the canal can make a dramatic difference to the desirability of a mooring. You don't always find out how noisy a stretch of 'cut' is until you have stopped the boat's engine, but at least there is always the option of moving on around the corner, and getting away from the worst of the traffic roar. It makes you spare a thought for those who live next to a dual carriageway all the time, and cannot just move on. I'm not one to claim any grand social purpose in my pursuit of acoustical engineering, but many people will feel a real benefit if we as a profession can reduce the noise made by the ubiquitous motor vehicle.

I have been asked by a few people if we can include some kind of caption for the front cover photograph. Well, it's too late in the production process to put a caption on the contents page this time, where you might expect to find it, but I can reveal that the front cover picture is of the M62, looking eastwards between junctions 22 and 23. The overbridge from which the photo was taken is the one my children used to refer to as the 'Road Runner bridge' because of its resemblance to the typical structure in the eponymous cartoon!

My office move is now complete, and I can be found using the address and phone numbers listed in the usual place. As ever, e-mail is the preferred contact method. I look forward to receiving contributions for the November/December issue, for which the copy date is Friday 7 October. See you at the Autumn Conference!

Ian Bennett
Editor

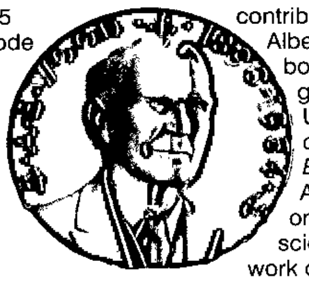
Nominations invited for the Institute of Acoustics A B Wood Medal 2006

The Institute of Acoustics is inviting nominations for its prestigious A B Wood Medal for the year 2006. The award is presented to an individual, usually under the age of 35, for distinguished contributions to the application of underwater acoustics.

The award is made annually, in even numbered years to a person from Europe and in odd numbered years to someone from the USA/Canada. The 2005 Medal was awarded to Dr A Thode from the USA for his innovative, interdisciplinary research in ocean and marine mammal acoustics.

Nominations should comprise the candidate's CV, clearly identifying peer reviewed publications, and a letter of endorsement from the nominator identifying the contribution the candidate has made to underwater acoustics. In addition, there should be a further reference from a person involved in underwater acoustics and not closely associated with the candidate. For the 2006 Medal, nominees should be citizens of a European Union country.

Nominations should be marked confidential and addressed to the President of the Institute of Acoustics at 77A St Peter's Street, St. Albans, Herts, AL1 3BN. The deadline for receipt of nominations is **15 October 2005.**



Dr Tony Jones, President of the Institute, commented that A B Wood was a modest man who took delight in helping his younger colleagues. It was therefore appropriate that this prestigious award should be designed to recognise the contributions of young acousticians.

Albert Beaumont Wood was born in Yorkshire in 1890 and graduated from Manchester University in 1912 (Pioneers of Acoustics, *Acoustics Bulletin* vol.30 no.2, March/April 2005). He became one of the first two research scientists at the Admiralty to work on antisubmarine defence.

He designed the first directional hydrophone and was well known for the many contributions he made to the science of underwater acoustics and for the help he gave to younger colleagues.

The medal was instituted after his death by his many friends on both sides of the Atlantic and was administered by the Institute of Physics until the formation of the Institute of Acoustics in 1974.

EXAMINATION RESULTS

Certificate of Competence in Workplace Noise Assessment April 2005

NESCOT
R C Justham, A J D Bromhead

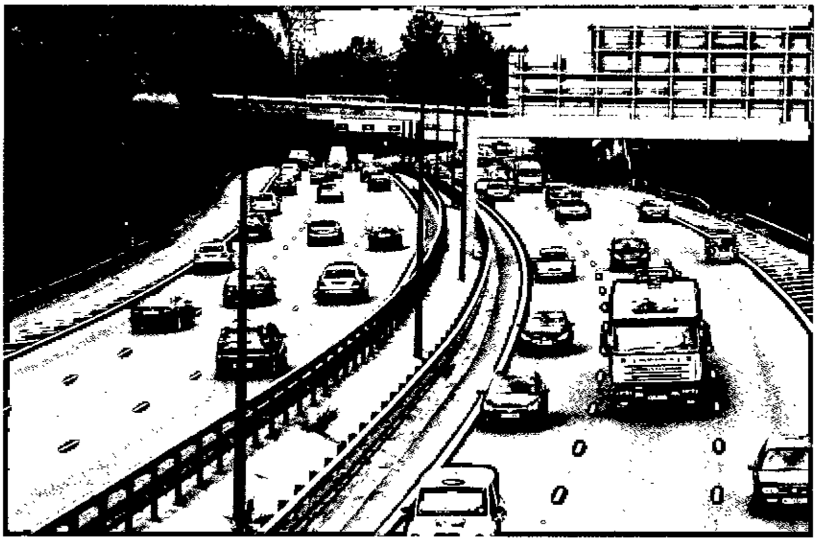
University of the West of England, Bristol
P Burgess, M Jackson, E Palmer, J Pritchard, A Phillips, P M Matthews

University of Derby
J Cawley, R P Palmer, A O Russell

Leeds Metropolitan University
D I Chaplin, D J Coleman, M A Hewitt, P W Rhodes

EEF Sheffield Association
K Stevens, AD Ridings, E M Reed, J Mmojieje, DR Hinks, M Durrington

EEF East Midlands
D J Tremain, M A Startin, C McMillan, R J Green, D Fry, R T Askew



Reducing traffic noise disturbance

Greg Watts

This article is closely based on the R W B Stephens lecture presented by the author at the 2004 Autumn Conference

In the UK traffic noise is a major source of noise nuisance causing serious disturbance to nearly 10% of the population. Research into mitigation measures has concentrated on a number of areas where worthwhile reductions in noise can be achieved. These can be broadly classified as measures to reduce noise generation and those that attenuate the transmission of sound to the receiver. Topics covered include the design of highway surfaces, the use of novel barriers and the provision of sound absorptive materials in the road cross-section.

Sometimes it might be necessary to affect a reduction at two stages. This is a 'combined mitigation' approach, *eg* the use of low noise surfaces with noise barriers. Cost-effectiveness is also very important especially when public funds are involved. Much of the research carried out by TRL has been funded by the Department of Transport or the Highways Agency and it has always been a central concern to maximise benefits while keeping costs down.

Public acceptability also needs to be considered since a mitigation measure may be highly effective in reducing noise but visually intrusive and therefore unacceptable, *eg* a tall noise barrier. Noise nuisance and the choice of appropriate noise indices to reflect disturbance are important areas of study which should not be neglected when mitigation measures are devised. Social survey, full-scale jury trials and well controlled laboratory studies have all been employed to understand more fully the response to noise.

In terms of implementation, the development of appropriate BSI, CEN, ISO and EC and UN-ECE standards and regulations standards are essential and international projects funded by the EC are increasingly important as a means of achieving state-of-the art solutions that can be applied across member states.

Generation

Tyre/road surface noise is a dominant source of traffic noise especially on high-speed roads. However, even on main urban roads subject to a 30 mph limit it is clear that the significant noise source for light vehicles is due to this mechanism. Tyre design has a part to play in the noise generation process and it has long been known that a bald tyre generally produces less noise than a tyre with tread. Skidding resistance depends on a good tread pattern so clearly there are trade-offs that may have to be made to achieve the overall optimum design.

Type approval testing of noise from tyres has recently been introduced across the EU which should stimulate further research into this noise generation process. TRL is currently involved with European projects SILVIA **(1)** and HARMONOISE **(2)** with the aims of providing advice to road authorities and a means to accurately predict this contribution. In addition, we are actively involved in developing a new vehicle noise emission standard through ISO WG42 and updating the corresponding UN-ECE regulation R51.02. This involves a consideration of both acceleration and cruise by conditions under realistic urban operating conditions of a wide variety of vehicle types and the development of a composite noise index L_{urban}. The test surface is also under consideration as there are issues concerning reproducibility and whether it represents typical surfacings.

The current noise regulation R51.02 requires vehicles to be tested at relatively high engine revs and can be considered a worst case test of the potential to cause disturbance. It has been successful in reducing propulsion noise although rolling noise has remained largely uncontrolled. Recently a new EC Directive 2001/43/EC **(3)** involving coast by tests at speeds of 70 and 80 km/h has been introduced to control this noise source although the effect on rolling noise is considered to be small with the current limit values.

Road surface effects

Noise from rolling tyres is caused partly by the generation of vibration in the tyre structure, which is excited by the road surface roughness and block impact, and movement in the contact patch. It is also produced by the movement of air in the cavities of the tread pattern in and around the contact patch ('air pumping'). The degree of macrotexture (*ie* large scale asperities) in the road surface, frictional characteristics between tyre and road and the porosity of the surface are all significant road surface factors.

Air pumping occurs when air is compressed in the grooves in the tyre tread pattern as tread elements deform in the contact patch. The compressed air is then expelled as the tread elements emerge from the contact patch causing noise. The noise due to tyre vibration tends to occur at frequencies below 1kHz while air-pumping noise is thought to be dominant from 1 to 3 kHz. If the surface is porous then noise produced by air pumping should be reduced as the air paths in the surface layer help to dissipate the air trapped in the tread grooves. The propagation of noise away from the tyre can also be reduced if a porous layer is present. Both sound absorption and sound interference processes can be involved. The latter can occur when a significant phase change occurs on reflection.

As a result of a greater understanding of the importance of rolling noise more emphasis is now placed on the appropriate choice of road surfacing. The use of traditional surfaces such as hot rolled asphalt (HRA) and brushed concrete is now restricted on high-speed roads in England and Wales. Quieter surfaces such as porous asphalt, thin bituminous surfaces and exposed aggregate concrete have also been used in recent years. The bituminous thin surfacings are the most widely used at present and a type approval scheme has been set up to regulate their acoustic performance.

TRL has assisted with the setting up of the Highways Authority Product Approval Scheme (HAPAS) which is being introduced by the British Board of Agrément (BBA). The test method was based on TRL's statistical pass-by procedure. This involves the recording of maximum noise levels and corresponding speed of a statistically valid sample of vehicles. Using regression analysis the average levels for different classes of vehicles, at standard pass-by speeds are obtained. This normalisation allows the noisiness of different surfaces to be compared at different sites. It can be demonstrated that relative to HRA there is a reduction in pass-by noise of several decibels using these newer surface types.

Despite the usefulness of the statistical pass-by procedure there are some limitations. Because the measurement is made at a specific location, the results can only be related to a relatively short section of road surface. Consequently the variability in noise along the road due to changes in the surface texture pattern cannot easily be determined. To overcome limitations of the method TRL is currently using a vehicle-based system of measurement where microphones are mounted close to a specified test tyre. This is based on the ISO draft ISO/CD 11819-2 close-proximity or CPX method. A special TRL vehicle called TRITON is used at present to collect data on a wide range of surfaces and can travel at test speeds of 110 km/h. This has greatly facilitated in-depth investigations of the effects of texture and tyre tread parameters on noise generation.

Figure 1 shows the CPX levels normalised to 80 km/h for a selection of car tyres on a range of reflective and absorptive surfaces based on TRL measurement programmes **(4)**.

The test surfaces were:

❑ ISO 10844 test surface, originally developed as a standard surface for vehicle noise testing and its specification was intended to help reduce the variability in test results. The surface achieves relatively low levels of tyre noise by using a dense bituminous material with a relatively smooth texture and a nominal maximum stone size of 8mm. The surface has been specified for use with the European tyre noise test procedure.

❑ Hot rolled asphalt (HRA) is one of the most common road surfaces in use on high-speed roads in the UK. The surfacing is laid with a maximum aggregate size of 14mm and pre-coated chippings with a nominal size of 20mm are then rolled into the surface. The chippings are added to the surface to provide it with good high-speed skidding resistance properties.

❑ Stone mastic asphalt 0/14 (SMA) is a monolithic, gap-graded material that has a very high stone content and is a widely used wearing course in Europe. The 14mm SMA has a specification similar to that adopted for UK motorways and has texture characteristics that are close to those that have been proposed for a second, rougher, ISO test specification.

❑ Brushed concrete is created on newly laid concrete surfaces by brushing across the carriageway. The section of brushed concrete chosen for this study has a lighter texture than the type generally used until recently on high-speed roads in England.

❑ MARS6 and MARS14 surfaces are bituminous in character and are described as porous surface dressings. The surface with the maximum aggregate size of 14mm (MARS14) was selected for the study since the texture fully meets that required for UK high-speed roads, whereas the surface with the smaller sized aggregate was assumed to have similar characteristics to surfaces found on high-speed roads in many European countries and on some medium speed roads in the UK.

❑ Colsoft is a proprietary road surfacing laid by Colas Ltd. The surface was originally developed by the French parent company for low noise applications in urban areas and includes a proportion of crumb rubber (approximately 2%) derived from recycled tyres.

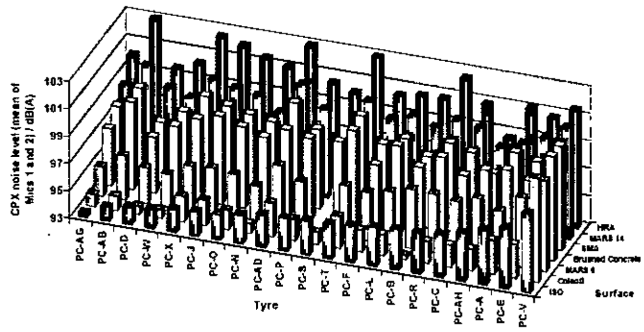


Figure 1: CPX levels at 80km/h by tyre and surface types

Noise levels have been shown to be influenced by the texture characteristics of the road surface. In studies carried out by Sandberg and Descornet **(5)** it was shown that for car tyres running on different surfaces, the effect of the road surface on the generation of tyre noise could be related to periodic features of the surface texture which can be characterised as texture wavelengths. In particular, the texture level at the 63 mm wavelength, referred to as T63, has previously been found to correlate well with overall noise levels.

It was also shown by Sandberg and Descornet **(5)** that the correlation between noise and the profile of the texture could be divided into two main frequency regions. For tyre/road noise frequencies below 1500Hz, the strongest correlations were obtained with texture wavelengths greater than 10mm. Higher frequencies in the noise spectra were correlated with smaller scale texture wavelengths. It was suggested that two separate mechanisms were involved with the resulting tyre noise spectrum being composed of two component or 'partial' spectra. The lower frequency elements of the spectra were attributed to noise resulting from tyre vibration whereas the higher frequencies were related to an air pumping mechanism.

Figure 2 shows for one of the study tyres, PC-O, how different frequencies in the noise spectrum are influenced by each of the texture wavelength components. These figures were generated by correlating changes in one-third octave band noise level with changes in one-third octave band texture level as each tyre was run on a different surface.

As can be seen from the figures, positive correlation between texture levels and noise levels tends to occur

continued on page 12

Reducing traffic noise disturbance

continued from page 11

for texture wavelengths between 20mm and 160mm, and in the frequency range 500-1000 Hz, whilst at higher frequencies, negative correlation with the short wavelength texture components (1.6mm to 8mm) was generally found. In practice, positive correlation between T20-T160 and the 500-1000 Hz frequency range means that road surfaces with high texture levels in this particular range of wavelengths tend to produce relatively high noise levels due mainly to mechanisms associated with tyre tread block impact and snap-out effects. The negative correlation between T1.6-T8 and frequencies greater than 1000Hz means that noise levels in this region decrease as short-wavelength texture increases due to reduced air pumping effects.

With such greater insights into the noise generation mechanisms the design of appropriate road surfaces is enhanced. Emphasis is now being placed on examining double layer porous surfaces where the greater depth enables a greater range of lower frequencies to be significantly attenuated. A further development is the inclusion of Helmholtz resonators in a third (bottom layer) to absorb even lower frequencies.

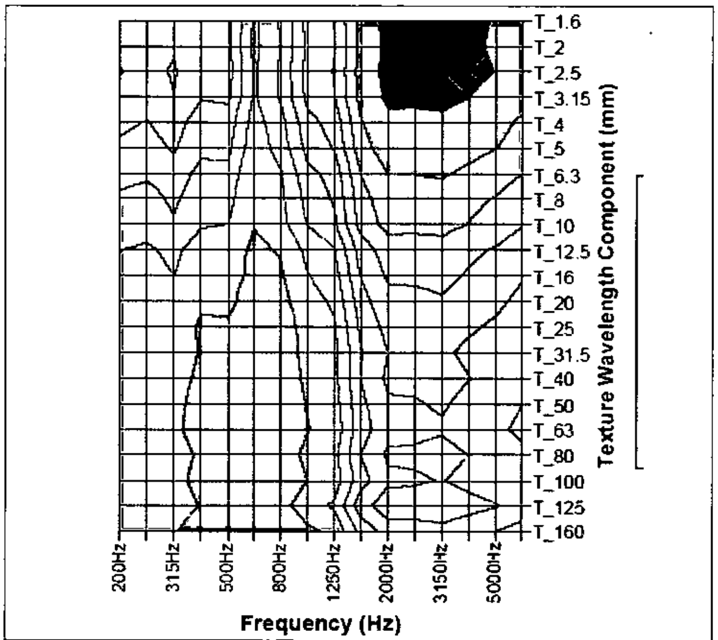


Figure 2: Correlation of texture characteristics with one-third octave frequency band coast-by noise levels for tyre PC-O

Tyre design

Rolling noise can be reduced by the correct selection of tyres but as can be clearly seen in *Figure 1* a 'quiet' tyre rolling on one surface does not necessarily deliver the same benefits on other surfaces. For example, car tyre PC-AG is quietest on the ISO surface but produces one of the highest levels of any of the tyres on the rougher HRA surface which is common on the UK road network. This is the result of the different noise generation mechanisms involved. On a smooth surface it has been found that air pumping noise is relatively important and the importance of tread block design is emphasised. Since much research has been carried out by tyre companies on the relatively smooth ISO 10844 surface in order to comply with the EC directive and UN-ECE regulations on vehicle noise emission the best designs are now thought to be similar in performance to completely smooth designs ('slick' tyres) on this surface.

However, on rougher surfaces tyre dimensions and construction are relatively more important due to the greater excitation of the whole tyre **(6)**. With this in mind it is hoped to include a rougher surface in the revision of ISO 10844 so that test results are more representative of typical conditions. This may in the long term have the effect of improving tyre design to a point where they are optimal for a range of road surface conditions. However, it may only be possible to optimise successfully for particular combinations of tyre and road surface type. This whole system approach may have implications for tyre selection in different countries reflecting the different proportions of road surface types.

Speed effects

The overall noise generated by vehicles is largely governed by vehicle speed. At low speeds the noise from the engine and its ancillaries, gearbox, exhaust, and cooling system, will often dominate over the noise generated by the tyres. However, as the speed of the vehicle increases, the noise generated by the tyres will also increase. Previous work at TRL has shown that tyre noise may increase at rates of between 9 and 13 dB(A) for each doubling of speed, depending upon the type of tyre and road surface. Harland **(7)** had shown that the general relation between the maximum sound level L_{Amax} and the speed of a passing vehicle for a measurement point located 7. m from the centre line of the vehicle path is given by:

$$L_{A\max} = A\log_{10}(V) + B$$

where A and B are constants.

This equation clearly assumes that a linear relationship exists between overall noise levels and the logarithm of vehicle speed. This assumption forms the basis for many forms of vehicle and tyre noise measurement procedures including the CPX method. This relationship allows linear regression techniques to be used, giving a relatively simple method of determining noise levels at any selected speed from random data gathered either at roadside locations or under test track conditions.

The rate at which the overall noise level increases with the logarithm of speed is heavily dependent on the type of road surface. Analysis of the results obtained using the CPX method has indicated that for any particular tyre, the rate of increase is greatest on the brushed concrete surface and lowest on the MARS-6. The rank ordering of the other surfaces displays some variation depending on the tyre under test, but by averaging the speed constants (which quantifies the rate at which noise levels increase with speed) for all tyres running on a particular surface, some idea of the influence that each surface has on the rate at which noise increases with speed was obtained. The result of this analysis is shown in *Figure 3*.

As can be seen, the speed constant tends to be higher for rougher surfaces, transversely textured surfaces (brushed concrete) and lower for porous surfaces.

The research is continuing to inform the Department for Transport's policy on appropriate road surfaces and the development of regulations on tyre and vehicle noise. TRL is currently actively involved in ISO WG42

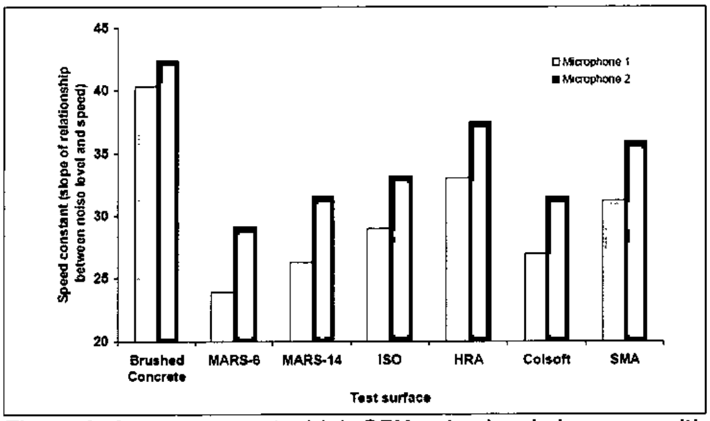


Figure 3: Average rate at which CPX noise levels increase with the logarithm of speed for each of the test surfaces

(vehicle emission) and WG33 (CPX) and UN-ECE GRB committee on vehicle noise regulation.

Transmission

An obvious way to reduce noise levels is to block the sound in the transmission path from source to receiver using noise barriers, earth mounds, cuttings or covers (both partial and complete). Generally the closer a barrier or earth mound is to the source the more effective it becomes. For simple plane barriers the height and length are the most important factors determining the degree of screening achieved **(8)**. The shadow zone of the barrier is the region where the receiver cannot see the source and here the greatest reductions in noise levels are recorded. Some sound will always be diffracted over the top and around the edges of the barrier into the shadow zone so it is not possible to eliminate all noise from the source. Typical sized barriers of a few metres high can achieve noise reductions of the order of 10dB(A). This corresponds to halving the subjective loudness of the sound.

Common factors that affect acoustic performance of a wide variety of noise barriers are:

(i) **Sound leakage through the barrier**
(ii) **Absorptive effects: absorptive elements on the traffic face or diffracting edge**
(iii) **Diffraction effects: basic geometry, elements or caps at the top of the barrier**
(iv) **Ground surface properties**
(v) **Meteorological effects**

At TRL a noise barrier test facility (NBTF) has been used to test barriers at full-scale under controlled conditions **(9,10,11)**. The facility consists of a powerful loudspeaker source, road surface and flat grassland beyond the barrier. Additionally, boundary element methods (BEM) have been developed in collaboration with Brunel and Bradford Universities to provide versatile numerical modelling techniques for examining the efficiency of a wide range of designs. Model results have been validated using full-scale and roadside measurements **(12)**. The BEM method has been used to design and patent a multiple edge diffractor which can be used to enhance screening performance of a plane barrier.

BEM model

The program used was developed at the Universities of Bradford and Brunel with assistance from TRL. The boundary element method (BEM) program calculates the wave field at a particular frequency by solving a

continued on page 14

Reducing traffic noise disturbance

continued from page 13

reformulation of the Helmholtz wave equation in terms of an integral equation. For this purpose the surfaces are divided into boundary elements of length in general no greater than $\lambda/5$ where λ is the wavelength. The effects of ground cover and absorptive surfaces are included in the definition of the elements. The vehicle model is two-dimensional which means that the traffic is effectively a coherent line source. Despite this limitation results have shown good agreement with measured values. For the purposes of barrier studies a typical rural dual three-lane motorway has been modelled.

The vehicle sources used in the model were represented by using average vehicle shapes for light and heavy vehicles with sources at heights of 0.05 m and 0.1 m respectively under the nearside and offside edges of the vehicle body. The source spectra for light and heavy vehicles were based on measured peak values for individual vehicle pass-bys at the edge of a motorway **(13)**. In most cases the road surface was assumed to be acoustically hard and the verge and flat ground beyond the barrier was assumed to be acoustically soft. Suitable parameters were chosen for flow resistivity, porosity, layer depth and tortuosity to represent typical values for reflective and absorptive surfaces including grassland. Predictions were made in terms of the A-weighted levels based on centre frequencies of one-third octave band levels from 100Hz to 5kHz. The calculation method described in ISO 9613-1 was used to take account of air absorption assuming 15°C and 50% humidity.

Sound leakage

An effective noise barrier will reduce the sound energy transmitted through its construction to much lower levels than the sound diffracted over and around the barrier. However, in some cases leakage will occur as a result of shrinkage, warping and splitting of the panels and weathering of acoustic seals. A TRL roadside survey using a novel sound intensity technique indicated that timber barriers had poorer sound transmission performance due to leaks than might be expected from the mass per unit area of the barrier **(14)**. BEM predictions were made with and without horizontal gaps of various dimensions and spacings in barriers of various heights. These predictions were compared with an approximate but simpler sound intensity approach with generally good agreement **(15)**. The method assumes that sound spreads evenly from each gap and that logarithmic addition of the secondary sound sources at the gaps on the rear face of the barrier with the sound diffracted over the barrier top can be used to obtain the resultant noise level.

It can be shown that the resultant change in the A-weighted insertion loss (screening performance) behind a barrier depends on factors such as the barrier height, horizontal distances from source to barrier, and from barrier to receiver, and on the fraction of the barrier area having air gaps. *Figure 4* shows predictions for a barrier with realistic air gaps (3% of total area) for 6m and 3m tall barriers.

In general it was found that the reduction in screening performance caused by gaps was greatest close to the barrier and reduced with distance. It follows that a barrier of higher sound insulation than that provided by a typical

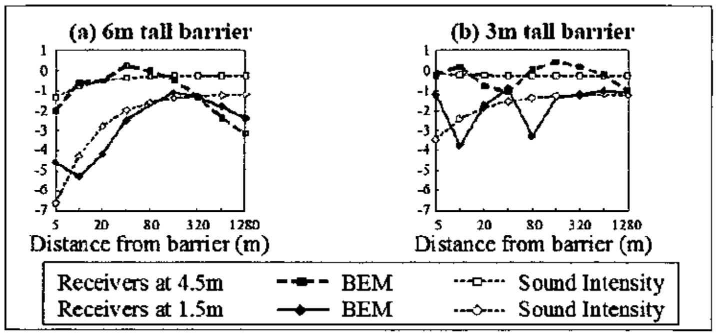


Figure 4: Changes in insertion loss due to 3% gaps

single leaf timber barrier is required to prevent significant decreases in screening performance at distances behind a tall barrier of less than about 20m.

TRL has been involved in developing in situ test standards for airborne sound insulation based on the maximum length sequence method (MLS) through the work of CEN TC226/WG6 on anti-noise devices **(16)**. *Figure 5(a)* shows the measurement with the barrier sample present, and *5(b)* without. The impulse response is obtained by cross correlating the input signal to the loudspeaker with the output signal; from the microphone. To obtain an average over an area of the panel measurements are made at nine microphone positions.

Using suitable time windowing the required transmitted signal is separated from the diffracted and reflected components. The transmitted component is then Fourier transformed to obtain the third-octave sound insulation values, which are then weighted by a standard traffic noise spectrum to give the overall single number rating of airborne sound insulation DLSI.

Sound absorption

There is a number of situations where sound absorptive materials can be used in the road cross-section to control the spread of noise from the highway. Where plane vertical barriers exist on both sides of the road there is a possibility that multiple reflections will lead to a loss of screening performance. Sound absorptive panels located on the sides of the barriers facing the traffic can reduce the reflected contribution by absorbing the sound energy from the incident wave. There are several types of system used for sound absorbing barriers. Clearly, to be effective the

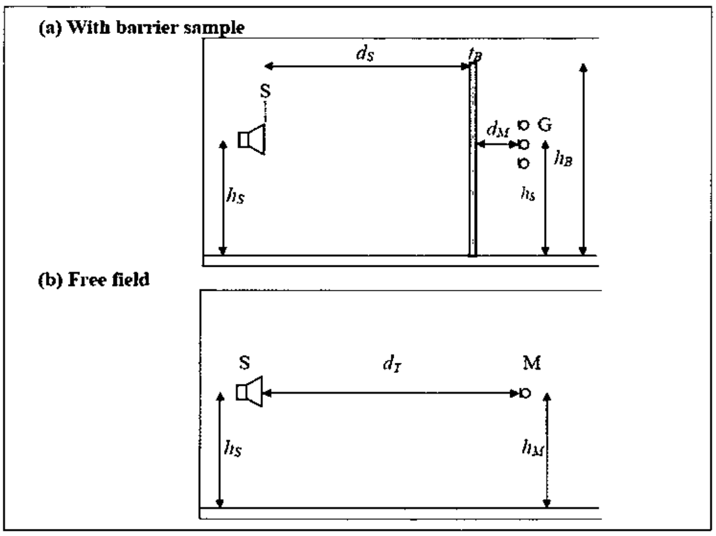


Figure 5: Transmitted components measurement in front of a barrier. S: loudspeaker, G: measurement grid, M: microphone. dS = 1m, dM = 0.25m and the microphones are spaced 0.3m apart in a 3 by 3 grid. hs=hB/2

barrier material must be highly absorptive at frequencies that are significant in highway traffic noise spectra and this is recognised in the recent CEN standard EN 1793 (part 1) which gives a test method for deriving a single number rating **(17)**. This method weights the absorption coefficients from 100Hz to 5kHz with a typical traffic noise spectrum (part 3).

While most of the absorptive materials perform adequately at mid to high frequencies the absorption at low frequencies varies considerably. Thick layers of absorptive materials or the use of a cavity behind the absorber are possible ways of improving performance. The effectiveness of absorptive materials in reducing noise levels will depend on the distance between parallel barriers and the barrier height. Roadside tests by TRL involving reversing barrier panels from absorptive to reflective have shown that the largest reductions from applying good absorbers are generally a few dB(A) **(18)**. *Table 1* shows the maximum increases that reflective far-side barriers have produced in other well controlled roadside studies where source strength and wind component have been taken into account. Larger effects of greater than 5dB have been predicted using physical and mathematical models due to the simplifying assumptions that are not realised in practice, *eg* screening effects of traffic, reflections from safety barrier and absorption by grassed embankments, influence of road curvature and meteorological effects.

experimental design	barrier separation/ height ratio	maximum increase in L_{Aeq}
pairwise comparison	8.6 : 1	2.8
barrier alteration	9.3 : 1	2.3
barrier erection	15 : 1	1.4

Table 1: Increase in L_{Aeq} dB due to the far-side reflective barrier

In narrow urban streets a canyon effect can be created by the presence of tall acoustically reflective building facades on both sides of the road. Under such circumstances noise levels can be relatively high due to the reverberant sound field created by multiple reflections from the facades and a typical reflective road surface such as hot rolled asphalt (HRA). The effect can be enhanced if horizontal covers project from each side of the building facades recreating a partially enclosed space. It has been predicted that in such circumstances the presence of a porous asphalt road surface (PA) which is sound absorptive can offer greater benefits than in a free field situation.

Contour plots of the A-weighted sound field close to a tall building façade bordering an 8m wide road are given in *Figure 6* using a typical emission spectrum for light vehicles. The SPL varies from relatively high sound pressure (red) to low (dark blues). The appearance and increase in the area of blue for the cases with the PA surface is striking and clearly illustrates the wide extent of the lowered noise levels. Some relatively narrow horizontal bands of higher noise levels are visible in the plots for opposite façades and with partial covers (horizontal covers extending 1.7m from the top of each façade). These indicate the presence of standing waves due to the interaction of reflected waves. The results indicate that PA is more effective in reducing noise levels where the conditions are more reverberant. Overall, in the case of the single façade, the improvement with porous asphalt is 3.9dB(A). With an opposite façade the improvement increases by just over 1 dB to 5.0dB(A).

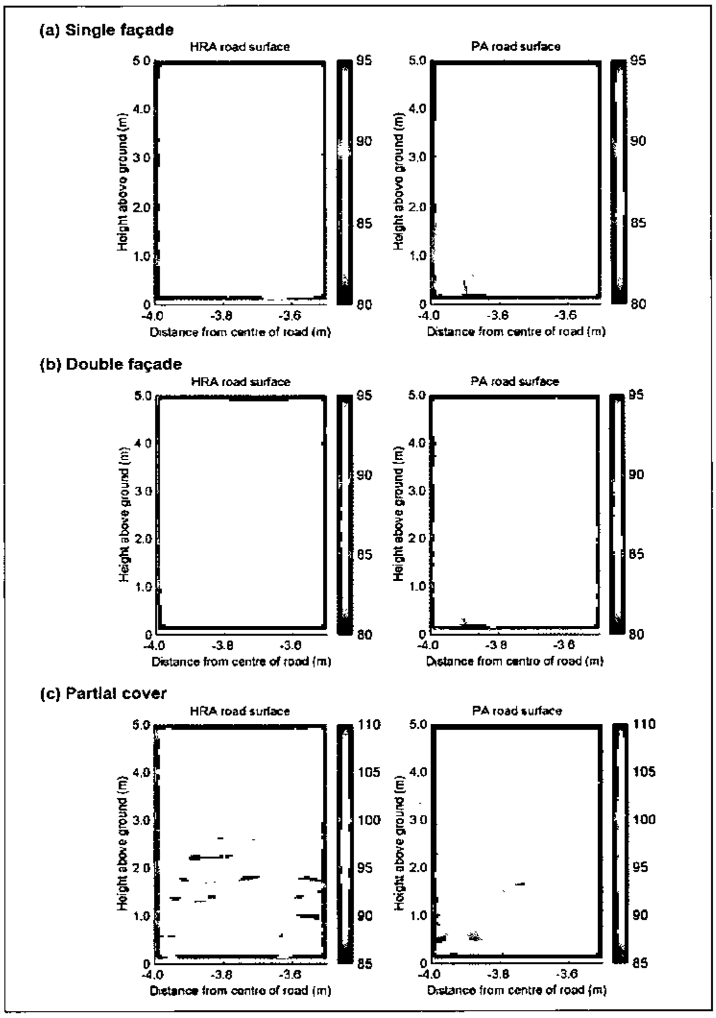


Figure 6 : Contour plots of A-weighted L_p near building facades

The addition of partial covers increases the benefits substantially to 9.7dB(A). Multiple reflections of sound waves on the absorptive porous asphalt occurs for the parallel façade and partial cover cases leading to greater reductions of overall noise levels compared with the reflective HRA case. With increasing distance between opposite façades, lower façade heights and where a cover is not present it would be expected that the advantage of PA over a reflective surface such as HRA would tend toward that of a single façade. Conversely inside tunnels and with narrower roads and closer façades with horizontal extensions greater improvements than those predicted should be observed.

Absorptive materials are also useful in controlling noise passing through louvered covers and noise barriers. A range of designs has been examined using scale model tests and BEM modelling. The results can be used to develop appropriate designs **(19)**.

Diffraction effects

The insertion loss of barriers can be determined in simple cases using the path difference approach. With suitable adjustments this approach was incorporated into the UK traffic noise prediction model CRTN**(8)**. In the case of more complex shapes the procedure may under-predict performance even when the effective height of thick barriers is taken into account, *eg* cranked barriers comprising a simple barrier with an extension overhanging

continued on page 16

Reducing traffic noise disturbance

continued from page 15

the carriageway. This is illustrated in *Figure 7 (a to e)* where the maximum insertion loss gains for receivers at 1.5 m above the ground produced by extensions of various lengths are based on BEM and path difference calculations.

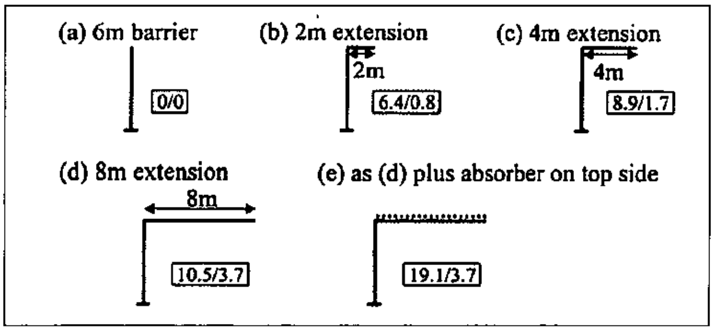


Figure 7: Maximum changes in insertion loss due to extensions (BEM / CRTN predictions in dB(A) posted

Barriers have been altered in cross-section in an attempt to reduce the noise diffracted into the shadow zone. Many designs have been examined at TRL using mathematical and scale modelling and the more promising designs have been tested at full scale at the NBTF**(9,10,11)**. *Figure 8 (a to l)* shows some of the designs in cross-section that have been tested with the average improvement in insertion loss posted.

The designs included T-shaped barriers and multiple edged barriers as well as commercially available designs, *eg* a rounded absorptive cap 0.5m in diameter *(k)* and a device designed to exploit the principle of sound interference *(l)*. The average reductions in noise levels for barrier profiles compared with a simple reflecting barrier of identical overall height were up to 3dB. Adding the most efficient profiles has the same effect as raising the height of a simple plane barrier by 0.5-1.0 m. Roadside tests have confirmed that such reductions are possible in practice **(12)**. Such barrier profiles might therefore be useful for screening traffic noise in situations where the maximum height of barriers needs to be limited because of other environmental considerations (*eg* visual intrusion, reduction in sunlight) or where extra screening is required from an existing barrier and the costs of increasing the height would be excessive.

The BEM approach has been used to develop diffractors of even greater efficiency and has also been used to examine the performance of earth berms of various shapes **(20)**, and the spread of sound from cuttings. An advantage of the modelling approach is that it can produce tailor-made solutions for specific noise control problems. For

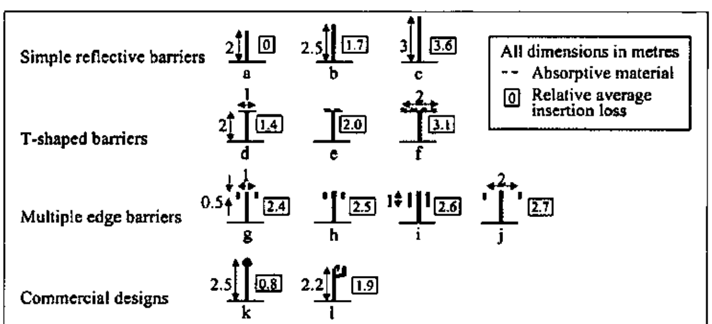


Figure 8: Insertion loss changes due to barrier caps

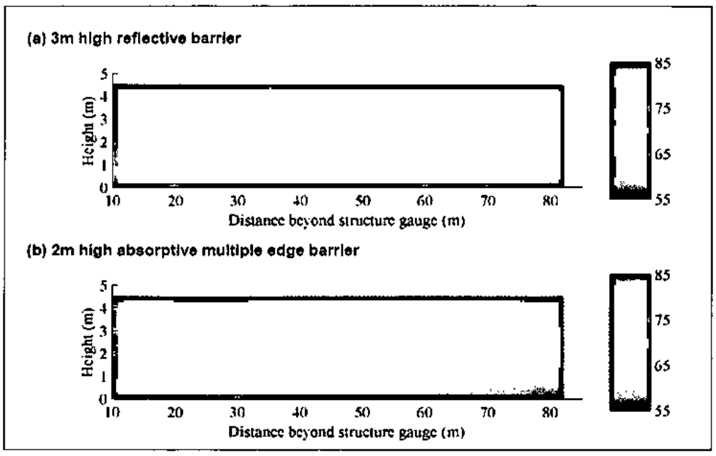


Figure 9: Contour plot of A-weighted L_p behind trackside barriers

example, tall barriers can reduce the view from railway carriages and low barrier solutions are required without compromising noise screening. *Figure 9(a)* shows contour plot of the predicted A-weighted SPL behind a 3m plane reflective barrier and *Figure 9(b)* beyond a 2m high barrier with a multiple edge barrier. It can be seen that despite the lower height the multiple edge barrier is predicted to provided significantly better screening performance and could be suggested as a viable alternative to the simple screen for trackside noise control.

Ground surface effects

The insertion loss of a barrier will depend on the road surface and the ground type in the screened area. It has been possible to model these effects using a combination of BEM modelling and site measurements to calibrate the model. The resulting effect has been shown to be different from the sum of the individual effects **(13)**. *Figure 10* shows the change in insertion loss when 2m and 8m high barriers are placed adjacent to a porous asphalt (PA) road surface compared with a conventional asphalt surface (HRA). Porous asphalt is strongly absorptive in the frequency range 1-1.6 kHz. Generally by changing to PA there is a decrease in the performance that depends on the distance behind the barrier and the height of the barrier. The largest decrease in performance for receivers at 1.5m height above grassland was predicted for the 8m high barrier where the loss was nearly 3dB at a distance of 80m behind the barrier. The nature of the ground over which sound passes beyond the barrier also has an important effect on the insertion loss of the barrier. Generally the more absorptive the ground cover the smaller is the insertion loss of the barrier.

Meteorological effects

Modelling work has indicated that the effectiveness of simple barriers is seriously degraded by wind blowing in the direction from the road to the receiver **(21)**. The problem is partly due to the sound speed profile which is altered around the barrier resulting in greater refraction in downwind propagation conditions. Further research is needed to model these atmospheric effects sufficiently accurately so that it will be possible to predict the performance of barriers under different meteorological conditions. Research is planned involving developments in the BEM approach to include layered atmospheres and the use of other techniques, *eg* the parabolic equation approach, so that the effects on screening of wind and temperature gradient conditions can be calculated. In

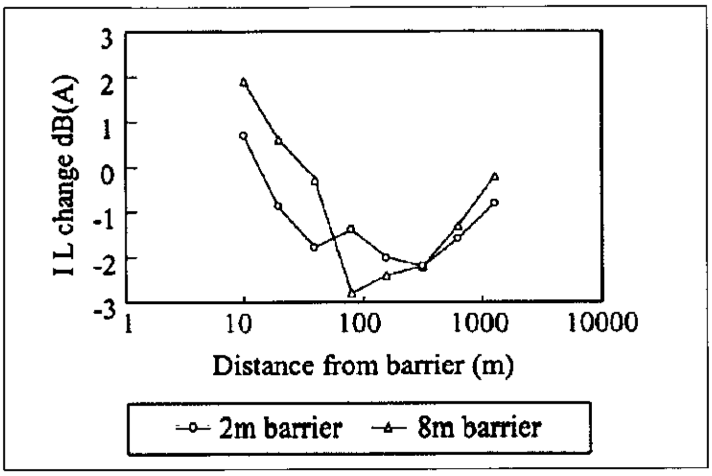


Figure 10: Predicted change in insertion loss from HRA to PA at 1.5m above ground

addition it is likely that air movements over the diffracting edge have a significant effect on acoustic screening performance **(22)**. With greater understanding of the nature of this interaction it may be possible to produce designs that are more efficient than plane barriers across a wide range of wind conditions.

Future developments

Research will continue into identifying characteristics of tyre design and road surface roughness that affect noise levels. It should then be possible by suitable design to avoid characteristics that cause excessive noise. The benefits of multiple layers of porous surfaces and the incorporation of Helmholtz resonators are currently being explored. This may mean looking at tyres and the road surface as a total system for low noise design purposes rather than in isolation. It may even be possible to use active noise cancellation (ANC) based on advanced signal processing techniques to produce destructive sound interference around the tyre contact patch to reduce noise levels even further although the problems are formidable.

However, it is likely that some residual noise will remain and in the foreseeable future there will be a continuing need to consider other mitigation measures that affect transmission, reception and perception. Recent studies have involved the examination of modified wheel arches and extended hubcaps to reduce propagation away from the tyre by providing additional screening and sound absorption. Research is continuing on improving the design of noise barriers and earth banks that will provide even better screening without increasing height. One possibility is to use a row of ANC devices on or near the diffracting edge of the barrier to produce sound cancellation that might result in significant noise reductions throughout the shadow zone **(23)**.

It is recognised that such devices as noise barriers are not effective under all meteorological conditions. Future research is needed to model these atmospheric effects so it will be possible to predict the performance of barriers under different wind and temperature conditions. It is likely that air movements over the diffracting edge have a significant effect on acoustic screening performance. With greater understanding of the nature of this interaction it may be possible to produce designs that are more efficient

continued on page 18

Reducing traffic noise disturbance

continued from page 17

than plane barriers across a wide range of wind conditions.

The nature of the ground over which sound passes also has an important effect. For example, ploughed ground and fields with standing crops are more absorptive than grassland and can lead to greater attenuation rates with distance. Stands of thickly planted trees with dense foliage down to ground level can also be effective. The effects of combining barriers with porous road surfaces or tree planting is not well understood and there are possibilities of optimising solutions if effects can be accurately modelled. Treating the hard shoulder and central reservation with sound absorptive material is also a possibility and BEM modelling has been used to explore a range of options.

Finally, the greater understanding of how people respond to noise and the factors in the noise signature of passing vehicles that cause particular irritation needs further research. It has been shown that the A-weighted level is not always a good indication of noisiness and more sophisticated measures such as loudness on the Sone scale offer some advantages **(24,25,26)**. Visual factors are known to affect the perception of noise **(27)** but studies are required to optimise any advantages that may be offered by manipulating the visual field.

Conclusions

The following conclusions can be drawn from this overview of TRL research into the generation and transmission of traffic noise.

Studies at TRL aim to identify the important characteristics of tyre design and road surface roughness that leads to the generation of significant noise. A special TRL vehicle called TRITON has been used to collect data on a wide range of surfaces. This will greatly facilitate in depth investigations of the effects of texture and tyre tread parameters on noise generation.

European co-operation through SILVIA and HARMONOISE are bringing added benefits in terms of access to larger databases and state-of-the-art modelling solutions.

Absorptive barriers can be designed to eliminate reflected noise but it is necessary to choose the absorptive material to eliminate the most important frequencies of traffic noise at the site of application. Porous road surfaces are predicted to be even more effective in situations producing reverberant fields, *eg* in narrow city streets with tall buildings adjacent to the carriageway.

Multiple edge barriers and other barrier shapes are a solution to enhancing the acoustic performance of barriers without raising the overall height of the barrier system.

The usefulness of the boundary element method modelling for investigating the spread of noise from the traffic source and designing effective mitigation measures has been demonstrated. The fruitful cooperation with Bradford and Brunel Universities has facilitated the further development of the model.

Future research should include the study of optimising designs of the tyre/road system to reducing rolling noise, meteorological factors on sound diffraction and the use of ground cover to control noise as well as the innovative use of absorptive materials in the road cross-section.

The human response to noise is not well understood although some headway has been made on understanding the issues such as the deficiencies in the A-weighted scale for reflecting noisiness and the importance of visual factors. Further research is required so that mitigation measures are correctly targeted.

References

1 www.trl.co.uk/silvia

2 www.harmonoise.org

3 European Parliament and of the Council, Directive 201/43/EC, June 2001 (2001)

4 S M Phillips, S Kollamthodi, P M Nelson and P G Abbott, Study of medium and high speed tyre/road noise, *TRL Report PR SE/849/03*, TRL, Wokingham, Berkshire (2003)

5 U Sandberg and G Descornet G, Road surface influence on tyre/road noise - Parts I and II, *Proceedings of Inter-Noise 80*, Miami, Florida, 259-266; 267-272 (1980)

6 P Abbott and G R Watts, *Proceedings of Internoise 2003*, Segowipo, South Korea (2003)

7 D G Harland(1974) Rolling noise and vehicle noise, *TRRL Report LR 652*, TRL, Wokingham, Berkshire (1974)

8 Department of Transport and Welsh Office, *Calculation of Road Traffic Noise*, HMSO, London (1988)

9 G R Watts, D H Crombie and D C Hothersall, Acoustic performance of new designs of traffic noise barriers: full-scale tests, *J Sound and Vib* 177(3) 289-305 (1994)

10 G R Watts and P A Morgan, Acoustic performance of an interference type noise barrier profile, *Applied Acoustics* 49 1-16 (996)

11 G R Watts, Acoustic performance of parallel noise barriers, *Applied Acoustics* 47 95-119 (1996)

12 G R Watts, Acoustic performance of a multiple edge noise barrier profile at motorway sites, *Applied Acoustics* 47, 47-66 (1995)

13 G R Watts, S N Chandler-Wilde and P A Morgan, The combined effects of porous asphalt surfacing and barriers on traffic noise, *Applied Acoustics* 58 351-377 (1999)

14 G R Watts, In-situ method for determining the transmission loss of noise barriers, *Applied Acoustics* 51 421-438 (1997)

15 G R Watts, Effects of sound leakage through noise barriers on screening performance, *Proceedings of the International Congress on Sound and Vibration* 2501-2508, Technical University of Denmark, Lyngby (1999)

16 European Committee for Standardisation, Road traffic noise reducing devices - Test method for determining the acoustic performance Part 5 In-situ values of sound reflection and airborne sound insulation Intrinsic, CEN/TS 1793-5, Brussels (2003)

17 British Standards Institution, Road traffic noise reducing devices - Test method for determining the acoustic performance Part 1 Intrinsic characteristics of sound absorption, BS EN 1793-1:1998, Chiswick (1998)

18 G R Watts and N Godfrey, Effects on roadside noise levels of sound absorptive materials in noise barriers, *Applied Acoustics* 58 385-402 (1999)

19 G R Watts, D C Hothersall and K V Horoshenkov, Measured and predicted acoustic performance of vertically louvred noise barriers, *Applied Acoustics* 62 1287-1311 (2001)

20 G R Watts, Effectiveness of novel shaped bunds in reducing traffic noise, Institute of Acoustics conference on Advances in Transportation Noise, London, *Proceedings of the Institute of Acoustics 21* (2) 41-50 (1999).

21 A Muradali and K R Fyfe, Accurate barrier modelling in the presence of atmospheric effects, *Applied Acoustics* 56 157-182 (1999)

22 G R Watts, P A Morgan and M Surgand, Assessment of the diffraction efficiency of novel barrier profiles using an MLS-based approach, *J Sound and Vib* 274 669-683 (2004)

23 G R Watts and P M Nelson, The relationship between vehicle noise measures and perceived noisiness, *J Sound and Vib* 164 3 425-444 (1993)

24 A Omoto and K Fujiware, A study of an actively controlled noise barrier, *J Acou Soc Am*, 94 (4) 2173-2180 (1993)

25 G R Watts, Comparison of noise measures for assessing vehicle noisiness, *J Sound and Vib* 180 3 493-512 (1995)

26 G R Watts, Perception of noise from traffic running on concrete and bituminous road surfacings, *J Sound and Vib* 191 415-430 (1996) JSV comparison of road surfaces

27 G R Watts, L Chinn and N Godfrey, The effects of vegetation on the perception of traffic noise, *Applied Acoustics*, 56 39-56 (1999)

Harmonoise models for predicting road traffic noise

Greg Watts

The European Directive for the Assessment and Management of Environmental Noise (2002/49/EC) or END requires the production of strategic noise maps and noise action plans for major roads, railways, airports and in agglomerations **(1)**. From 2012, the maps will have to be produced using harmonised prediction methods. The Directive referred to the lack of a harmonised and reliable method for noise prediction and as a consequence a new method was required which could be adopted across Member States.

The project Harmonoise (**H**armonised, **A**ccurate and **R**eliable **M**ethods for the European Directive **O**n the Assessment and Management of Environmental **NOISE**) was designed to fulfil this need. It was part funded by the European Commission, DG Information Society and Technology, under the fifth Framework Program (IST-2000-28419) and partly by DfT and Defra. The project output is a description of the noise prediction methods for road and railway noise sources that have been developed. It is expected that software suppliers will subsequently supply computer programs for mapping and action plans.

The work was carried out within a number of work packages (WPs) which included the developments of road and railway source models (WP 1.1 and WP 1.2), propagation models (WP2) and an engineering model for use in noise mapping (WP3). Data was collected at 13 sites to validate the models that had been developed (WP4).

A summary of the road traffic model is given here and a fuller account is given in **(2)**. Final deliverables from the project are available on the Harmonoise web site: *www.harmonoise.org*

Noise levels are predicted in terms of L_{den} and L_{night} as these are the indices required by the environmental noise directive. The noise index L_{den} is defined as:

$$L_{den} = 10\log\left[\frac{12}{24}10^{\frac{L_{day}}{10}} + \frac{4}{24}10^{\frac{L_{evening}+5}{10}} + \frac{8}{24}10^{\frac{L_{night}+10}{10}}\right] dB(A)$$

where L_{day} is the L_{Aeq} level taken over 12 hours during the day, $L_{evening}$ is the L_{Aeq} over four hours in the evening and L_{night} is taken over eight hours during the night time. The weighting factors +5 and +10 in the exponents are designed to take into account the increased annoyance caused during the evening and night-time periods. Consequently, the weighting and averaging over traffic composition and weather conditions are carried out separately for each of these three periods of the day averaged over a year. Average weather conditions are based on several years of meteorological data.

The reference propagation model developed in WP2 is concerned with obtaining very precise predictions of sound propagation through different atmospheric conditions and is based on state-of-the-art propagation methods. These are restricted to a limited range of conditions where the developed theory allows the necessary accuracy of prediction. Typically these prediction tools are not appropriate for noise mapping purposes due to the complexity of use and the intensive computer resources that are required.

The engineering model uses a simpler propagation model which is suitable for noise mapping and has been validated against measured results at two road locations where the roads ran on embankments above essentially flat terrain. The differences between predicted and calculated A-weighted values of L_{den} were never greater than 1.5dB even at a distance greater than 1km from the road. However, further validation is required for example in the more complex situations typically found in urban areas.

A follow up project called IMAGINE, started in December 2003 and funded under the sixth EC Framework Program, will enable more data to be collected and added in order to refine the prediction methods developed in Harmonoise. It will also enable methods for data collection to be defined and advice given on the production of noise maps. The prediction method will also be extended to industrial sources and aircraft so comprehensive mapping of noise sources will be possible.

Components of the model

Figure 1 shows the components of the engineering model and lists the main factor influencing noise levels. The source strength will depend on a number of factors including the type of vehicle, its operating condition and the road surface and its condition. Propagation will be affected by wind speed and direction and temperature profiles in the atmosphere as well as obstacles to propagation such as noise barriers. The actual value of L_{den} will take into account average weather conditions.

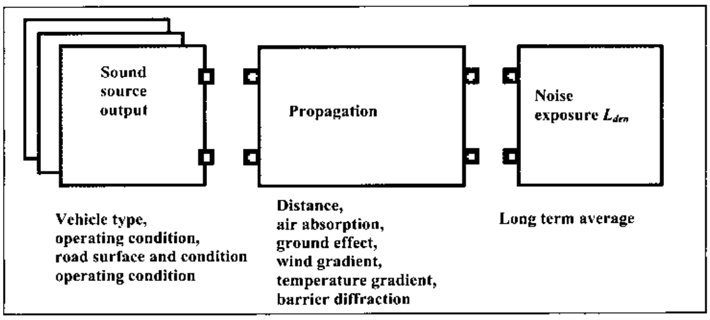


Figure 1: Components of the engineering model

For the road traffic noise prediction engineering model each of these components will be described in turn.

Source model

The source model entails the description of sound power of various categories of vehicle in terms of speed and acceleration. Corrections are applied for the road surface texture and condition including temperature and for directivity both in the horizontal and vertical plane. The sources on the vehicles are simplified into two point sources: a lower and higher source. The lower source is mainly due to tyre/road noise and the higher source is mainly propulsion noise. The height of the propulsion noise source depends on the vehicle category.

The sound power of the sources in a given direction is then used to calculate levels at any given receiver using a ray based propagation model developed in WP3 of Harmonoise. The road surface acoustic impedance

continued on page 20

Harmonoise models for predicting road traffic noise

continued from page 19

is included in the propagation model. A road segment will be composed of a series of point sources of different types depending on the percentage of vehicles of various categories and their speed. All these sources are integrated to arrive at the final averaged A-weighted traffic noise level.

Vehicle categories

The vehicles are divided into the categories shown in *Table 1*. It is likely that initially only the main categories will be used. Later, data on subcategories will become available.

It can be seen that separate categories have been reserved for low noise vehicles and electric vehicles. It is to be expected that the proportion of these vehicles will grow over time and relevant data can be added.

Description of sub sources

In Harmonoise two source heights are used for each vehicle category. One is 0.01m above the road surface and the other is either at 0.3m for light vehicles or 0.75m for heavy vehicles. For heavy vehicles with high exhausts

Main category	No.	Sub-categories	Notes
Light vehicles	1a	Cars (incl MPV:s up to 7 seats)	2 axles, max 4 wheels
	1b	Vans, SUV, pickup trucks, RV, car+trailer or car+caravan[1], MPV:s with 8-9 seats	2-4 axles[1], max 2 wheels per axle
	1c	Electric vehicles, hybrid vehicles driven in electric mode[2]	Driven in combustion engine mode: See note
Medium heavy vehicles	2a	Buses	2 axles (6 wheels)
	2b	Light trucks and heavy vans	2 axles (6 wheels)[3]
	2c	Medium heavy trucks	2 axles (6 wheels)[3]
	2d	Trolley buses	2 axles
	2e	Vehicles designed for extra low noise driving	2 axles[5]
Heavy vehicles	3a	Buses	3-4 axles
	3b	Heavy trucks[4]	3 axles
	3c	Heavy trucks[4]	4-5 axles
	3d	Heavy trucks[4]	**≥6 axles**
	3e	Trolley buses	3-4 axles
	3f	Vehicles designed for extra low noise driving	3-4 axles[5]
Other heavy vehicles	4a	Construction trucks (partly off-road use)[4]	
	4b	Agr. tractors, machines, dumper trucks, tanks	
Two-wheelers	5a	Mopeds, scooters	Include also 3-wheel motorcycles
	5b	Motorcycles	

Table 1: Vehicle categories

[1] 3-4 axles on car & trailer or car & caravan. [2] Hybrid vehicles driven in combustion engine mode: Classify as either 1a or 1b. [3] Also 4-wheel trucks, if it is evident that they are >3.5 tons. [4] If a high exhaust is noted, identify this in the test report. Categorise this as 3b', 3c', 3d' or 4a'. [5] For example, low noise ('whisper mode') delivery trucks and buses.

(stack exhausts) an additional position at 3.5m should be used. However, emission data for these vehicles are not yet available. The rolling noise is assumed to radiate 80% from the lower source and 20% from the higher source. This allows for some 'smearing' of the source which in practice rarely takes the form of a discrete point source. The rolling noise for the reference condition is described by the equation:

$$L_{WR}(f) = a_R(f) + b_R(f)\log\left[\frac{v}{v_{ref}}\right]$$

where v_{ref}= 70 km/h. The coefficients $a_R(f)$ and $b_R(f)$ for each main vehicle category and third octave band from 25 Hz to 10 kHz are contained within a Harmonoise WP1.1 report **(3)**. The difference between category 2 (two-axle medium heavy vehicles) and category 3 (heavy vehicles with more than two axles) depends on the number of axles. It is assumed that L_W increases as 10 log (number of axles).

For propulsion noise 80% is assumed to radiate from a source at a height of 0.3m for light vehicles and at a height of 0.75m for heavy vehicles. *Figure 2* shows a plot of the sound emission of a stationary goods vehicle indicating the distribution of the propulsion noise based on measurements with a microphone array carried out at TRL by TNO of the Netherlands **(4)**.

Note that 20% of the sound power is assumed to radiate from the low source 0.01m above the road surface. In contrast to rolling noise it has been found that propulsion noise is best described as a linear function of speed:

$$L_{WP}(f) = a_P(f) + b_P(f)\left[\frac{v - v_{ref}}{v_{ref}}\right]$$

where the speed coefficient $b_P(f)$ is the same for category 2 and category 3 vehicles whereas $a_P(f)$ varies across all categories. The reference speed v_{ref} is again at 70km/h.

As would be expected propulsion noise is assumed to be independent of the road surface. The effect on the radiation of propulsion and rolling noise over a porous road surface is taken into account by introducing an appropriate road surface impedance into the propagation calculations. In *Figure 2* some examples of rolling and propulsion noise for light and heavy vehicles on a stone mastic surface (SMA) with 16mm maximum size chippings at a typical urban speed of 50km/h are shown.

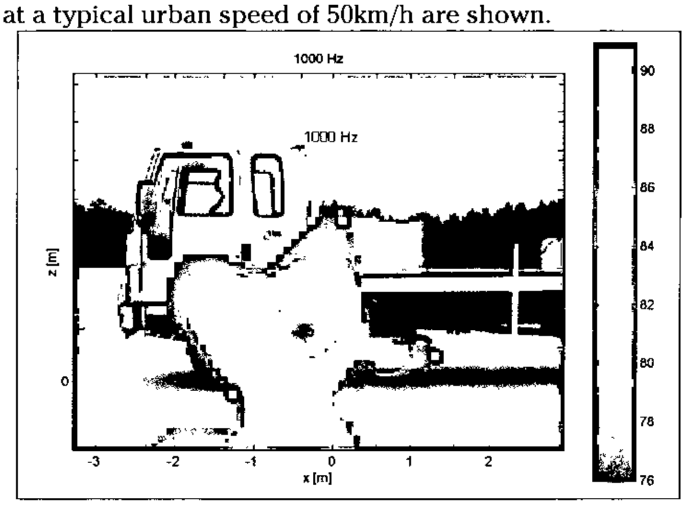


Figure 2: Third octave band level contours at 1 kHz for a stationary test on Ford Cargo indicating position of engine source and image in the road surface

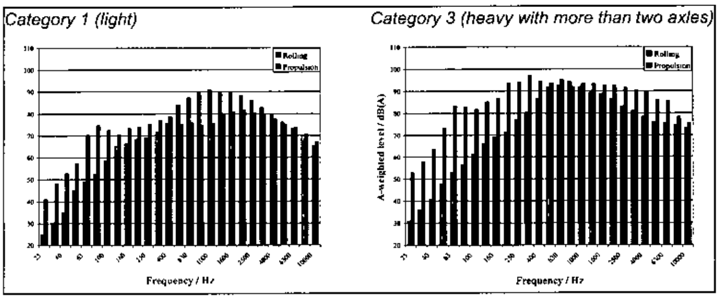


Figure 3: Sound power levels for rolling and propulsion noise at 50km/h on SMA (0/16)

It can be seen that below about 500Hz propulsion noise dominates whereas at mid frequencies rolling noise becomes relatively more important and dominates propulsion noise in the case of light vehicles. It can be shown that for light vehicles the rolling noise is in fact 7.7dB higher than the corresponding A-weighted sound power for propulsion noise. In the case of heavy vehicles it is the propulsion noise which is higher than the rolling noise. The difference (rolling noise-propulsion noise) in this case is -4.9dB.

At higher speeds the contribution of rolling noise to the total sound power radiated is greater across all vehicle classes. For example, at the higher speed of 100km/h on the same surface rolling noise becomes even more dominant in the case of light vehicles. The difference in the A-weighted level is 11.6dB. For heavy vehicles the difference between rolling and propulsion noise was found to narrow with a difference of -2.2dB.

Source model corrections

A number of corrections is made to the basic sound power levels. These include corrections for surface type and condition, acceleration and directivity of the sources and corrections for tyres.

The road surface taken as the reference for calculating rolling noise sound power has a maximum chipping size of 11mm and is a surface having the acoustic characteristics based on the average of dense asphalt concrete (DAC) and stone mastic asphalt (SMA) more than two years old but with no signs of deterioration.

Table 2 gives the correction to the rolling noise sound power levels for category 1 vehicles in terms of a simple decibel correction across all frequency bands by surface type and maximum chipping size. Note that owing to a lack of appropriate data there are no corrections for heavy vehicles. In addition there is at present no reliable correction for hot rolled asphalt (HRA). It is hoped to extend the range of corrections in the EC part funded IMAGINE project which will build on the results obtained in Harmonoise.

As an example of the correction a 14mm SMA over two years old would have a correction to rolling noise of +0.3 + 3 × 0.25 dB, ie +1.05dB. The corrections are made to each third octave band.

Road surface	**Correction relative to the reference**
Harmonoise reference with chip size 11 mm, (mean value of DAC and SMA)	0dB
DAC	-0.3dB
SMA	+0.3dB
Chip size (valid range 8-16 mm)	+0.25dB/mm above 11mm -0.25dB/mm below 11mm
Age (*T* years)	$-(0.2T^2 - 1.2T + 1.6)$; $T \leq 2$

Table 2: Corrections within the reference cluster for category 1 vehicles

For other surfaces outside this range of reference surfaces tables are given, based on Dutch data, which list the corrections by third octave band centre frequency for cars and trucks. However, the corrections are independent of speed and therefore must only be viewed as interim corrections pending further research. Corrections currently available included those for porous asphalt, surface dressing and brushed and exposed aggregate concrete.

Propulsion noise increases during acceleration and decreases during deceleration. The correction is given by

$\Delta L_{acc} = C \cdot a$; $-2\ ms^{-2} < a < 2\ ms^{-2}$

where a is the acceleration/deceleration in ms^{-2} and the coefficient C is given by *Table 3*. For category 3 vehicles an engine brake is often applied and in such cases the absolute value of the deceleration should be used thus increasing the level also when decelerating.

Vehicle category	C
Category 1	4.4
Category 2	5.6
Category 3	5.6

Table 3: Acceleration/ deceleration coefficient

Corrections are made to each frequency band of the propulsion noise component.

Propagation model

The building blocks of the propagation model in the engineering model form a 'point to point' model. Thus only one point source and one receiver position are treated at a time although there may be more than one propagation path owing to reflected sound. The contribution from each of the different point sources (including vehicle sub-source) is assessed one after the other. All calculations are

continued on page 23

Harmonoise models for predicting road traffic noise

continued from page 21

carried out in third octave bands from 25Hz to 10kHz, but a reduction to octave bands is optional if it is desired to reduce computation times. The calculation is repeated for all relevant meteorological classes. The long term average per period of the day/night is computed from weighting the results from each meteorological class considered by the frequency of occurrence of that class. Finally the results for the three periods day, evening and night are combined into a single index L_{den} taking into account the penalties for evening and night time periods.

Segmentation

To increase calculation speed the traffic source which can be approximated by a source line is divided into a number of segments along the road *(see Figure 4)*. For noise mapping purposes a reasonable value for the maximum angle each segment subtends at the receiver position (angle of view) is 5°. This can be decreased where greater precision is required. The contribution of each segment is represented by point sources placed in the middle of the segment. The point source has the correct sound power and height in order to simulate the vehicle flow and speed on that segment.

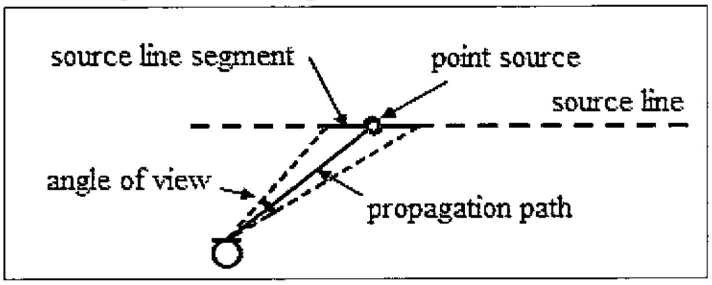


Figure 4: Segmentation of traffic stream

The contribution of the segment to the sound level at the receiver is determined by calculating the attenuation along the propagation path. The overall level is then obtained by summing the contributions from all segments.

The total attenuation between source and receiver is affected by geometrical spreading, atmospheric absorption, and attenuation due to barriers and ground surface. If reflected propagation paths are possible because of the presence of building facades or barriers, a correction is made for each successive reflection. The attenuation by the atmosphere is calculated according to the method described in ISO 9613-1 **(5)** with ambient temperature, pressure and humidity as input parameters.

Reflections and diffraction

For the computation of excess attenuation the approach adopted by the Nordic prediction model Nord2000 has been adopted with some further developments. The attenuation of sound over absorptive ground uses the model of Chien and Soroka based on the spherical reflection coefficient **(6)**. However, the point of reflection is no longer a mathematical point but an area bounded by an ellipse or Fresnel zone: the lower the frequency the larger the zone. Where the ground is 'mixed' the reflection coefficient is based on the weightings of coefficients for the different ground types within the zone **(7)**.

Diffraction effects of barriers and earth mounds are taken into account by the Deygout approximation **(8)**. The method can be extended to predict the attenuation using multiple diffracting edges and for earth bunds.

Meteorological effects

In order to assess the effects of meteorological refraction the radius of curvature from source to receiver is determined for each propagation path based on wind speed, wind direction, and atmospheric stability estimated from cloud cover and period of the day.

A combined linear/logarithmic sound speed profile is assumed:

$$c(z) = c_0 + Az + B\log\left(\frac{z}{z_0}\right)$$

where $c(z)$ is the speed of sound at a height z and A, B, c_0 and z_0 are constants. These profiles can be converted to equivalent linear sound speed gradients.

Under such conditions ray paths are transformed into circular arcs that can be constructed analytically. However, it has been found that rather than curving the sound rays there are computational advantages in curving the ground and maintaining straight ray propagation and results are comparable **(9)**.

Statistical variations of vehicle speed

Information is required on the statistical description of the input data and the influence of their variations on the outcome of the calculation of the Harmonoise engineering model. For example, it would clearly be useful to use average speeds if the actual speed distribution was insignificant. Variations in speed are known to effect the overall pass-by level but the effect of the statistical variation about a mean value on the long term average noise level are not well understood.

Consequently there is a need to examine the extent of the effect since, for example, it is not known to what extent the additional noise produced by relatively fast moving traffic cancels out the benefits of lower speed vehicles. There is also the variation of speed along a section of road where there is a junction, pedestrian crossing or traffic calming device. A similar situation arises where it is possible that the extra noise arising from accelerating vehicles leaving the junction or traffic calming device is compensated by the lower noise of vehicles required to decelerate.

To illustrate this, *Figure 5* shows the change in the average noise level L_{Aeq} for light vehicles that was predicted following the introduction of a junction where vehicles are required to stop. Close to the junction there is up to a 3dB increase in noise whereas beyond a distance of 50m from the stop line the increase is less than 1dB.

continued on page 24

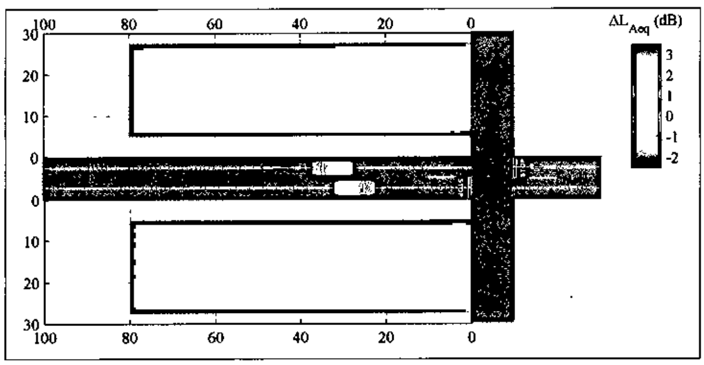


Figure 5: Increase average level L_{Aeq} for light vehicles approaching at 50km/h

Harmonoise models for predicting road traffic noise

continued from page 23

Validation

The reference propagation model has been validated through comparison with results from measurement surveys carried out at a number of sites. The measurement sites for road traffic noise are described in *Table 4*.

At each measurement site, acoustic and meteorological data were measured over intervals of 15 or 30 minutes. Acoustical data are recorded in third-octave bands from 50 to 4000 Hz. Meteorological measurements were performed with an ultrasonic anemometer, traditional cup-anemometers and thermometers. In addition, impedance measurements of the surrounding terrain were carried out. Traffic data was collected during the measurement interval including the number of vehicles and their speeds along each carriageway of the road.

The total measurement period at one measurement site ranged from 1 to 13 weeks. The microphones were located at approximately 25m, 150m, 300m, 600m and 1.2km from the edge of the nearside carriageway.

measurement site	sound source	geometry	measurement period
Ladenburg, Germany	4 lane motorway	flat terrain	02.08.02-11.09.02 and 18.03.03-25.04.03
La Crau, France	Road	flat terrain	18.10.02-25.10.02 and 08.04.03-15.04.03
Unna, Germany	6 lane motorway	flat terrain with 4m noise barrier	03.09.03-06.10.03
Uttrichshausen, Germany	4 lane motorway	hilly terrain	12.06.02-30.07.02

Table 4: Overview of the measurement sites

The results of these validations for the road sites are currently only available for Ladenburg and Unna. In addition, the predictions of the engineering model have been checked against the corresponding results from the reference model. In particular, the point-to-point excess attenuation in the engineering model has been compared with reference propagation computations for over 25,000 geometries for homogeneous meteorological conditions using a standard road traffic source. The results show for a road embankment an average difference in L_{Aeq} of less than 0.1dB and a standard deviation of just over 0.5dB.

Ladenburg

This site is a four-lane motorway (A5 in Germany) of total width 23m on a 1 to 3 metre high embankment. The surrounding is essentially flat farmland. Measurements were made in the autumn and again in the spring of the following year in order to span a range of meteorological conditions. *Figure 6* gives the comparisons between the measured and predicted L_{den} at 5 microphone positions (M1 – M5) at distances of 26, 153, 305, 547 and 1104 metres from the edge of the carriageway. All microphones were positioned at a height of 4m above local ground level except the closest microphone which was set at a height of 6m.

Figure 6 shows that the differences between predicted and measured values in both measurement periods did not exceed 1.5dB even at the furthest distance of over 1km. The average difference (predicted - measured) was -0.22dB in the spring and 0.02dB in the autumn.

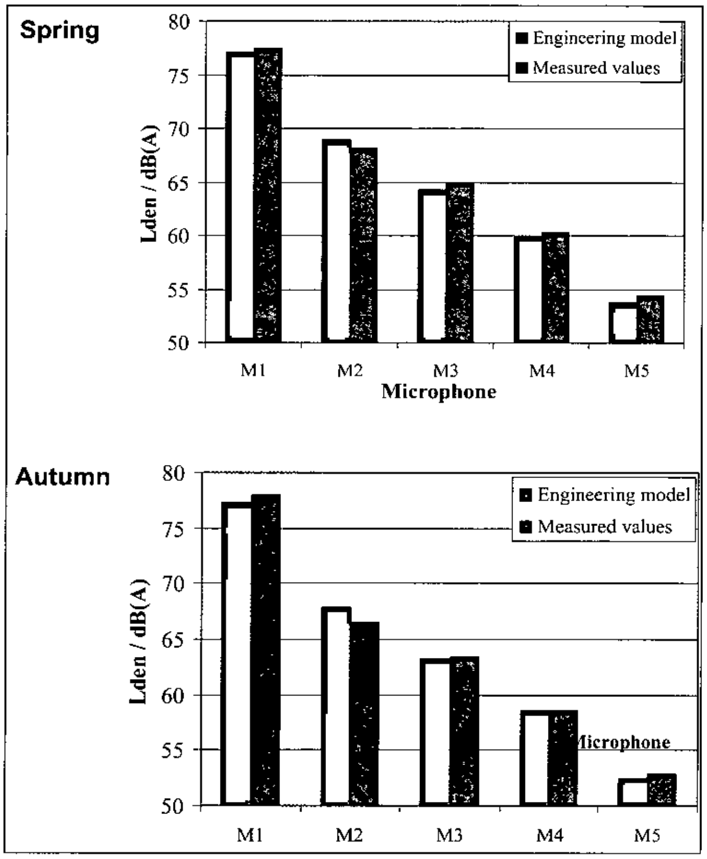


Figure 6: Comparison between predicted and measured L_{den} at Ladenburg

Unna

The site at Unna in Germany is the A5. The road is a four-lane motorway which runs on an embankment 6m above flat agricultural land. At the edge of the road is a 4m high noise barrier. Microphones M1 to M4 were placed at a height of 4m above local ground level at distances of 25, 150, 300 and 550 metres from the noise barrier, respectively.

Figure 7 shows the predicted measured values. The largest difference was 0.6dB and the average difference (predicted minus measured) was -0.2dB.

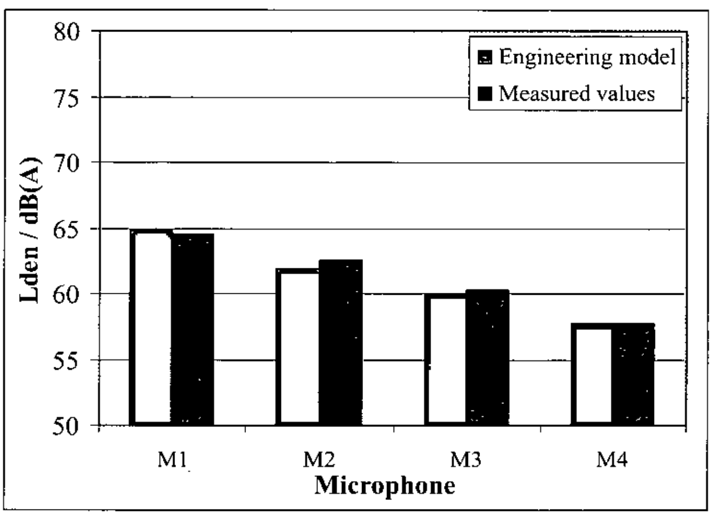


Figure 7: Comparison between predicted and measured L_{den} at Unna

Conclusions

The following conclusions can be drawn from this review of the Harmonoise project:

- The Harmonoise reference propagation model is based on state of the art prediction methods and has been used to validate the engineering model. The reference model is a toolkit of methods that can be used singularly or in combination. In many situations a hybrid model approach can be used. For example in the road cross-section the boundary element method can be used while in the far field a parabolic equation method can be used to take account of atmospheric effects.
- The engineering model uses a state-of the art source model combined with a simplified propagation model which utilises a ray model approach although atmospheric effects are taken into account. The engineering model is intended to be used in the production of noise maps in 2012.
- The engineering model has been validated against measured results at two road locations where the roads ran on embankments above essentially flat terrain. The differences between predicted and calculated values of L_{den} were never greater than 1.5dB even at a distance greater than 1km from the road. On average, the difference (predicted - measured) varied from 0.02dB to -0.2dB. However, further validation is required for example in the more complex situations typically found in urban areas.
- In the follow on project IMAGINE further refinement of the source model will take place and the method will be extended to include aircraft and industrial noise sources.

References

1 European Parliament and the Council of the European Union, 2002, Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise. *Official Journal of the European Communities*

2 Watts G R, 2005, Harmonoise prediction model for road traffic noise, *Laboratory Report PPR 034*, TRL, Wokingham

3 Jonasson H, Sandberg U, van Blokland G, Ejsmont J, Watts G and Luminari M, 2004, Source modelling of road vehicles, *Deliverable 9 of the Harmonoise project*

4 Watts G, Balsom M, Ainge M, Morgan M, Mast A, van den Dool and van der Toorn, 2003, Array and subtraction methods for characterising vehicle power train noise - an investigation for the European Harmonoise project, *Proceedings of Internoise 2003, Paper N476*, Seogwipo, Korea

5 International Organisation for Standardisation, 1996, Acoustics: attenuation of sound during propagation outdoors – Part 1: Calculation of the absorption of sound by the atmosphere, *ISO 9613-1, International Organisation for Standardisation*, Geneva

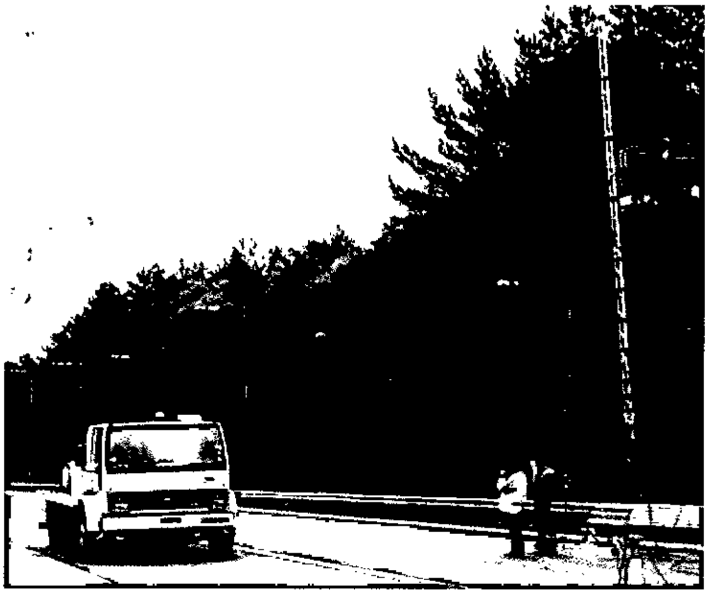
6 Chien C F and Soroka W W (1980), A note on the sound propagation along an impedance plane, *Journal of the Acoustical Society of America*, 69 (2), 340-343

7 Hottersall D C and Hariott J N B, 1995, Approximate models for sound propagation above multi-impedance plane boundaries, *Journal of the Acoustical Society of America*, 97, 918-926

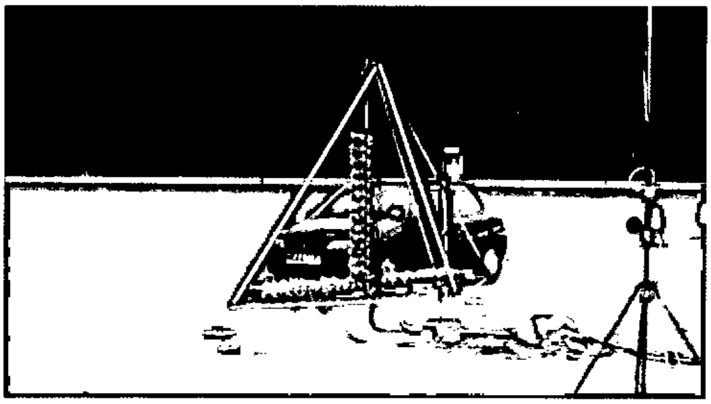
8 Deygout J, 1966, Multiple knife-edge diffraction by microwaves, *IEEE Trans. Antennas and Propagation*, 14(4), 480-489

9 Almgren M, 1987, Simulation by using a curved ground scale model of outdoor sound propagation under the influence of a constant sound speed gradient, *Journal of Sound and Vibration*, 118 (2), 353-370

Greg Watts *is with TRL, Crowthorne, Berkshire*



(a) Syntacan



(b) T-array
Figure 1: Views of microphone arrays

Array and subtraction methods for characterising vehicle noise sub sources

Arjan Mast, Teun van den Dool, Johan van der Toorn and Greg Watts

Within the European Harmonoise project (1) partly funded by the EC to develop a state-of-the-art prediction model for rail and road traffic noise, there was a need to determine the power and the effective heights of vehicle sound sub sources. Microphone array methods have the potential to provide both sound exposure levels (*SEL*) and source heights, while single microphone subtraction methods allow a precise determination of *SEL* for tyre/road noise and power train noise but not effective heights. Tests were conducted at TRL to determine the accuracy of two array methods developed by TNO by comparison with the single microphone subtraction method, and also to demonstrate the arrays' ability of revealing sound sub sources on light and heavy vehicles.

One array was in the form of an inverted T-shape (*Acoustic Camera*; shown in *Figure 1b*) with overall height of 1.5m. The other was a 9.5m long linear array (*Syntacan*; shown in *Figure 1a*) held in a vertical position. The single microphone subtraction method involved coast-by and cruise-by measurements at very similar vehicle speeds. Measurements were made on a surface conforming to ISO 10844, a porous surface (MARS6) and a hot rolled asphalt surface (HRA) which is commonly used on the UK road network. Test vehicles included two cars and two trucks.

Syntacan is a sound-measuring instrument with highly directional sensitivity, that has been developed and described by Boone (6). Its front end is a linear, 10 to 84 m long, sparse array of 20 to 32 microphones. *Syntacan* covers the octave bands with centre frequencies from 125Hz to 2kHz. TNO upgraded the instrument in 1994 and applied it to high-speed trains (8) and road vehicles (2). Van der Toorn *et al* have used the *Syntacan* to measure source heights and strengths for vehicles on a motorway (2). Using the array they were able to generate sufficient data to provide power levels and source heights for cars, lorries, buses and motorcycles.

During the tests presented below the antenna is used in a vertical position, with 24 microphones. Sound sources at different heights are measured by decomposing the impinging sound according to propagation directions and frequencies. An important advantage is that direct sound is measured by 'looking' directly at the source, eliminating ground effects. For a measurement distance of 10m the spatial resolution is 0.26m in the octave bands with centre frequencies 1000 and 2000 Hz and about 2m in the octave band with centre-frequency 125Hz. The 1-D vertical array integrates over a vehicle in the lateral direction and is therefore considered sufficient for characterising the vehicle sound sources for application in traffic noise prediction models.

A further development has been the T-array or *Acoustic Camera* that can be used to make images of both stationary and moving sound sources (3). The *Acoustic Camera* samples a passing vehicle and generates acoustical pictures based on the pass-by event. The pictures of one vehicle are projected back in a reference frame, which results in one 'photograph' of the vehicle at a reference distance, in which sound sources are shown and strengths of sound sub sources can be measured.

Figure 2 shows an example where the sound exposure level (*SEL*) values during pass-bys have been measured. Sound pressures are integrated within the white square to obtain the noise level of the front wheel. *Table 1* presents the measurement result.

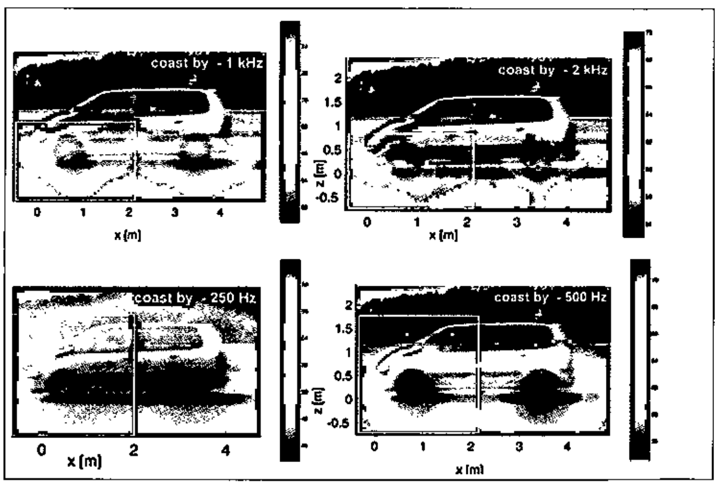


Figure 2: Example ***Acoustic Camera*** images of a test vehicle (Renault Espace coast-by at 50kmh^{-1})

source	400	500	630	800	1000	1250	1600	2000	2500	total
front wheel	47	56	57	57	59	56	55	50	45	65
rear wheel	52	56	56	59	60	57	54	52	47	66
total	53	59	59	61	63	60	57	54	49	68

Table 1: Sound exposure levels (*SEL*) of different sound sub sources in [dB(A)], as measured in Figure 2

The *Syntacan* as well as the *Acoustic Camera* are examples of sparse arrays. The *Syntacan* is equivalent to a full, linear array that is twice as long (6). The T-shaped *Acoustic Camera* represents a full planar array that is as wide as the T and twice as high (7). Spatial cross-correlation beam steering is applied to the microphone signals as an efficient procedure to identify the directions of sound propagation and to obtain the emission levels of multiple uncorrelated noise sources. This technique provides image resolutions equivalent to that of a full array, but requires significantly fewer microphones. This results in substantially lower cost due to reduced requirements for data acquisition and signal processing.

The *Syntacan* as well as the *Acoustic Camera* have one calibrated Brüel & Kjær microphone as reference. This enables the time history of the sound pressure level to be sampled during pass-by. The other microphones in the array are used to determine the direction of the incident sound.

The *single microphone subtraction method* relies on examining the differences between the noise levels obtained during cruise-bys and coast-bys. Although the source height cannot be determined directly, the difference in *SEL* levels under the two conditions allows an estimate of the sound power of propulsion noise (engine, exhaust and transmission). Note that the tyre/road noise component measured during coast-by would in addition include a contribution from any aerodynamic noise. Jonasson (4) describes tests carried out with a car at a speed of approximately 70 kmh^{-1}. The differences between cruise-by and coast-by were small (<2dB) at frequencies above 100Hz demonstrating the importance of tyre/road noise at such speeds.

Test procedures

To allow comparisons between an array technique (TNO methods) and the single microphone subtraction, simultaneous measurements were taken for each pass-by. However, the two array techniques could not be used together due to lack of sufficient microphones, so most runs were repeated to provide comparable measurements with both the T-array and *Syntacan*.

Road surfaces and vehicles

Initially test measurements were made on an ISO test surface, which is a fine graded surface that is used for vehicle noise emission tests, and conformed to the specification given in ISO 10844 (5). This surface was developed to test the noise emitted from the power unit related sources on the vehicle and was therefore intended to minimise the contribution from tyre/road noise. This was achieved by limiting the texture depth by specifying a small maximum chipping size of 8mm and placing a lower limit of 0.4mm on the mean value. In addition a reflective low absorption surface was specified with a normal incidence sound absorption value α of less than 0.1.

In addition a relatively high textured bituminous hot rolled asphalt surface with pre-coated chippings (HRA) was used for testing. This has been widely used on the trunk road and motorway network in the UK.

Lastly, a porous bituminous surface with maximum stone size of 6mm was employed (MARS6). The HRA produced relatively high levels of tyre/road noise while the MARS6 produced relatively low levels.

The vehicles tested on the ISO surface included: Peugeot 106 (diesel engine), Renault Espace (petrol engine), Ford cargo truck (4 × 2 flatbed with diesel engine) and Daf 95 (4 × 2 tractor unit with diesel engine).

It was also important to ensure that for a particular comparison the speeds of pass-bys under coast and cruise conditions were very similar, so that the subtraction would yield the true contribution of the power train sources. Generally this was ensured by carrying out two or more coast-by conditions first and recording the speeds achieved. Three cruise-bys were then carried out in order to match one of the speeds achieved in coast-bys as closely as possible. A radar speed meter was used to indicate the speed as the vehicle passed the microphones.

After each run the driver was given feedback on his performance in matching speeds. Often an identical pair of radar speed readings was obtained but occasionally this was not possible and a difference of 1kmh^{-1} was accepted. During coast-bys the driver was instructed to cut the engine and disengage the transmission before reaching the entrance to the test section.

Single microphone subtraction measurements

Both A-weighted *SEL* and maximum levels were recorded over a 30m length of the test surface. The measurement of *SEL* followed the method proposed by

continued on page 29

Array and subtraction methods for characterising vehicle noise sub sources

continued from page 27

Jonasson **(4)**. The positions of the microphones are shown in plan in *Figure 3*.

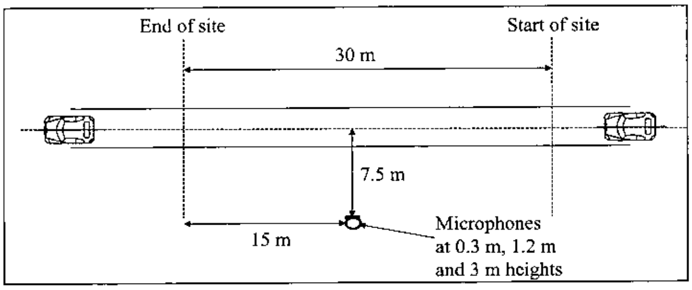


Figure 3: Location of single microphone and Syntacan at the test site (note that the measurement distance of the Acoustic Camera was closer at 2.5m)

Microphones were set up at heights of 0.3, 1.2 and 3m at a distance of 7.5m from the middle of the test lane. Infra-red sensors were set up at the entrance and the exit of the test area which was 30m long, and the microphones were positioned opposite the midpoint position. Reflective strips were attached at the midpoint position on each vehicle tested.

Two Brüel & Kjær 2144 analysers were used to collect noise data from the three microphones and the pulses from the infra-red detectors at the entrance and the exit to the test strip. The pulse generated as the vehicle entered the test strip started the sampling and the number of samples taken for analysis was determined from the time interval (*T*) between entry and the exit pulses. Samples were taken every 30ms and the averaging was set at 'fast' exponential. The frequencies analysed ranged from 20 to 10,000 Hz. The L_{Aeq} was obtained by averaging the samples over period *T*, and the *SEL* was derived from:

$$SEL = L_{Aeq} + 10\log T \quad (1)$$

The maximum level L_{Amax} was obtained by finding the maximum value of the samples taken within the time interval *T*.

Array measurements

The *Syntacan* as well as the *Acoustic Camera* register the time signals on the different microphones during the time interval *T*. The *Acoustic Camera* samples a passing vehicle by dynamically focussing on the vehicle. In the data post-processing process different acoustical pictures are generated during the time interval *T*, by performing a decomposition of the sound field in the directions of sound propagation. These directions are connected with sound sub source positions. From the corresponding sound pressures sound sub source strengths can be calculated. The different pictures are projected in one 'photograph' in which sound sources are shown, and partial source strengths can be measured, as has been shown in *Figure 2*. The time signals *Syntacan* registers are decomposed in the directions of sound propagation in the vertical plane only, and integrated in time to measure the sound exposure level *SEL*.

The resolution of the *Acoustic Camera* image is almost equal to the *Syntacan* plots. Although the *Syntacan* is much longer (10m against 3m), it was positioned 7.5m from the middle of the lane, whereas the *Acoustic Camera* was only 2.5m from the middle of the lane. Because the resolution depends on the length of the array, the wavelength of interest and the distance to the sound source, the two arrays have similar resolutions.

Results

Light vehicles

All results presented for the single microphone subtraction method were obtained for the 1.2m high microphone and are given in terms of *SEL* calculated over the 30m test surface. It is expected that the results for the contribution of the power train noise will not differ greatly for the different microphone heights but this will need to be checked during subsequent analyses.

The pass-bys selected for analysis for the T-array and single microphone subtraction methods were identical but tests with the *Syntacan* were taken on the following day and it was not always possible to match speeds exactly. However, the speed differences between runs were of the order of 1-2 kmh^{-1} and it is unlikely this variation would make a substantial difference to the calculations of the power train contribution.

The array methods are limited in frequency range from 200-2,500 Hz and for this reason it is only possible to compare the results from the single microphone subtraction method in this range. The TNO analysis has concentrated on measurements taken on the ISO surface and these will be presented in this paper. *Figure 4* compares the power train noise calculated for the Peugeot 106 at 49-50 kmh^{-1}.

It is clear that over the frequency range from 200 to 2,500 Hz the methods show similar trends of increasing power while frequency and differences are generally less than 5dB.

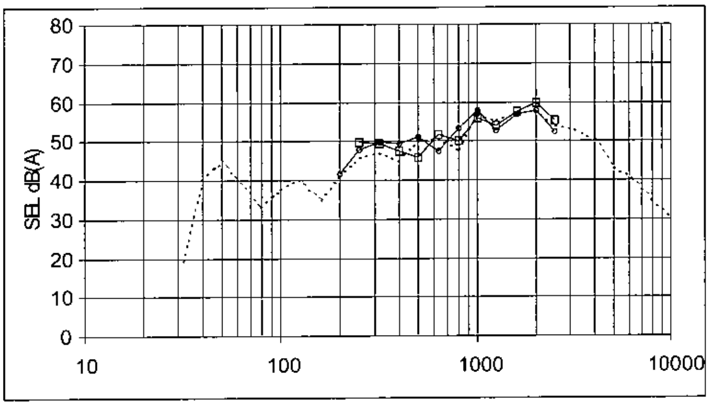


Figure 4: A-weighted SEL third octave band levels for power train noise of the Peugeot 106 at 49-50 kmh^{-1} calculated for T-array (-o-), Syntacan (-∂-) and single microphone subtraction (...) methods

The T-shape array was used to obtain contour plots of the sound exposure level during pass-by that were superimposed on a picture of the vehicle. *Figure 5* shows examples of these contour plots for the Peugeot 106. *SELs* of specific sources (*eg*

continued on page 30

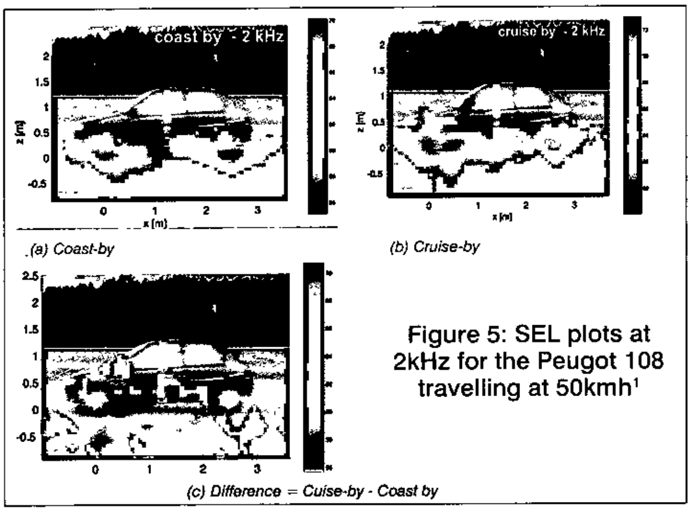


Figure 5: SEL plots at 2kHz for the Peugot 108 travelling at 50kmh[1]

Array and subtraction methods for characterising vehicle noise sub sources

continued from page 29

front or rear wheel) can be measured by integrating the energy over the area of interest in the picture as has been shown in *Figure 2*. These 'acoustic pictures' were taken during both cruise-by and pass-by so that it was possible by subtraction to get a fair estimation of the location and the absolute strength of the apparent power train sub-sources. The dynamic range of the 'acoustic pictures' was 15dB.

It can be seen that the effective source position of power train noise lies between the vehicle body and the track surface and is concentrated behind the front wheel. There is a smaller contribution from the exhaust pipe outlet behind the rear wheels. Similar source positions were found for the other vehicles tested.

Figure 6 compares the results for power train noise for the Renault Espace. The general trends are similar with fairly good agreement between the array and single microphone subtraction methods *ie* within 10dB.

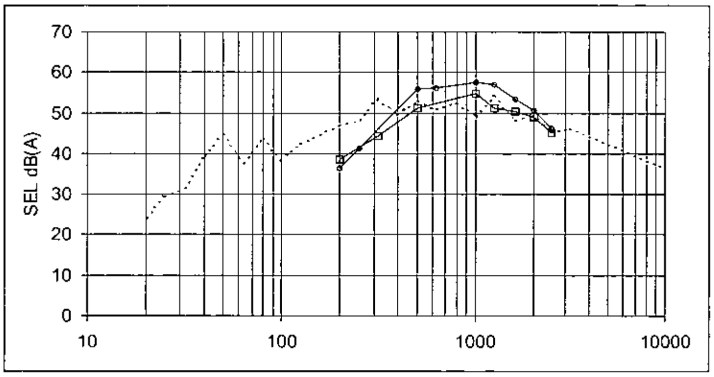


Figure 6: A-weighted SEL third octave band levels for power train noise of the Renault Espace at 50-51 kmh^{-1} calculated for T-array (-o-), Syntacan (-∂-) and single microphone subtraction (...) methods

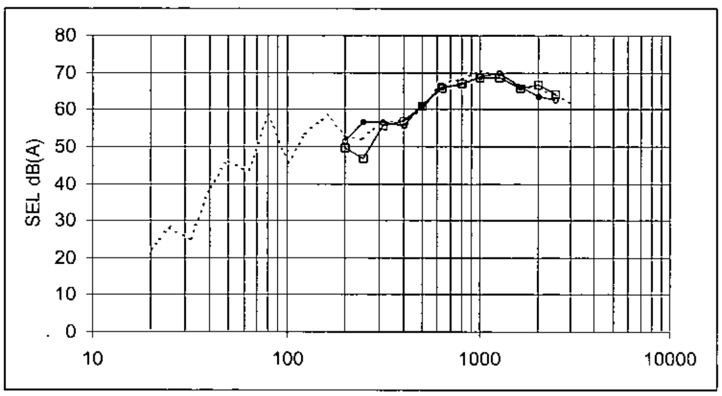


Figure 7: A-weighted SEL third octave band levels for power train noise of the Ford Cargo at 35-36 kmh^{-1} calculated for T-array (-o-), Syntacan (-∂-) and single microphone subtraction (...) methods

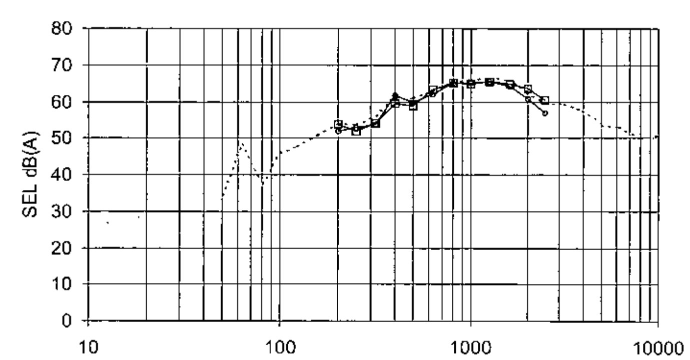


Figure 8: A-weighted SEL third octave band levels for power train noise of the Daf 95 at 35-36 kmh^{-1} calculated for T-array (-o-), Syntacan (-∂-) and single microphone subtraction (...) methods

Heavy vehicles

Figure 7 shows the good agreement obtained for the power train noise for the Ford Cargo at 35-36 kmh^{-1}. Differences between the spectra obtained with different methods are never greater than 3dB except at 250Hz where the difference is 9dB.

Figure 8 gives the results for the Daf 95. The general trends for the methods are very similar especially at the lower speed, where differences were less than approximately 3dB. There were very few missing values and it is likely that the large power train contribution to the total power output was responsible for ensuring good measurement accuracy.

Examples of sound source localisation

The *Acoustic Camera* spectra have been normalised to a measurement distance of 7.5m to make the calibrated levels directly comparable with the *Syntacan* spectra measured at 7.5m.

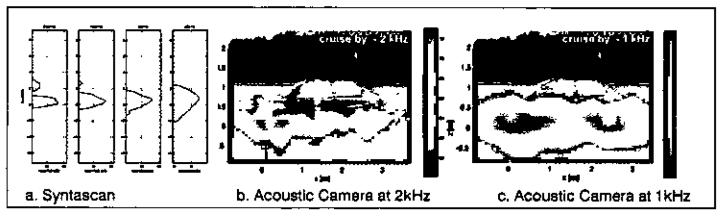


Figure 9 Syntacan plot and Acoustic Camera pictures of the Peugeot 106 at cruise-by at 50kmh^{-1}

Figure 9 reveals that *Syntacan* and the *Acoustic Camera* locate the noise sources at the same height. The *Acoustic Camera* image of the Peugeot 106 cruise-by at 50kmh^{-1}, shows front and rear wheels separately, where the *Syntacan* only shows one noise source at the road surface.

The coast-by results shown in *Figure 10* of the Peugeot 106 and the Renault Espace are of particular interest. The noise levels of the front wheel and the rear wheel appear to be the same. Besides this, the noise level at the rear wheel of the Renault Espace is the same during coast-by and cruise-by. The cruise-by and coast-by sound levels of the Peugeot 106 rear wheel show a 1dB difference.

The engine noise of the Renault Espace is dominated by the rolling noise. The total noise level of the Renault

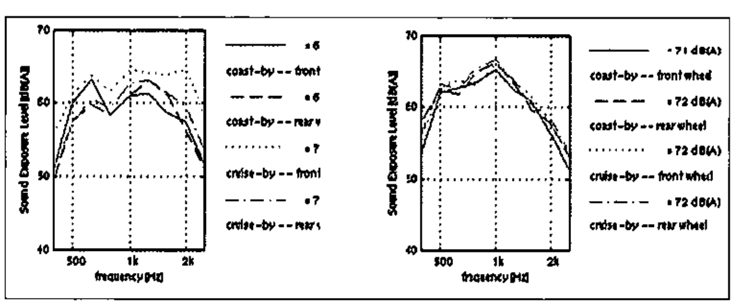


Figure 10 Third-octave spectra of front wheel and rear wheel at coast-by and cruise-by condition at 50kmh^{-1} for: (left) Peugeot 106 and (right) Renault Espace

Espace at cruise-by is almost the same as for coast-by condition. Listening to this car reveals that this car is very silent. The engine is almost not heard.

In these cases the rear wheel represents quite accurately the tyre/road sub sound source, also under cruise-by condition. This observation makes it possible to apply the 2-dimensional array for measuring tyre-road noise along the public road, by selecting the less noisy wheel of passenger cars.

For the Ford Cargo *(Figure 11)* and the DAF tractor however, the difference in noise level of the rear wheel for coast-by and cruise-by was varying between −1dB and 3dB, probably due to a worse separation of the noise from the rear wheel and other noise sources at the rear, *eg* rattle noises.

The images of the *Acoustic Camera* for the two passenger cars (Peugeot 106 and the Renault Espace) at cruise-by condition show that the noise from the engine is radiated around the front wheel, and from the space between the car body and the road surface *(see Figure 2)* Tyre/road noise and drive line noise can not be distinguished well for the wheels that are near the engine compartment.

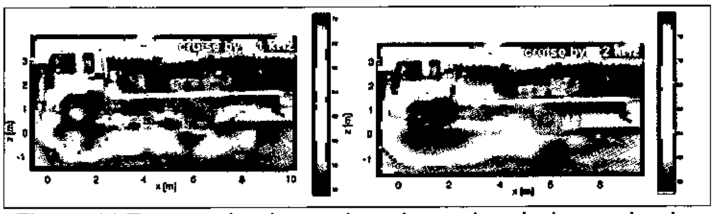


Figure 11 Tyre-road noise and engine noise during cruise-by of Ford Cargo at 35kmh^{-1}

The engine compartments of the Ford Cargo and the DAF tractor lie higher above the ground than in the case of passenger cars. *Figure 11* shows that the engine noise is radiated around the front wheel and combines with the tyre-road noise. Subtracting the spatially distributed sound sources of the coast-by event from the sources during cruise-by results in a picture of the apparent driveline sound source distribution. *Figure 12* and *Figure 13* show the results for the Peugeot 106 and for the Ford Cargo

continued on page 32

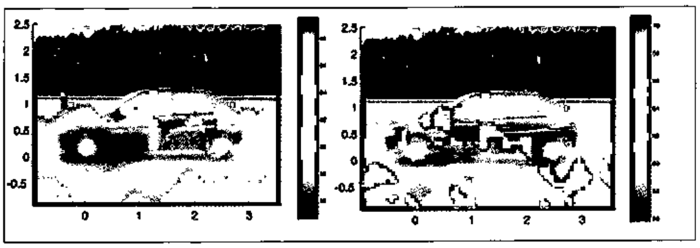


Figure 12 Estimated image of the driveline noise of the Peugeot 106 at 50kmh^{-1}, in the octave bands with centre frequencies 1kHz (left) and 2kHz (right)

(The white parts in the second image of this figure are due to artefacts of the graphical processing of the images. The white parts should be considered as transparent).

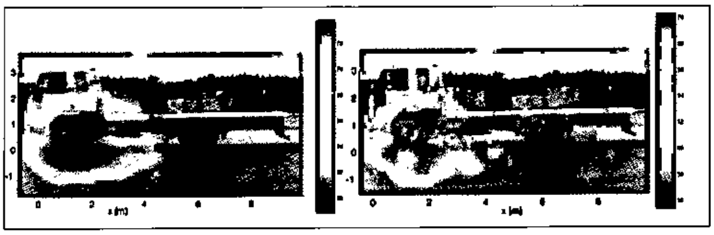


Figure 13 Image of the driveline noise of the Ford Cargo at 35kmh^{-1}, in the octave bands with centre frequencies 1kHz (left) and 2kHz (right)

Array and subtraction methods for characterising vehicle noise sub sources

continued from page 31

respectively. The hot spot of the engine is behind the wheel. Results for other cars and driving speeds appeared to be similar.

Figure 14 shows an example of flow noise sources that were detected with the *Acoustic Camera*. Flow noise, however, did not contribute significantly to the total sound level of the vehicle. The white circle indicates the noise source generated by the side mirror. In the middle of the vehicle the light reflecting strip appears as a source of flow noise.

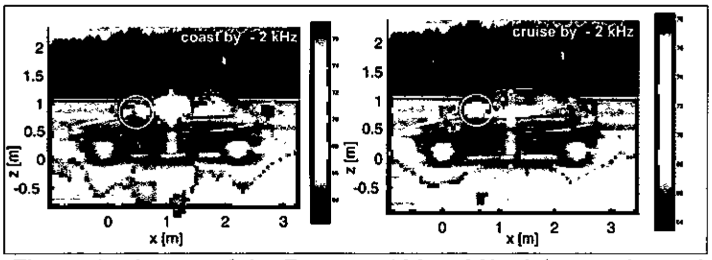


Figure 14: Image of the Peugeot 106 at 90kmh^{-1} coast-by and cruise-by in the 2kHz octave band.

Conclusions

Using the single microphone subtraction method and based on measurements at a height of 1.2m and 7.5m from the middle of the vehicle track, it was possible to estimate power train noise levels in terms of *SEL* over a wide frequency range from 20-10,000 Hz. These measurements indicate that the fundamental engine firing frequency below 100Hz is readily detected in all vehicles under all conditions tested, except that it was found to be insignificant in the petrol engine car (Renault Espace) at a relatively high speed (84kmh^{-1}). From these results it will be possible to calculate the sound power level using an appropriate propagation model **(4)**. Note that further work, not reported here, demonstrated that the results are insensitive to the road surface over which the tests are conducted since very similar results were obtained from relatively quiet and noisy road surfaces (reflective hot rolled asphalt (HRA) and absorptive MARS6). Errors will be largest where the contributions are relatively small although it has also been demonstrated that the method is sufficiently accurate to detect a weak aerodynamic noise source. It is considered especially important to closely match speeds when comparing results from coasting and cruising runs so that the tyre/road noise is very similar under the two conditions.

Generally, the *SEL* results from the array methods agree well with the trends obtained with the single microphone subtraction technique with maximum differences confined to 10dB in most cases. The array methods were restricted to a frequency range of 200 to 2,500 Hz so it has not been possible to make comparisons at low (20-160 Hz) and high (3,150-10,000 Hz) frequencies. This agreement supports the use of array methods for determining sub-source power levels. The arrays identify sound sub sources, measure their positions and absolute strengths, and show their relative importance within this frequency range. For the cars tested it was demonstrated that the main sub-sources lie between the vehicle body and the road surface.

The two-dimensional array results show that power train noise of the front wheel driven passenger cars is radiated around the front wheel and via the spacing between vehicle body and road surface. Also the power train noise of the Ford Cargo and the DAF truck appeared to be radiated around the front wheel. The *Acoustic Camera* separates sounds of the front wheel and the rear wheel of a passing passenger car for frequencies above 400Hz. The power-train sound level of a passenger car in real traffic can be estimated in this frequency interval by subtracting the sound level of the less noisy wheel from the sound level of the more noisy wheel (the wheel that is closer to the engine). The source strength of the less noisy wheel is an estimate for the strength of tyre/road noise. The apparent location and the levels of power train noise of heavy vehicles can be estimated applying the subtraction method.

References

1 www.Harmonoise.com

2 J D van der Toorn, T C van den Dool and W J A van Vliet, 2001, Sound emission by motor vehicles on motorways in The Netherlands: 1974-2000, *Proceedings of the International Congress and Exhibition on Noise Control Engineering, Internoise 2001*

3 Arjan Mast, Teun van den Dool, Johan van der Toorn and Greg Watts, 2003, Sound photographs to reveal vehicle pass-by sources with a calibrated source-strength level, *Proceedings of the Tenth International Congress on Sound and Vibration*, Stockholm

4 H G Jonasson, 1999, Measurement and modelling of noise emission of road vehicles for use in prediction models, *SP Report 1999:35*, Borås, Sweden

5 International Organisation for Standardisation, 1994, Acoustics - Specification of test tracks for the purpose of measuring noise emitted by road vehicles, *ISO 10844*, Geneva

6 M M Boone, Design and development of a synthetic acoustic antenna for highly directional sound measurements, *Thesis*, Delft, 1987

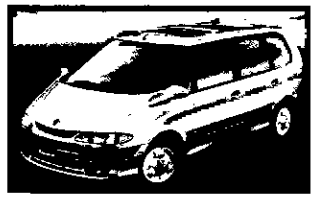
7 M M Boone, N Kinneging, T C van den Dool, Two-dimensional noise source imaging with a T-shaped microphone cross array, *J Acoust Soc Am* **108** (6), December 2000. pg. 2884-2890

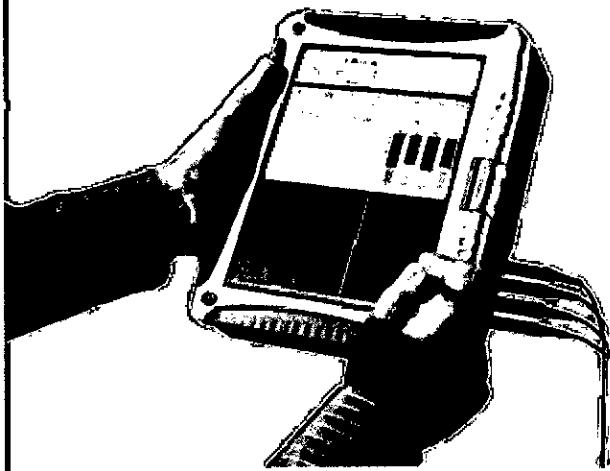
8 J D van der Toorn, H Hendriks, T C van den Dool, Measuring TGV source strength with Syntacan, *J Sound Vib* **193** (1), 1996, pp 113-121

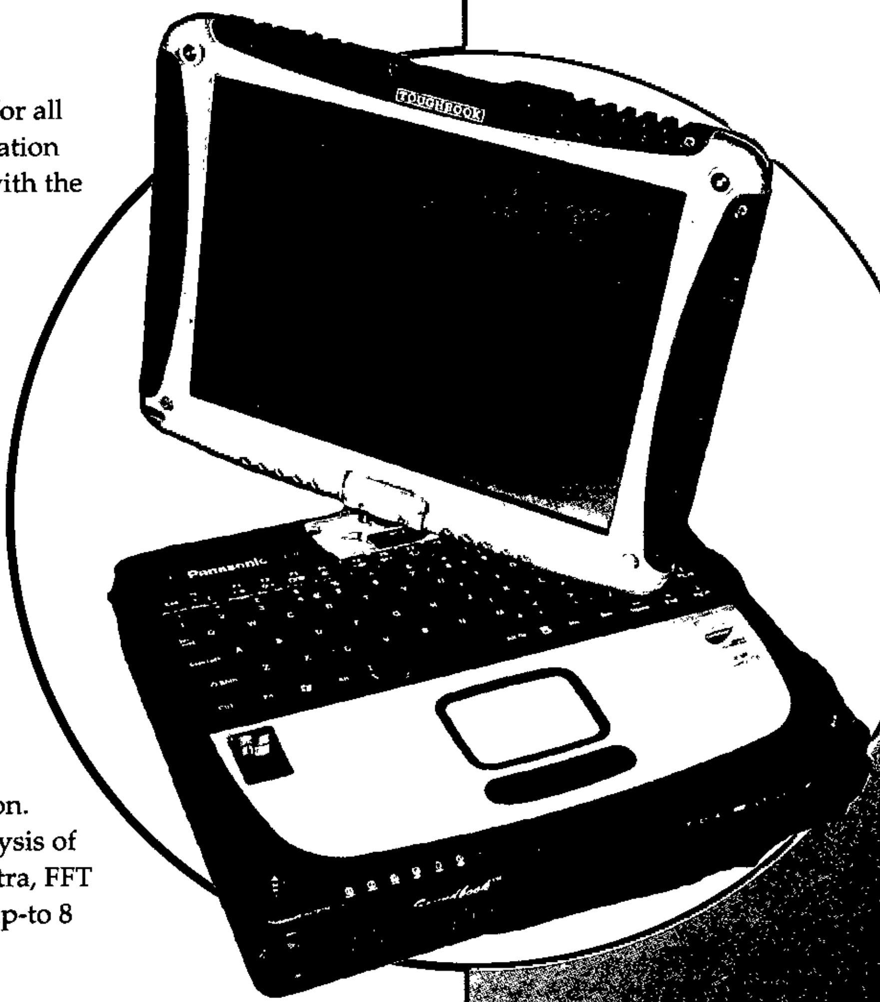
Acknowledgements: The authors acknowledge the support by the Netherlands Ministry of Housing, Spatial Planning and the Environment and the UK Department for Transport and the Department for Environment, Food and Rural Affairs.

Arjan Mast, Teun van den Dool, Johan van der Toorn *are with TNO, PO Box 155, NL-2600 AD Delft, The Netherlands*
email address: arjan.mast@tno.nl, teun.vandendool@tno.nl, johan.vandertoorn@tno.nl

Greg Watts *is with TRL Ltd Crowthorne House, Nine Mile Ride, Wokingham, Berkshire, RG40 3GA*
email address: grwatts@trl.co.uk







The Merseyside Noise Study

Peter Hepworth

Research was commissioned in 2003 to investigate the impact of ambient noise levels on residents on Merseyside. The project's key aim was to ascertain the extent to which people on Merseyside perceived noise to be a problem and to identify which types of noise and noise sources are perceived to have the greatest impact. The study was commissioned by the Merseyside Transport, Health and Environment Forum, which comprises representatives from the five Merseyside councils (Sefton, Liverpool, Knowsley, St Helens, Wirral), the passenger transport authority, Merseytravel, the Primary Care Trusts and other interest groups. The information has been obtained to provide base data to assist in developing an environmental noise strategy for Merseyside, and subsequently to formulate, adopt and implement a noise action plan for the region. This paper describes briefly the results of the study and considers some of the obstacles that will have to be overcome in developing a noise action plan.

Approximately 1.4 million people live in Merseyside. The region exhibits a wide range of environments, land use patterns, socio-economy and demographics. The project was primarily concerned with the impact of transportation noise. The region has a well developed transport infrastructure including a number of motorways (M57, M62, M58 and M53), railways, an international port, and an international airport.

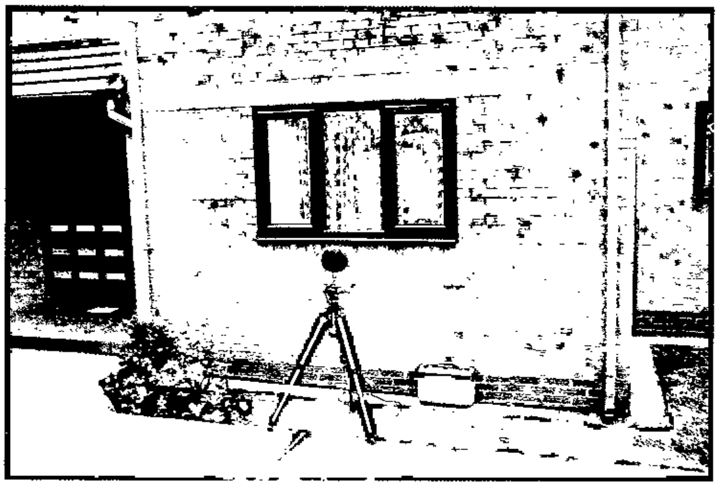
In order to be in a position to formulate a framework in which an environmental noise policy can be developed for the Merseyside region, it is first necessary to understand the current impact of noise on the resident population. Therefore, in accordance with the project brief, the following work was carried out:

- **Review of available research and information about the contribution and significance of transport noise to overall background noise levels;**
- **Review of current thinking and research on the effects of noise, specifically transport-related noise, on quality of life and interpretation of its relevance for Merseyside;**
- **Identification and assessment of the perception of the noise environment experienced by people in Merseyside and, in particular, the sources that are most prevalent and most likely to cause annoyance, with specific reference to the perception of transport sources;**
- **Characterisation of the range of ambient noise conditions occurring on Merseyside, particularly in relation to transport noise;**
- **Recommendation of a framework within which a possible future Merseyside environmental noise strategy could be developed that will address key noise related issues and the possible role of the transport sector;**
- **Identification of the requirements for further research and information as a basis for better describing the key factors affecting people's experience of noise.**

Surveys

Noise surveys

In accordance with the project brief a survey of noise levels was carried out over 24-hour periods at 90 locations throughout Merseyside. The survey locations covered ten examples in each of nine different noise environments. The aim was to choose typical sites rather than sites representing the extremes of the noise environments.



Measurements were made at nine different types of noise environment

The noise survey work was carried out in spring and autumn 2003, thus avoiding the school holiday period. Automatic data logging sound level meters were used fitted with 'all weather kits', although surveys were not carried out during periods of heavy rain or strong winds. As the survey was to be unattended, safe and secure locations had to be found. The local Environmental Health Officers suggested possible survey areas and it was then a case of our staff 'door knocking' to gain access to suitable sites. These were mainly residential properties with some public buildings and offices. Where possible the microphone was located at a height of 1.5 metres above the ground. However in some inner city areas, microphones had to be extended from first floor windows.

The nine different types of environment where noise measurements were made were:

i) **Adjacent to a busy urban road**
ii) **Adjacent to a motorway**
iii) **Adjacent to a railway line**
iv) **Adjacent to a transport interchange**
v) **In a suburban residential street**
vi) **In a city/town centre**
vii) **Near the airport**
viii) **In a city park**
ix) **In a rural area**

In addition, noise contour mapping of 15 different locations was undertaken, and 15 further 24-hour noise surveys were carried out at the same locations to investigate the correlation of noise mapping results with actual values.

Attitude surveys

A public perception survey on noise sources and attitudes to noise was carried out at a random sample of ten households in each of the 117 wards in Merseyside.

The surveys were carried out by Woodholmes, acting as a sub-contractor to Hepworth Acoustics. The survey questionnaire was based on the questions used in the *UK National Noise Attitude Survey* **(1)** so that direct comparisons could be drawn between the Merseyside and national results.

Findings

Noise surveys

The study resulted in a considerable amount of noise data but it is only possible to summarise some of the findings in this article. *Table 1* shows a summary of the daytime and night-time L_{Aeq} results for the nine different types of environment. The table shows the mean values and the range of values.

There is a 15dB L_{Aeq} range in the mean results for the nine types of environment, during both day and night. For each type of environment there is a range of levels of between 10 and 22 dB L_{Aeq} during the day and 8 and 21 dB L_{Aeq} at night, with the greater range of levels generally appearing at those locations with the highest mean values. This illustrates that there is a wide range of noise levels associated with nominally similar types of area.

The table shows that locations adjacent to busy roads are the noisiest of those monitored. Parks, particularly during the daytime, are shown not to be particularly quiet areas. This is probably because many were located in urban areas close to main roads and, also, for reasons of security of the monitoring instrumentation, the noise measurements were generally carried out at residential properties on the edges of parks: noise levels may well be lower in the middle! The table also demonstrates that suburban residential areas are slightly quieter than rural areas.

survey location type	mean daytime noise level dB $L_{Aeq,16hr}$	range of daytime noise levels dB $L_{Aeq,16hr}$	mean night-time noise level dB $L_{Aeq,8hr}$	range of night-time noise levels dB $L_{Aeq,8hr}$
urban road	65	52-73	58	44-64
motorway	61	52-67	55	46-60
transportation interchange	60	48-70	55	42-63
town centre	58	52-68	51	44-62
park	57	44-72	47	38-56
railway	56	50-66	52	44-62
airport	54	47-60	48	40-55
rural	51	47-58	45	39-51
suburban	50	46-56	43	40-48

Table 1: Summary of L_{Aeq} results in different environments

In Merseyside there is a network of motorways and main roads passing through most of the rural areas. The open nature of rural areas means that traffic noise can propagate over a considerable distance whereas, in suburban areas, the density of housing acts to minimise the spread of noise. Thus, some suburban areas can be quieter than some rural areas.

Public attitude surveys

Results of the public attitude survey demonstrate that noise is an important issue for people living in Merseyside. When asked about the factors that have a negative impact on their quality of life the residents placed noise as the fourth most important factor after 'litter and graffiti', 'crime and personal security' and 'traffic congestion'.

Road traffic noise was found to be the most common type of noise heard by the interviewees (79%) and was also the type of noise source that bothered the highest percentage of interviewees (44%). Interestingly 30% of those that reported hearing traffic noise consider that it has become 'definitely worse' over the last five years.

continued on page 36

The Merseyside Noise Study

continued from page 35

The results of the survey indicate that as many as 340,500 residents across Merseyside may have their home lives either 'totally spoilt' or 'spoilt quite a lot' by noise. It is also estimated that some 354,000 Merseyside residents may have their sleep affected by road traffic noise.

Comparison with national studies

National noise and attitude surveys have been carried out recently in England, with the *National Noise Attitude Survey* (NAS) **(1)** being carried out in 1999/2000 and the *National Noise Incidence Study* (NIS) **(2)** in 2000/2001. However, the only NAS sites on Merseyside were ten addresses from each of five wards in Liverpool. Similarly in the NIS, noise measurements were only carried out at 20 sites in Merseyside, all of which were in Liverpool. Therefore, data from the national studies are not sufficient to provide the necessary information on the response to different types of noise on Merseyside that is required to develop a noise action plan.

Road traffic was found to be the most common type of noise heard by interviewees

In accordance with the project brief, the noise survey locations for the Merseyside study were chosen to provide a representation of the noise levels experienced in a number of land use categories across Merseyside. The locations were not chosen to make the noise measurements statistically representative of the population of Merseyside. However, the measurement locations for the NIS were chosen to be statistically representative of the population of England and Wales so that figures could be derived for percentage of the population exposed to different noise levels. This means that the results obtained from the Merseyside measurements and the NIS are not directly comparable.

The results of the Merseyside noise monitoring show that 47% of the locations had noise levels above a daytime level of 55dB $L_{Aeq,16hr}$ and 67% of the locations exceeded the night time level of 45dB $L_{Aeq,8hr}$. To put this into a national context, the NIS 2000 found that 55% ± 3% of the population of England and Wales was exposed to daytime noise levels above 55dB $L_{Aeq,16hr}$ and 68% ± 3% of the population was exposed to night time noise levels above 45dB $L_{Aeq,8hr}$.

Noise mapping

Some initial noise mapping was carried out in 15 locations using the 'LIMA' noise modelling software. The Forum had hoped that it would prove possible to adopt a 'broad brush' noise mapping approach in order to quantify the percentage of population in Merseyside exposed to different levels of transportation noise based solely on propagation distance from the source. However, in order to obtain the required level of accuracy, it was found that fully detailed noise mapping was necessary taking into account noise shielding by barriers/buildings, ground type, and topography.

The opportunity was taken to carry out 24-hour noise monitoring at 15 locations in order to check the accuracy of the detailed noise mapping. A very good correlation was found with a mean difference between calculated and measured A-weighted values of 1.5dB for the daytime and 0.8dB at night.

In order accurately to quantify population exposure to transportation noise on Merseyside a full noise mapping exercise will be necessary to cover the whole region. The fact that a total of 105 24-hour surveys have been carried out will assist with checking of the model. Once completed it would then be straightforward to investigate the potential effect of possible noise mitigation measures such as acoustic barriers or traffic re-routing.

Towards an environmental noise strategy

The evidence produced by the study on the level of importance attached to ambient noise by residents has demonstrated the need for a Merseyside Environmental Noise Strategy (MENS). In the report that was produced at the conclusion of the study, recommendations were made on a possible route towards developing the MENS. Information on the strategy proposed, and progress since the report in mid 2004, is given below.

Within the United Kingdom no detailed environmental noise strategies have yet been implemented at a regional or local level. There is, therefore, no readily available 'road map' that could be adapted for Merseyside. The London Ambient Noise Strategy has been finalised recently by the Mayor of London, but this has not, as yet, been linked to the results of a detailed attitude survey within London. However, some comments on the steps required to develop the MENS and noise action plan for Merseyside are set out below.

Firstly, to assist with the successful formulation of the MENS, it is essential that a Merseyside Noise Map is produced to provide information on the number and location of residents exposed to different bands of noise levels from the various noise sources.

The development of a successful noise action plan will require the implementation of 'joined-up' government and the involvement of many local authority departments into the development of the plan. It will be necessary to assemble a project board from various departments across the local authorities, and other transportation organisations, to determine the feasibility of various options for noise control, and the associated costs. This is likely to involve staff from Transportation, Environmental Health and Planning departments within the various local authorities, Merseytravel, Liverpool John Lennon Airport and Network Rail.

One fundamental role of the project board would be to develop clear project deliverables taking into account the end user preferences. This would include choosing noise criteria, developing measurable targets, and developing policies to ensure that the targets are met.

In addition to assessing the technical implications, a wide range of policy decisions must be made on how the noise mitigation works should be targeted. For example, is it better to reduce noise levels by 10dB at one house

Some 354,000 Merseyside residents may have their sleep affected by road traffic noise

or 1dB at ten houses? To help make these decisions, it is recommended that public participation is developed, such as by establishing Citizens Panels or making a further attitude survey.

A number of trial noise mitigation schemes will probably be needed. These would most likely be those involving physical works such as installation of noise barriers, noise insulation and quieter road surfaces, although it may be possible to investigate traffic planning schemes as well. Noise mapping should be used to help choose the trial areas by modelling 'before and after' scenarios before any actual works are carried out. It would also be possible to carry out 'before and after' social surveys to assess the public perception of the effect of these measures.

Ideally, it would be necessary to evaluate the results of the trial noise mitigation schemes, and finalise the noise action plan taking in to account this feedback.

A contract has recently been awarded by DEFRA to carry out road traffic noise mapping of Merseyside as part of the Noise Mapping England work. In addition, the Merseyside Local Transport Plan is currently undergoing revision and consideration is being given to including noise mitigation measures as part of area wide improvements or specific transportation schemes.

Conclusions

The European Environmental Noise Directive (END) requires that a Noise Action Plan shall be drawn up no later than 18 July 2008 for agglomerations of more than 250,000 inhabitants. This requirement will apply to Merseyside, and the timescale for the implementation of regional Noise Action Plans has been fixed. Doing nothing is not an option. In order to meet the timescale, authorities throughout the UK must take steps now to develop appropriate environmental noise strategies for their regions.

The Merseyside Transport, Health and Environment Forum has taken a lead in commissioning a noise measurement and attitude survey throughout the region as a first step towards a Noise Action Plan. The noise survey results indicate the range of noise levels experienced in different types of environment and the results of the public attitude survey demonstrate that noise is an important issue for people living in Merseyside.

The study identified a number of steps required to develop a Noise Action Plan. One vital activity is a full noise mapping exercise of the Merseyside region in order to quantify population exposure to noise. Once completed the noise map can be used as a basis for identifying problem areas, prioritising noise reduction and investigating potential effects of implementing noise mitigation measures.

The Merseyside Noise Study has produced a vast amount of data which will help the development of a cohesive and focused environmental noise strategy. There will be many obstacles to overcome. In particular, for this regional approach to be successful it is critical that effective multi-agency working takes place between the officers and members of the various Councils and transport organisations. It must be said that generally there is little precedent for this sort of cooperation in the UK.

Nevertheless, having commissioned the Merseyside Noise Study in 2003, Merseyside is well placed to take a leading role in the UK towards implementing a regional Noise Action Plan and hopes to be able to pass on the experience gained to other authorities. Some of the necessary preparatory work has commenced, but a great deal of work is still required to meet the 2008 deadline.

More information about the Merseyside Noise Study, including copies of the study reports, is available on the noise study website, www.merseysidenoisestudy.org.uk/

References

1 DEFRA, The UK National Noise Attitude Survey (NAS) 1999/2000
2 DEFRA, The UK National Noise Incidence Study (NIS) 2000/2001

Acknowledgements

The author acknowledges the contribution of the two project managers for the Merseyside Noise Study, Stephen Birch of Sefton Council and Karen Booth of Merseytravel.

Peter Hepworth, *Hepworth Acoustics, Warrington*

11 July 2005

Marine noise pollution

Mr Drew: To ask the Secretary of State for Environment, Food and Rural Affairs whether marine noise pollution was discussed at the recent International Whaling Conference; and if she will make a statement.

Mr Bradshaw: At last year's (2004) annual meeting of the International Whaling Commission a special symposium was held on the impacts of anthropogenic noise on cetaceans. This year's meeting continued discussions on the potential negative impact of rising levels of disturbance on whale populations, due to factors such as ship traffic and seismic surveys, and it was decided to hold a scientific workshop to consider the effects of anthropogenic noise at next year's meeting.

My Department has been working with other countries, through the Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS) toward the prevention of significant disturbance to cetaceans, including that of acoustic disturbance.

12 July 2005

Heathrow

Mr Davey: To ask the Secretary of State for Transport **(1)** what investigations his Department has carried out into the additional *(a)* air and *(b)* noise pollution that will result from a fifth terminal being built at Heathrow airport; and what plans he has to combat these increases; **(2)** what discussions he has had with the British Airports Authority regarding the limitation of environmental damage in the construction of the fifth terminal at Heathrow; **(3)** what assessment he has made of the effect the building of the fifth terminal at Heathrow will have on the surrounding transport infrastructure, with particular reference to the *(a)* M25 and *(b)* rail network.

Ms Buck: These matters were examined at the Planning Inquiry and the Inspector's conclusions and recommendation were set out in his report. The 20 November 2001 decision struck a balance between the benefits and the disbenefits of this development and imposed strict controls.

These include a limit on flights of 480,000 per annum, a noise contour cap, a requirement that the Heathrow Express and Piccadilly Lines are extended to Terminal 5 before it opens, a reduction in car parking spaces, including for employees, below the levels proposed by BAA, consultation on stricter controls on night flights and no widening of the M4.

18 July 2005

Miners' compensation

Paul Farrelly: To ask the Secretary of State for Trade and Industry how much compensation has been paid so far to claimants from Newcastle-under-Lyme for coal mining industrial injuries.

FROM HANSARD

Malcolm Wicks: As at 31 May 2005, £6 million had been paid for chronic obstructive pulmonary disease and £3.8 million for vibration white finger.

Paul Farrelly: To ask the Secretary of State for Trade and Industry how much has been paid by his Department in fees to each firm of solicitors dealing with coal mining industrial injury compensation under the British Coal Claims Handling Agreement; how many *(a)* claims have been made and *(b)* cases have been settled by each firm; and how much has been paid out in compensation through each firm.

Malcolm Wicks: A table containing the requested information entitled 'Claim receipts, settlements, damages and costs paid (COPD/VWF) by solicitor' has been placed in the Libraries of the House.

John Mann: To ask the Secretary of State for Trade and Industry how many medicals for *(a)* chronic obstructive pulmonary disease, *(b)* vibration white finger and *(c)* hearing loss have taken place at the Union of Democratic Mineworkers' office, Berry Hill, Mansfield since 1999; and at what cost to his Department.

Malcolm Wicks: 7,714 medicals in total in relation to vibration white finger have taken place at Berry Hill, Mansfield since 1999. This figure excludes the pilot examinations that took place up to 1 September 1999. The Department's claims handlers do not record how many chronic obstructive pulmonary disease or hearing loss medicals have taken place at individual centres. The Department therefore is unable to assess the total cost of the medicals undertaken at Berry Hill.

John Mann: To ask the Secretary of State for Trade and Industry how many appeals to medical examinations have been *(a)* pursued and *(b)* accepted since 1999 under the Miners Compensation Scheme.

Malcolm Wicks: Since 1 January 1999, 44,154 appeals relating to respiratory disease medical examinations and 4,182 appeals relating to vibration white finger medical examinations have been lodged. The number of successful appeals is not recorded separately but incorporated into all claims in which revised offers have been issued. Therefore, this figure is not available.

John Mann: To ask the Secretary of State for Trade and Industry what the average settlement *(a)* to the claimant and *(b)* in solicitors' and medical fees was for coal health claims relating to deafness settled by his Department in the last year for which figures are available.

Malcolm Wicks *[holding answer 11 July 2005]:* Noise Induced Hearing Loss Claims are not handled under a specific scheme. There are two types of claim, one settled under the Iron Trades Tariff and the other through Common Law. The average settlement under the Iron Trade Tariff for claimants is approximately £1,500 with costs and disbursements ranging from £485 to £800 +VAT. Claims under Common Law have an average settlement of between £3,000 and £3,500. Costs paid are negotiated and can range from £2,000 to £4,000.

John Mann: To ask the Secretary of State for Trade and Industry which claims handlers have been referred by the Coal Health Claims Unit to the Corporate Governance Unit for investigation.

Malcolm Wicks *[holding answer 11 July 2005]:* No such referrals have been made.

John Mann: To ask the Secretary of State for Trade and Industry how many requests were made to his Department to investigate coal health claims handlers through the Department's Corporate Governance Unit in *(a)* 2003 and *(b)* 2004.

Malcolm Wicks *[holding answer 11 July 2005]:* No such requests have been received.

John Mann: To ask the Secretary of State for Trade and Industry if he will suspend payments of fees to the Union of Democratic Mineworkers and Vendside in respect of coal health claims; and if he will make a statement.

Malcolm Wicks: I refer my hon. Friend to my written statement to the House of 30 June 2005.

20 July 2005

Health and safety

Mr Hancock: To ask the Secretary of State for Defence what plans his Department has to monitor the prevalence of noise-related hearing loss among servicemen and women serving in Iraq.

Mr Touhig: There are currently no specific measures in place to monitor the prevalence of noise-related hearing loss among servicemen and women serving in Iraq. However hearing tests of all service personnel are carried out at periodic medical examinations.

Aviation (complaints)

Mr Duncan: To ask the Secretary of State for Transport how many complaints his Department has received about *(a)* night flights, *(b)* aircraft noise and *(c)* aircraft pollution in each year since 1997, broken down by *(i)* airport, *(ii)* Government Office Region and *(iii)* constituency.

Mr Darling: Complaints about night flights, aircraft noise and pollution (as distinct from representations about policy) are properly a matter for individual airports, many of which regularly publish their own summary statistics of complaints or enquiries. The Department also receives a number of representations direct from members of the public or via Members of Parliament and, in responding, is able to comment on the Government's overall policy on these matters. The Department does not operate a 'complaints database' and could not provide information in the form requested.

Moving vehicles (music volume)

Mr Amess: To ask the Secretary of State for Transport if he will introduce legislation to control the playing of loud music from a moving vehicle; and if he will make a statement.

Dr Ladyman: Legislation already exists to deal with this problem. Under regulation 97 of the Road Vehicles (Construction and Use) Regulations 1986, it is an offence to use a motor vehicle on the road in such a manner as to cause any excessive noise which could have been avoided by the exercise of reasonable care on the part of the driver. Enforcement of these powers is a matter for the police.

21 July 2005

Health and Safety

Mr Hancock: To ask the Secretary of State for Defence what steps are taken to protect the hearing of British servicemen and women in the armed forces during active service.

Mr Touhig: The Ministry of Defence, like all UK employers, is subject to the Health and Safety Executive 'Noise at Work Regulations (NAWR) 1989'. The instructions promulgated by the armed forces to their personnel are summarised as follows.

Navy: Under the new regulations set out in the PA(N)D, RN warships will have until 2011 to comply with the prescribed weekly and daily limits. In 2003 the RN introduced a hearing conservation programme to ensure compliance with 'NAWR 1989'. This programme requires noise assessments to be carried out where personnel may be at risk from noise-induced hearing damage.

Army: Hearing protection forms part of a serviceman's personal equipment that he will carry with him on operations. Additionally, hearing protection is included in the equipment schedule of the equipment that the serviceman may be operating.

RAF: Where RAF personnel work in an area that is deemed a noise hazard, hearing protection is issued on an individual basis. The wearing of such protection is made mandatory in the RAF at the First Action Level of 'NAWR 1989', which exceeds NAWR recommendations. In addition, noise assessments are conducted to determine the level and type of hearing protection required.

We are also working with HSE on the need for hearing protection for military band personnel.

BSI update July 2004 – June 2005

New standards

BS EN ISO 17624:2004	Acoustics. Guidelines for noise control in offices and workrooms by means of acoustical screens
BS ISO 10813-1:2004	Vibration generating machines. Guidance for selection. Equipment for environmental testing
2004 BS EN 60034- 14:2004	Rotating electrical machines. Mechanical vibration of certain machines with shaft heights 56mm and higher. Measurement evaluation and limits of vibration severity
BS ISO 16587:2004	Mechanical vibration and shock. Performance parameters for condition monitoring of structures
BS ISO 2017- 1: 2005	Mechanical vibration and shock. Resilient mounting systems. Technical information to be exchanged for the application of isolation systems
BS ISO 14839- 2:2004	Mechanical vibration. Vibration of rotating machinery equipped with active magnetic bearings. Evaluation of vibration
BS ISO 18437- 2:2005	Mechanical vibration and shock. Characterisation of the dynamic mechanical properties of viscoelastic materials. Resonance method
BS ISO 18431- 2:2004	Mechanical vibration and shock. Signal processing. Time domain windows for Fourier Transform analysis
BS ISO 7919- 5:2005	Mechanical vibration. Evaluation of machine vibration by measurements on rotating shafts. Machine sets in hydraulic power generating and pumping plants
BS ISO 5344: 2004	Electrodynamic vibration generating systems. Performance characteristics
BS ISO 13379:2003	Condition monitoring and diagnostics of machines. General guidelines on data interpretation and diagnostics techniques
04/30116654 DC, 2004/30116654 DC.	ISO 18431-1. Mechanical vibration and shock. Signal processing. Part 1. General introduction
05/30128398 DC	ISO 14839-3. Mechanical vibration. Vibration of rotating machinery equipped with active magnetic bearings. Part 3. Evaluation of stability margin
05/30130575 DC	ISO 18431-4. Mechanical vibration and shock. Signal processing. Part 4. Shock response spectrum analysis
05/30131431 DC	ISO 18434-1. Condition monitoring and diagnostics of machines. Thermography. Part 1. General procedures
BS EN 1915-4:2004	Aircraft ground support equipment. General requirements. Noise measurement methods and reduction
BS EN ISO 16032:2004	Acoustics. Measurement of sound pressure level from service equipment in buildings. Engineering method
BS EN ISO 10052:2004	Acoustics. Field measurements of airborne and impact sound insulation and of service equipment sound. Survey method
BS EN ISO 11904-2:2004	Acoustics. Determination of sound immission from sound sources placed close to the ear. Technique using a mannequin
BS EN 14366:2004	Laboratory measurement of noise from waste water installations
BS ISO 13347-2:2004, BS 848-2.2:2004	Industrial fans. Determination of fan sound power levels under standardised laboratory conditions. Reverberant room method
BS ISO 13347-1:2004, BS 848-2.1:2004	Industrial fans. Determination of fan sound power levels under standardised laboratory conditions. General overview
BS ISO 13347-3:2004, BS 848-2.3:2004	Industrial fans. Determination of fan sound power levels under standardised laboratory conditions. Enveloping surface methods
BS ISO 13347-4:2004, BS 848-2.4:2004	Industrial fans. Determination of fan sound power levels under standardised laboratory conditions. Sound intensity method
BS EN 60704-2-10:2004	Household and similar electrical appliances. Test code for the determination of airborne acoustical noise. Particular requirements for electric cooking ranges, ovens, grills, microwave ovens and any combination of these
BS EN 60645-5:2005	Electroacoustics. Audiometric equipment. Instruments for the measurement of aural acoustic impedance/admittance
BS EN 61094-6:2005	Measurement microphones. Electrostatic actuators for determination of frequency response
04/30124314 DC, 2004/30124314 DC	EN 15068. Gas welding equipment. Laboratory measurement of noise emitted by blowpipes for DC welding, cutting, heating, brazing and soldering. Measurement method
04/30126355 DC	ISO 20361. Liquid pumps and pump units. Noise test code. Grades 2 and 3 of accuracy
05/30127567 DC	ISO 20283-3. Mechanical vibration. Measurement of vibration on ships. Part 3. Pre-installation vibratory noise measurement of shipboard equipment
05/30128617 DC	IEC 60318-6 ED.1. Electroacoustics. Simulators of human head and ear. Part 6. Mechanical coupler for the measurements on bone vibrators

Bureau Veritas and Casella Stanger join forces

The noise and vibration consultancies, **Bureau Veritas** (formerly Acoustic Technology) and **Casella Stanger**, have joined forces through the acquisition by Bureau Veritas UK of Casella Consulting Ltd. This integration is seen as of major benefit to both organisations, given that Bureau Veritas has its roots deeply founded in the industrial sector, whereas Casella Stanger has strong experience working for the transportation sector and local and central government.
The merged consultancies will provide strong regional representation, with acoustic capabilities in Central London, Southampton, St. Albans, Manchester, Tamworth, Glasgow and Aberdeen. Full integration is expected to take six months. However, a first meeting between senior members from the two acoustics teams has clearly confirmed the considerable synergy between them. As Stephen Turner, Casella Stanger's business director, commented: "The breadth and depth of experience that we can offer in noise, acoustics and vibration is greatly enhanced by this new combined team and this will benefit both our clients and our staff."
The merged group is now thought to be the largest independent acoustic consultancy in the country. Attractive employment opportunities currently exist for both newly qualified and experienced personnel. For more information about the group and immediate job prospects contact:
Simon lent and Bernard Postlethwaite (tel: 023 80381440);
Stephen Turner (tel: 0207 902 6176);
Colin Grimwood (tel: 01727 840580); or
Paul Freeborn (tel: 0161 8887130).

A growth spurt for Hepworth Acoustics

Hepworth Acoustics Ltd is expanding again, with a new office in Birmingham and two top-class graduate recruits swelling numbers at the Warrington head office.
As part of its planned expansion, the company's new office in Birmingham has been established to cope with increased demand for Hepworth's services throughout the Midlands. It is headed up by principal consultant, Peter Piroze, who comes from an established acoustics consultancy background in Australia. Having experience in a wide range of consultancy work, he is looking forward to consolidating and developing the company's presence in and around Birmingham.
Two new recruits from Salford University have joined the head office team in Warrington. James Trow and Charlotte Willis, who both graduated with first-class degrees, will be working in different divisions of the company. Charlotte is headed for the consultancy division, where she will be carrying out a wide range of survey and assessment work for new development projects. James, who spent a year with the company for his industrial experience, joins the software and noise mapping division, where he will be working on a number of recently-won noise mapping and research contracts.
Further details tel: 01925 579100 email: peter.hepworth@hepworth-acoustics.co.uk www.hepworth-acoustics.co.uk

New Arup acoustics team in the Midlands

Arup Acoustics has recently established its fifth UK team. At the beginning of this month (September) Stuart Colam, Simon Ham and Colin Waters joined the 350 technical staff based at Arup's multi-disciplinary Midlands Campus in Solihull.
Stuart did postgraduate study and research in acoustics at the ISVR before joining Arup, working in both Cambridge and Manchester; he specialises in building and architectural acoustics.
Simon graduated in Audio Technology from Salford University and worked at Arup Acoustics' Cambridge office before a secondment to the CTRL project in 2002 where he was primarily involved in rail related noise issues.
Colin is a director of Arup with over thirty years experience in environmental acoustics - he will be based in the Midlands two days a week.
Further details tel: 0121 213 3000
email: stuart.colam@arup.com
web: www.arup.com/acoustics

Procedure for assessing low frequency noise complaints

On 24 May 2005 Defra (Department for Environment Food and Rural Affairs) published a procedure for the assessment of low frequency noise (LFN) complaints, written by Dr Andy Moorhouse, Dr David Waddington and Dr Mags Adams from the University of Salford. This provides a comprehensive set of guidelines to local authorities for assessing complaints, and includes a pro-forma report to be completed by the investigating officer.
The report is the culmination of a Defra-funded research project on 'Methods for the Assessment of Low Frequency Noise', carried out since January 2004 following recommendations from Dr Geoff Leventhall.
Also available are two other reports published by the Salford team. The first gives a detailed description of the Case Studies and Laboratory Tests from which the procedure was derived. The second describes a set of field trials in which the procedure was 'road tested' by a number of Local Authorities on 'live' LFN cases.
The reports are available as a free download from:
http://www.defra.gov.uk/environment/noise/research/lowfrequency/pdf/nanr45-procedure.pdf

'Blue Book' goes online

provides a free acoustics reference resource

IAC has now published its Noise Control Reference Handbook (known as the 'Blue Book') online. As leaders in the field for over 50 years, the company receives many requests for information and guidance from engineers, both students and professionals. The company confidently predicts that anyone needing readily available acoustical information will find this reference resource very useful. As Geoff Crowhurst, division director, acoustics comments: "When it comes to acoustics we've been in the business longer than most and so there's not much we don't know!"
To access the Noise Control Reference Handbook online, go to www.iacl.co.uk/uk/student/bluebook

New Chairman for Engineering Integrity Society

Dr Peter Blackmore has been appointed Chairman of the Engineering Integrity Society following the retirement of Professor John Draper from the post. Dr Blackmore, who is principal technical specialist, Fatigue Technology, at Jaguar Cars, is a founder member of the Society and has served as Chair of the EIS's Durability and Fatigue Group and as a Council member.
His predecessor, John Draper (managing director, Safe Technology Ltd) was also a founder member of the EIS in 1985 and has served the Society as Chairman since 1990. Professor Draper has steered the Society from modest early beginnings to its current position as an established international body organising conferences, exhibitions and workshops.
The Engineering Integrity Society was formed in 1985 and has established itself as a professional body dedicated to the engineering integrity of manufactured products. Its primary objective is to stimulate the exchange of ideas and information between engineers and technologists, whose interests lie in designing, developing or manufacturing products that must achieve high standards of integrity.
The society, which is a registered charity, also provides a unique forum for industrial engineers to exchange ideas and experience by holding major national and international conferences, organising and co-ordinating specialist task groups, and presenting regular technical seminars and exhibitions. It comprises three groups: 'Durability & Fatigue'; 'Simulation Test & Measurement'; and 'Noise Vibration & Harshness'.
Individual membership is open to engineers working in all aspects of research, design, development, analysis and testing. Company sponsorship is welcomed.
For the future, the new Chairman wants to see the influence of the EIS continue to grow with new members and sponsors enhancing our community of engineers and technologists, ensuring that the Society remains vital and relevant in today's industrial climate.
For further information about the EIS and membership/sponsorship details contact:
Catherine Pinder, tel: (0)114 262 1155 fax: (0)114 262 1120 email: cpinder@e-i-s.org.uk http://www.e-i-s.org.uk/

ASA/CAA conference spotlights classroom acoustics

The 149th meeting of the Acoustical Society of America (ASA) was held jointly with the Canadian Acoustical Association in Vancouver from 16 to 20 May 2004. Many colleagues from the UK were among the 1000 delegates at the conference which, apart from its technical content, was notable for the standard of accommodation and food - the chocolate fountain was a particular highlight!

Colloquium on classroom acoustics

As part of the conference Murray Hodgson (University of British Columbia, Vancouver) organised a special international colloquium on classroom acoustics. This attracted speakers from Europe, Hong Kong, Japan, Mexico and New Zealand in addition to Canada and the USA. Topics discussed included teachers' voice problems, speech intelligibility testing of schoolchildren, design of new schools, national standards and guidelines for acoustic design of schools and modelling and auralisation of classrooms. The technical sessions, which lasted for three days, consisted of around 40 invited and contributed papers.

In addition to the technical sessions, an evening Public Forum on classroom acoustics was held, providing local stakeholders with an opportunity to meet academics and others working in the field. The meeting, which was attended by around a hundred conference delegates and local people, comprised presentations and panel discussions. Bridget Shield (London South Bank University) was invited to give the opening plenary lecture at the meeting, which provided an overview for the general public of the important issues in classroom acoustics.

Sustainability

It was interesting to note that, as at this year's IOA Spring Conference, there was a technical session on sustainability, or 'green buildings'. In the US the LEED (Leadership in Energy and Environmental Design) system, equivalent to BREAM in the UK, is used to assess the sustainability of new buildings. LEED, which was developed by the US Green Building Council, is a voluntary national standard for the development of high performance sustainable buildings.

The session included papers on the low priority given to acoustics in sustainable building design, particular acoustic problems that may arise, and some design solutions such as those presented by Jian Kang (Sheffield University) and David Oldham (Liverpool University).

There was also a panel discussion on acoustics and sustainability, for which the IOA provided an indirect input. The LEED-accredited representative on the panel was Alexis Kurtz, from Arup Acoustics' New York office. Alexis attended the IOA Spring Conference specifically to familiarise herself with the UK perspective on acoustics and sustainability before appearing on the panel at the ASA meeting. Her fellow panellists included architects, building services engineers and other acoustical consultants.

Women in Acoustics lunch

The ASA has a very active committee on Women in Acoustics, which is a standing committee of the association. Set up in 1995, it has both male and female members. Its aims are to promote acoustics as a career option for women, to provide support for women of all ages working in the field and to organise mentoring for young people of both sexes in the early stages of their careers in acoustics.

At every conference the Women in Acoustics committee hosts a lunch, open to all delegates, to provide a social and networking opportunity for women (and men!). The committee also sponsors Young Investigators' Travel Grants which are presented during the lunch.

Bridget Shield and Anne Carey attended the lunch and enjoyed the opportunity to meet conference delegates of all ages who are active in many different branches of acoustics. The numbers of women, particularly young women, attending the conference demonstrate the success of the committee and the increasing contribution by women to acoustics in America.

Honour for 'Mr Noise Mapping'

IOA congratulates John Hinton on his OBE

Birmingham City Council's John Hinton was recently recognised for his services to noise mapping with the award of an OBE.

Known as 'Mr Noise Mapping', John and his team demonstrated the feasibility of producing comprehensive Birmingham-wide transport and industry noise maps by means of digital modelling and calculation techniques. Of the initiative, John said: "This was all quite a challenge because at the time the project was the largest, most comprehensive and most detailed noise mapping exercise ever to be carried out in one step".

When the European Commission drafted the Environmental Noise Directive, adopted in 2002, the noise mapping of Birmingham was a prime example of what could be achieved. John has since been deeply involved in the development and implementation of the Directive.

Since 1997 John has been chairman of the EC's working group on noise mapping, and in 2002 he became chairman of the EC Working Group on the Assessment of Exposure to Noise which oversees the implementation of the Directive. The Working Group has produced the *Good Practice Guide* on noise mapping and, under John's continuing chairmanship, is currently preparing the latest update to the guide.

John is helping Defra meet the requirements of the Directive, and among his present workload is the Birmingham Updated Noise Mapping Project, which will provide the city with a baseline over which plans of action to combat transport noise can be developed. Central government views this as a further important milestone in progressing its policy of compliance with the Directive.

The Institute of Acoustics congratulates John Hinton on the receipt of this well deserved national honour.

New acoustics engineer for Hoare Lea

Hoare Lea Consulting Engineers has appointed Mark Jiggins MSc as Acoustics Engineer. Having 14 years' experience within the acoustics industry, Mark worked in local government environmental health providing noise control services for seven years before joining the National Physical Laboratory as a senior research scientist in the field of environmental noise. He then joined npower Renewables as an acoustics engineer, with a remit to ensure its wind energy projects were developed and built within current guidelines on noise.

Mark has been involved in many projects featured in a number of publications, for example 'The West London schools study: the effects of chronic aircraft noise exposure on child health', published in *Psychological Medicine*, and 'Night-time aircraft noise and sleep - the 1999 UK trial methodology study using both field and laboratory methods' published in the proceedings of *Internoise 2000*.

Mark will be based in the Scottish Borders, enabling him to serve the company's growing customer base in the north of the UK. He will be responsible for handling a range of environmental noise projects with a particular focus on wind energy schemes.

David Walker, Senior Partner, Hoare Lea Consulting Engineers welcomes Mark's appointment and wishes him every success in his new position.

Obituary

EurIng **Frank Irving** CEng MIMechE MIOA MIOSH *(1940 – 2005)*

Frank's early years were spent on a small farm near Carlisle, now known as Cumbria but never accepted by Frank who always referred to his native Cumberland. After attending Carlisle Grammar School he joined the English Electric company in Stafford as a student apprentice in 1959. He graduated in 1964 and qualified as a mechanical engineer. Being an engineer was something of which Frank was intensely proud, and which he defended at all times. He later moved to the Manganese Bronze Company in 1967.

Moving to Ipswich he met his wife Christine in 1968 and they were married in 1970, their three boys Ian, Alan and Andy were born while in Suffolk. Joining the Health and Safety Executive in 1975 his career took him to the HSE Leeds office in 1977, the family moving to Yorkshire a year later.

Like everything Frank turned to he became passionate about his job as a Noise and Vibration Specialist Inspector with the HSE, becoming one of the most experienced and respected specialists in the organisation. When he was called on to give presentations to industry and his peers, his work took him to China, Korea and the USA. Frank's passion for his work in the prevention of hearing damage is shown by his favourite charity - hearing dogs for the deaf.

Members who met Frank will be unaware of the other, more private, side of his hectic life. In his younger days he was an outstanding rugby player, reaching county standard in both Staffordshire and Suffolk. In his adopted village of Burton Leonard near Ripon, he participated in all the village activities from running the local sports day to being a sidesman (assistant churchwarden) at the village church. He had a passion for walking - leading walks with the local group - and he was a beekeeper and prominent member of the local society.

The year 2000 was an important milestone for Frank. It was his sixtieth year, which marked his retirement from the HSE and the birth of his first grandson, the second grandchild being born in 2004.

Frank has been a member of the Institute of Acoustics for many years. In typical character he joined the Engineering Committee, making sure 'true engineers' were given a push into the realms of chartership with the Engineering Council. He attended his last meeting this February 2005.

He was a Chartered Engineer, a member of the Institute of Mechanical Engineers, a member of the Institute of Acoustics and a member of the Institute of Occupational Safety and Heath. He had been granted the title of European Engineer (EurIng) by the European Federation of National Engineering Associations.

Frank will be remembered by all his fellow members and friends for the way he threw himself into everything he approached.

The profession will be considerably worse off without the experience he brought to acoustics. He will be sadly missed by all who knew him.

Keith Broughton

Letter

Rain noise and guidance for schools at BRE

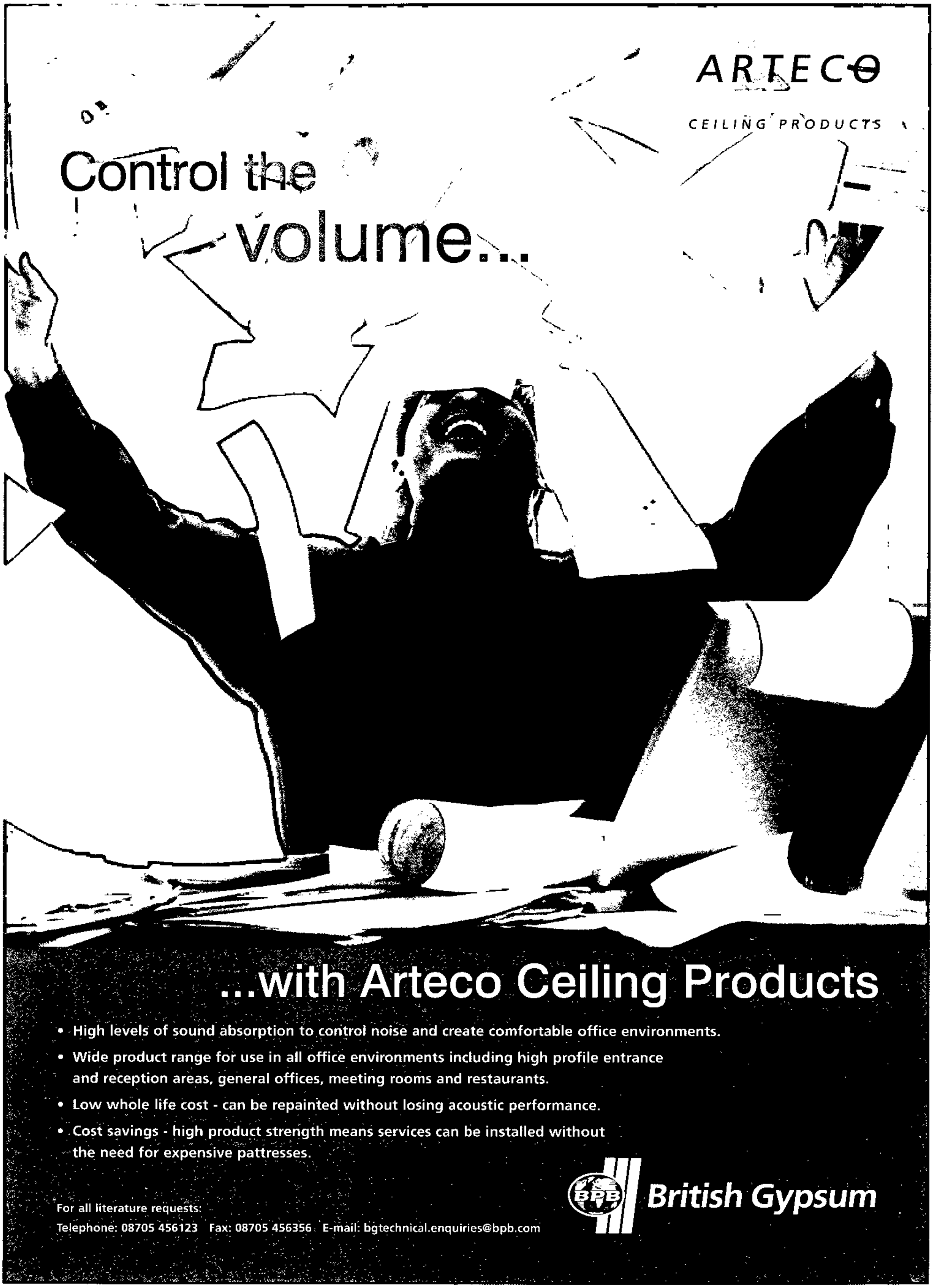
The article, 'Rain drops keep falling on my roof' (*Acoustics Bulletin*, July/August 2005), written by Peter Rogers of SRL is incorrect in asserting that: 'This is the first commercially available test rig to apply the draft ISO standard in the UK'.

BRE has been conducting commercial measurements of rain noise on roofs and roof elements in accordance with the draft ISO/DIS 140-18 for over a year now. The results from some rain noise measurements are currently available on the BRE website and can be accessed from the following address - www.bre.co.uk/schools - by selecting 'Rain Noise in School Buildings' from the list of options displayed.

The BRE document, *Rain noise from roof glazing, polycarbonate roofing and ETFE roofing*, is intended to assist those designing schools and contains a proposal for using rain noise measurement data to demonstrate that lightweight roofs are suitable for schools. This document can be accessed by clicking on the link 'Guidance on determining rain noise' and has links within it to the formal BRE report containing all the relevant measurement data.

For further information or enquiries regarding rain noise measurements at BRE, please contact acoustics@bre.co.uk

Dr Robin Hall
BRE Acoustics,Garston,Watford


ARTECO
CEILING PRODUCTS
Control the volume...
...with Arteco Ceiling Products
• High levels of sound absorption to control noise and create comfortable office environments.
• Wide product range for use in all office environments including high profile entrance and reception areas, general offices, meeting rooms and restaurants.
• Low whole life cost - can be repainted without losing acoustic performance.
• Cost savings - high product strength means services can be installed without the need for expensive pattresses.
For all literature requests:
Telephone: 08705 456123 Fax: 08705 456356 E-mail: bgtechnical.enquiries@bpb.com
British Gypsum

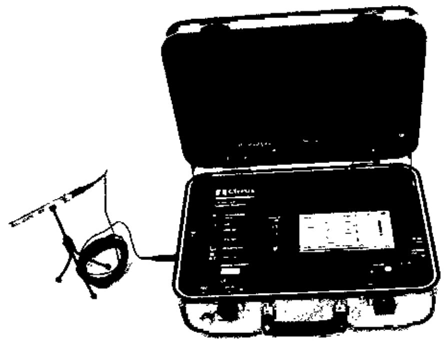
Cirrus Research

Easy-to-use digital noise nuisance recorder

The *CR:290* digital noise nuisance recorder from **Cirrus Research** has been designed for operational simplicity, a feature essential to busy environmental health officers and housing association managers.

This state-of-the-art noise measurement tool is specifically designed for the recording and analysis of noise complaints. An ideal replacement for sound level meter and tape-recorder based noise nuisance recording systems, it provides all the features of a DAT-based system, whilst eliminating the problems associated with cables, tapes and recording quality.

The built-in colour touch screen provides a simple step-by-step setup routine that can be followed quickly and easily to ensure high quality recordings. Calibration is a simple matter of attaching the calibrator to the microphone and selecting 'calibrate' on the colour screen. After calibration, the user can record a voice log to store details of the location, time, date and any other useful information for future reference.



The CR:290 is a single integrated unit with all the electronics housed in a secure, rugged case. The instrument consists of the digital audio recording system and the noise level measurement system with a Type 1 microphone to capture the noise levels. It is supplied complete with all the accessories needed, including an acoustic calibrator and the reporting software.

The instrument can be upgraded to 'Professional' standard with a set of options including timer mode, threshold trigger mode and an advanced sound level meter mode. All features can easily be switched on and off, allowing the unit to be used by more experienced staff for advanced measurements, whilst retaining its simplicity for straightforward operation.

'Frequency Master' software can also be added. This allows the recorded audio files to be analysed in full or third octave bands or by FFT.

The software has been designed to allow very quick analysis and playback of both the logged noise levels and the recorded audio files. Recordings can be played back in any order and the user can jump to any recording instantly, dramatically reducing the time taken to find, listen and analyse noise sources.

By using a touch screen, the user is taken through a simple setup and operation procedure which removes most of the common mistakes and problems that users come across. By making the system so easy to use, the unit can be deployed by less senior staff, saving time and money.

Further details contact: James Tingay, tel: 01723 891655, email: james.tingay@cirrusresearch.co.uk www.cirrusresearch.co.uk

IAC

Modernising Scotland's audiology services

A review of audiology services in Scotland carried out by the Public Health Institute Scotland in 2001 highlighted the need for radical improvement to bring them in line with the rest of the UK. A four-year, £30m modernisation programme was launched in 2003.

Apart from training more staff to provide quality services for the 750,000 people in Scotland with hearing impairment, 'proper accommodation' was also required. Approximately £3m was earmarked for the supply of top-class audiometric testing facilities to hospital sites around the country, each to be accompanied by related accommodation. These would all need to be compliant with the Disability Discrimination Act, whether they were upgrades or new buildings. At that point, leading audiometric facility manufacturer, **IAC** of Winchester, became involved.

As part of the Scottish modernisation programme so far, it had provided new audiology facilities for adult and paediatric testing on seven sites, to a total value in excess of £500,000.

The sites are: Crosshouse hospital, Kilmarnock (NHS Ayrshire & Arran); Prince's Gate, Hamilton (Lanarkshire Primary Care NHS Trust); Gilbert Bain hospital, Lerwick, Shetland and Peterhead community hospital (NHS Grampian); and Aboyne and Inverurie hospitals and Buckie's Seafield hospital, the last four projects all sharing a similar profile.

The new state-of-the-art Audiology unit at Crosshouse Hospital is the flagship project among all these undertaken by IAC. Taking just six months to complete, it was actually the first in the entire modernisation programme and cost about £220,000 over two improvement stages.

Firstly, four purpose-built test rooms were built, including a paediatric test facility. Next came a comprehensive refurbishment and expansion of the existing accommodation into a high-grade suite of acoustically-treated consulting rooms, each with an integral air-conditioning system.

IAC's other major project in Scotland was undertaken at Prince's Gate in Hamilton. The installation of four custom-designed audiometric testing rooms, two paediatric and two adult, was particularly challenging. This installation was co-ordinated by the company's project manager, Shaun Moore, who explains that the striking hilltop building hosting the new testing rooms had curved walls, with several supporting pillars restricting internal access. This was a problem in itself, but the building also had no lifts or means of access for a crane, which meant that all components for the audiometric facility had to be manhandled up to the second floor of the building. In order to accommodate the varying needs of those using the different facilities, each testing room was fitted with a stand-alone air-conditioning system.

Shetland is home to the most recently completed Scottish modernisation project. Before the refurbishment programme, local patients could only be offered 15 days' service a year, using an older-design mobile booth on castors. NHS Grampian's Gilbert Bain hospital in Lerwick has now been supplied with a purpose-built paediatric audiometric room. This sophisticated room-within-a-room facility is fitted with specialist Visual Response Audiometry and speaker socket cabling; it also has an integrated two-way intercom system, a DDA-compliant entrance lobby and air-conditioning throughout.

According to IAC's Jason Saunders, the NHS is keen to purchase high quality at minimum cost, and so extend its purchasing power. With this in mind, a new, lower-cost acoustic floor option has been developed for their audiology facilities.

Further information on audiology booths and suites can be found at www.iacl.co.uk

ProsCon Environmental

New LxT sound level meter launched

The new *LxT* range of sound level meters from Larson Davis has now been released by **ProsCon Environmental Ltd.** Available in either Class 1 or Class 2 versions, the new meter offers real time filters in both octave and third-octave bands.

It can be operated with just one hand, and provides 20 hours of running time on four AA alkaline batteries. A USB 2.0 interface, high-contrast LCD screen and the TaskMate noise survey guidance system simplify operation, and the unit is extremely rugged, compact and lightweight.

Further details (Southampton) tel: 01489 891853 fax: 01489 895488 email: info@proscon.co.uk (Perth) tel: 01738 550176 fax: 01738 550197 email: dneil@proscon.com

Bruel & Kjaer

New environmental noise management concept solves integration and interaction headaches

A modular environmental noise management solution has been developed by **Bruel & Kjaer** to address current and future noise mapping needs and action plans. This new *Noise Management Concept* simplifies the management of environmental noise by efficient handling of the interaction between measured and calculated environmental noise results.
The system is suitable for handling multiple clients and areas as well as dealing with smaller semi-permanent tasks. It has been developed to optimise the data exchange between different users, consultants and clients. The system's new environmental noise calculation software, monitoring and measuring equipment combine to implement noise maps, develop action plans and provide data to the public as well as regulatory organisations such as the European Environment Agency.
The system has been developed as the result of a major customer research project aimed at providing solutions to address requirements of the ED Environmental Noise Directive 2002/49/EC. The Bruel & Kjaer Noise Management Concept offers an integrated approach to environmental noise management that make all tasks and activities more effective.
Environmental noise calculation and mapping software is combined with monitoring and measurement equipment in a single, cost effective, integrated noise management system. A key element is the Noise Management Software Type 7843A installed on a Noise Management Server Type 3642. The software's modern architecture provides a versatile platform to handle proposed future noise management requirements.
The system's hardware also features a Bruel & Kjaer Noise Monitoring Terminal Plus, Type 3639-E, which is powerful, modular, and can be used in all environments and conditions. Featuring a specially designed enclosure, the terminal can be left unattended as part of an environmental noise monitoring system for permanent, mobile or semi-permanent monitoring. Alternatively, it can be controlled by a remote PC using a selectable modem. The Type 3639-E has a dynamic range of 110dB and provides the ability to log several parameters down to half-second periods. Remote verification of the entire measurement chain is achievable using the patented Charge Injection Calibration check (CIC). The terminal comes with a selection of options such as sound recording, weather-data monitoring and third-octave real time analyses.

The Noise Management Concept system comes equipped with a Bruel & Kjaer Type 4952 Outdoor Microphone that is guaranteed for unattended outdoor use with no significant change in sensitivity for a year. The microphone functions correctly under conditions of up to 96% relative humidity and in ambient temperatures ranging from -30 to 55°C. Construction is simple and features a protective anti-bird spike.
The integrated environmental noise management system can cover complaints, mapping, monitoring, calculations and abatement. The system will also provide reports, public information, and safe, intuitive archival of data, results, reports and analyses.
Further details contact: Brian MacMillan, tel: 01438 739000 fax: 01438 739099
email: ukinfo@bksv.com
website: www.bksv.com

Cirrus Research

Dual function sound level meter

With the imminent introduction of new Control of Noise at Work Regulations in 2006, many companies are looking to re-assess their noise measurements and controls to ensure that they will be able to comply with the lower limits.
Besides the new limits for occupational noise, many safety officers must deal now with environmental noise issues, increasing the need for a dual-purpose tool that can cope with any measurement situation.
The *CR:821B* sound level meter from **Cirrus Research** has been designed to meet these requirements in one simple-to-operate package. The instrument will

provide for the measurement of L_{eq} and L_{Cpeak} for compliance with the Control of Noise at Work Regulations, with the *Deaf Defier3* software providing for the calculation of noise exposures and $L_{EP,d}$. Octave band levels can be measured and the software will aid in the selection of any appropriate personal protective equipment using the built-in database of over 85 types of hearing defenders and ear plugs.
The sound level meter will also measure L_{eq}, L_{max}, L_{A10} and L_{A90} when measuring environmental noise levels. If the instrument is used with an outdoor measurement kit, noise levels can be measured and automatically logged for up to 14 days in any weather.
The CR:821B, as with all in the CR:800B Series, meets requirements of the latest Standards for sound level meters (IEC 61672-1:2002) as well as the older standards, making the instrument ideal for future noise measurement applications.
As with any noise measuring instrument, the CR:821B should be calibrated before and after use to check the calibration of the unit. It can be supplied as a complete measurement kit which includes all the accessories needed, including an acoustic calibrator.
The CR:821B can also be used with the Frequency Master software package, which allows recording and analysis in real time, as octave, third octave or narrow band (FFT) levels. The Frequency Master package can be added at any time to any of the CR:800B or CR:260 series sound level meters from the same manufacturer.

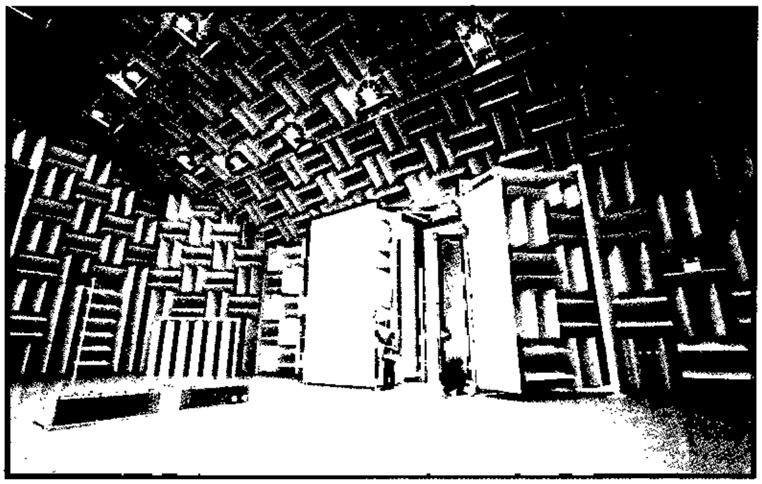
University of Salford

UKAS accreditation for NW England's only acoustic calibration laboratory

The University of Salford's School of Computing Science & Engineering (Acoustics Discipline) is pleased to announce that it has received official notification of the UKAS accreditation for its Acoustic Calibration Laboratory. It is the North West's first and only acoustic calibration laboratory.
The new UKAS scope covers: verification of type 1 sound level meters to BS7580, calibration of sound calibrators and pistonphones, and calibration of microphones.
The laboratory specialises in carrying out calibrations for local authorities and consultancies, offering a local service, fast turnaround times and value for money. There is a standard price list covering many common instruments, and contract calibrations can be carried out for clients with several instruments requiring regular calibration. Contracts offer the benefit of up to 15% discount on calibration prices, with fixed prices for the duration of the contract. There are no delivery charges, and jobs can be scheduled in advance to suit equipment usage.
For timescales, to book instruments in or for any further information, contact Claire Lomax on 0161 2953030 (c.lomax1@salford.ac.uk) or Gary Phillips on 0161 2953319 (g.phillips@salford.ac.uk)

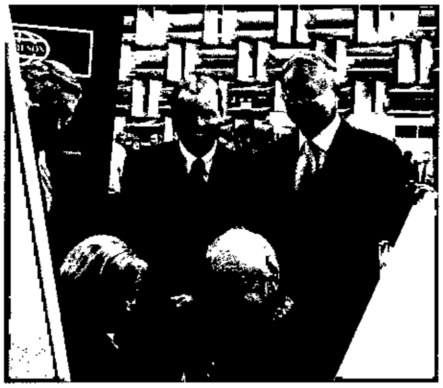
IAC

Giant anechoic chamber meets Caterpillar testing needs



One of the company's largest ever anechoic test facilities has been built by **IAC** in Northern Ireland. The anechoic chamber provides a state-of-the-art engine test facility for FG Wilson, part of the Caterpillar Group, and one of the largest manufacturers of diesel and gas generator sets in the world. Located right in the heart of the local community in Larne, the company's previous open-air 'grass circle' testing facility was causing noise nuisance. The new chamber eliminates virtually all environmental impact by keeping noise in, and also provides a perfect 'repeatable' sound testing environment, keeping wind and weather out.

The project took just 12 months to complete, and has two components: a hemi-anechoic chamber designed with 60Hz and 40Hz cutoff, to meet both UK and USA regulations, and a reverberation chamber. The hemi-anechoic chamber, believed to be a world best, has high acoustic performance at low frequencies. It is fully calibrated down to 25Hz and noise directivity can also be measured as well as noise level. It has specially designed 10m hemispherical microphone measuring locations, believed unique in such a chamber. The 275m³ reverberation room is constructed with concrete walls that are non-parallel to prevent echo generation, and has a 100 Hz cut off (ISO3741).



Pictured at the 'grand opening, from left (back row): Bill Rohner, Vice President, Electric Power Division, Caterpillar; Mark Sweeney, Managing Director, FG Wilson; John Leslie, Chairman of Invest Northern Ireland; (front row) Angela Smith MP, Minister for Enterprise, Trade and Investment; John Matthews, Mayor of Larne

Over 3MW of heat and exhaust had to be removed from the building during machinery tests. A large exhaust extraction system with 100m^{3}s^{-1} capacity was installed. Three IAC air handling units were also installed to attenuate noise emissions from the plant room, which was enclosed with Noise Shield acoustic louvres.

As turnkey providers, IAC handled all aspects of the design and build. Geoff Howse was designer and chief engineer on the project, whose team was responsible for all mechanical, electric, acoustic and civil aspects of the job. This project used all the company's acoustic design manufacturing expertise right across a whole range of product areas, including acoustic louvres, silencers, acoustic panels, AHUs, low frequency 'Metadyne' acoustic wedges, and acoustic doors. The basket doors in the chamber are the largest IAC has ever manufactured.

The location on the north-east coast of Northern Ireland meant that civil engineering was tricky: 500 tonnes of building had to be built on a bog on a cliff top! To lessen the environmental impact and to please the local community the original design of the roofline was adjusted to give a curved outline, and the eaves were lowered by 5m.

At the end of June this year, the 'grand opening' of the Engineering Centre of Excellence, as it is called, was hosted by FG Wilson's managing director, Mark Sweeney. Its economic significance for the area was such that the ceremony was attended by Angela Smith MP, Minister for Enterprise, Trade and Investment, as well as Bill Rohner, Vice President, Electric Power Division of Caterpillar, and John Leslie, Chairman, Invest Northern Ireland.

For further information on IAC's anechoic chambers visit www.iacl.co.uk or contact Graham Dale on tel: 01962 873024 email: grahamd@iacll.co.uk

Sound Reduction Systems

Ceiling insulation treatment for town centre apartments

To meet acoustical requirements, planning conditions regarding eight of the top-floor apartments at Summerfield Developments' Old Brewery project in the heart of Yeovil, between a night club and a supermarket, meant that five separate layers of ceiling materials would have to be installed above and below the roof trusses to meet the acoustical requirements. By using **Sound Reduction Systems'** *Maxiboard*, the developers were able to reduce the requirement to just two layers. As Summerfield Developments' senior quantity surveyor Phil Braddick explained, the planners were particularly worried about external noise coming through the roof. The initial specification called for five separate layers of material. Maxiboard, therefore, provided a very practical solution to the problem, achieving the necessary acoustical results, while saving a considerable amount of installation time.

Left: Summerfield Developments Old Brewery project

In all, 600m² of *Maxiboard* were used at the development, which is on the site of an old brewery. Taunton-based Summerfield Developments, whose portfolio includes all types of housing from one-bedroom apartments to luxury detached properties, has also used *Maxiboard* to provide acoustic solutions in five other projects to date, including Approved Document E compliant ceilings beneath beam and block floors.

Further details tel: 01204 380074
email: info@soundreduction.co.uk
website: www.soundreduction.co.uk

Institute Sponsor Members

Council of the Institute is pleased to acknowledge the valuable support of these organisations

Key Sponsors

Brüel & Kjær | CASELLA CEL | Cirrus Research plc

Sponsoring Organisations

Acoustic Consultancy Services Ltd

AcSoft Ltd

AEARO

AMS Acoustics

A Proctor Group Ltd

Arup Acoustics

Bridgeplex Ltd (Soundcheck™)

BRE

Campbell Associates

Castle Group Ltd

Civil Aviation Authority

Eckel Noise Control Technologies

EMTEC Products Ltd

Faber Maunsell

Firespray International Ltd

Gracey & Associates

Greenwood Air Management Ltd

Hann Tucker Associates

Hodgson & Hodgson Group

Industrial Acoustics Company Ltd

Industrial Commercial & Technical Consultants

LMS UK

Mason UK Limited

National Physical Laboratory

Rockfon Limited

Sandy Brown Associates

Shure Brothers Incorporated

Tiflex Ltd

Wardle Storeys

Applications for Sponsor Membership of the Institute should be sent to the Institute office. Details of the benefits will be sent on request

Institute Diary 2005

29 September
Medals & Awards & Executive
St Albans

6 October
Diploma Tutors & Examiners & Education
St Albans

7 October
CCENM Examination
Accredited Centre

13 October
Council
St Albans

18 October
Engineering Division
St Albans

20 October
Publications
St Albans

25 October
Research co-ordination
London

27 October
Membership
St Albans

9 November
CCENM Examiners & Committee

11 November
CCWPNA Examination
Accredited Centre

17 November
Meetings
St Albans

18 November
CMOHAV Examination
Accredited Centre

24 November
Executive
St Albans

6 December
CCWPNA Examiners & Committee
St Albans

8 December
Council
St Albans

13 December
CMOHAV Examiners & Committee
St Albans

Conference and Meetings Diary 2005

27 September
Scottish Branch
Wind Farm Noise – call for papers
Edinburgh

18 - 19 October
Measurement & Instrumentation Group
Autumn Conference 2005 – What Noise Annoys?
Oxford

26 October
Noise & Vibration Engineering Group
European Week for Safety and Health at Work "Good Practice in Reducing Noise"
Oxford

4-5 November
Electroacoustics Group
Reproduced Sound 21 – Feedback to the Future
Oxford

15 November
London Branch
Workshop on PPS24
London

Further details can be obtained from Linda Canty at the Institute of Acoustics Tel 01727 848195 or on the IOA website www.ioa.org.uk

ADVERTISERS INDEX

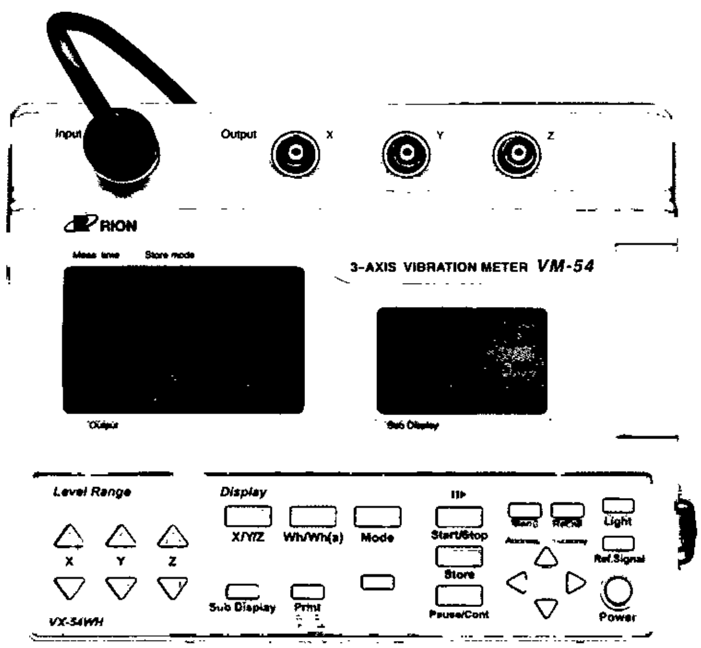
The UK Distributor of RION

Sales ■ Hire ■ Calibration

ANV Measurement Systems

The New Standard for Vibration Measurement

RION VM-54



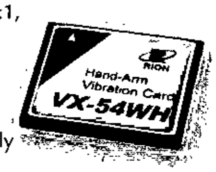
Easy to use Tri-Axial Vibration Meter for Occupational & Environmental Vibration

RION VM-54 Tri-Axial Vibration Meter

- Easy to use, compact, lightweight and practical
- 2 clear illuminated LCD displays
- Can be used with most tri-axial or individual accelerometers (including line drive)
- Data storage to compact flash

VX-54WH Hand-Arm Vibration Program Card

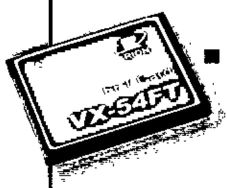
- Complies with BS EN ISO 5349:1, BS EN ISO 5349:2 & ISO DIS8041 (2003)
- True tri-axial measurement measures rms average a_{hv} directly

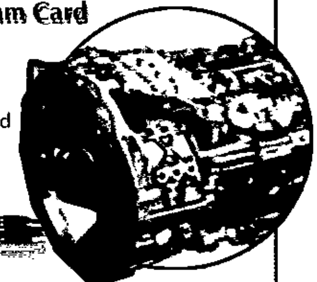


RION PV-97C

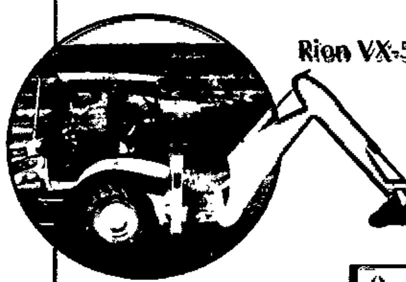
VX-54FT FFT Analysis Program Card

- 400 line FFT with overall and weighted acceleration
- Instantaneous, linear average and max hold display functions





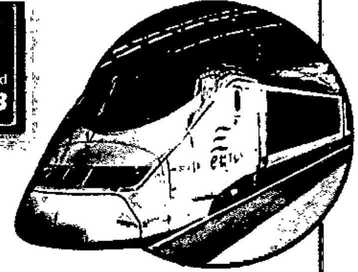
RION PV-93



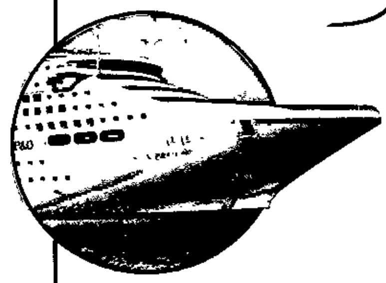
Rion VX-54WB Whole Body Vibration Card

- Complies with BS 6472, ISO DIS 8041 (2003), ISO 2631: Parts 1, 2 & 4
- Frequency weightings w_g, w_b, w_d, w_m, w_k, w_c and w_j can be independently set on each channel

RION PV-62



RION PV-83CW



Rion VX-54WS Ship Vibration Card

- Complies with ISO 6954 (2000)
- Measures wm, wm (a)

At Last! A Simple Meter from a Top Manufacturer that Measures and Logs VDV's

ANV Measurement Systems - Hastings House, Auckland Park, Milton Keynes MK1 1BU
☎ 01908 642846 🖷 01908 642814
✉ info@noise-and-vibration.co.uk 💻 www.noise-and-vibration.co.uk