

Vol 40 No 1 January/February 2015

ACOUSTICS

BULLETIN

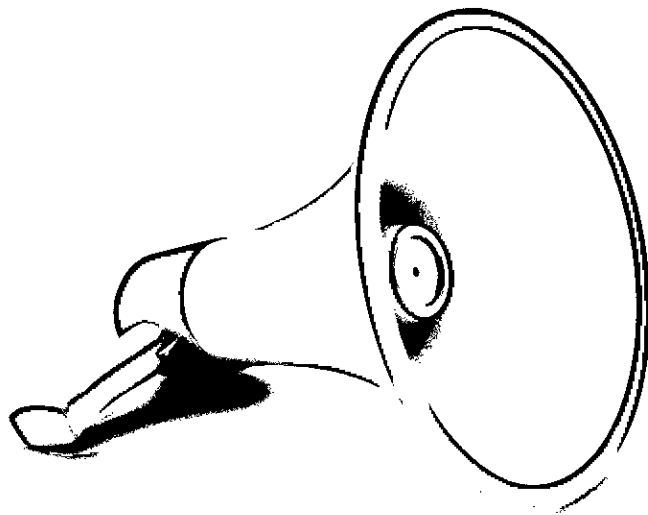


in this issue... One hundred not out: Leo Beranek dazzles delegates at Institute's 40th Anniversary Conference

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plus... Reproduced Sound 2014
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at Birmingham conferences
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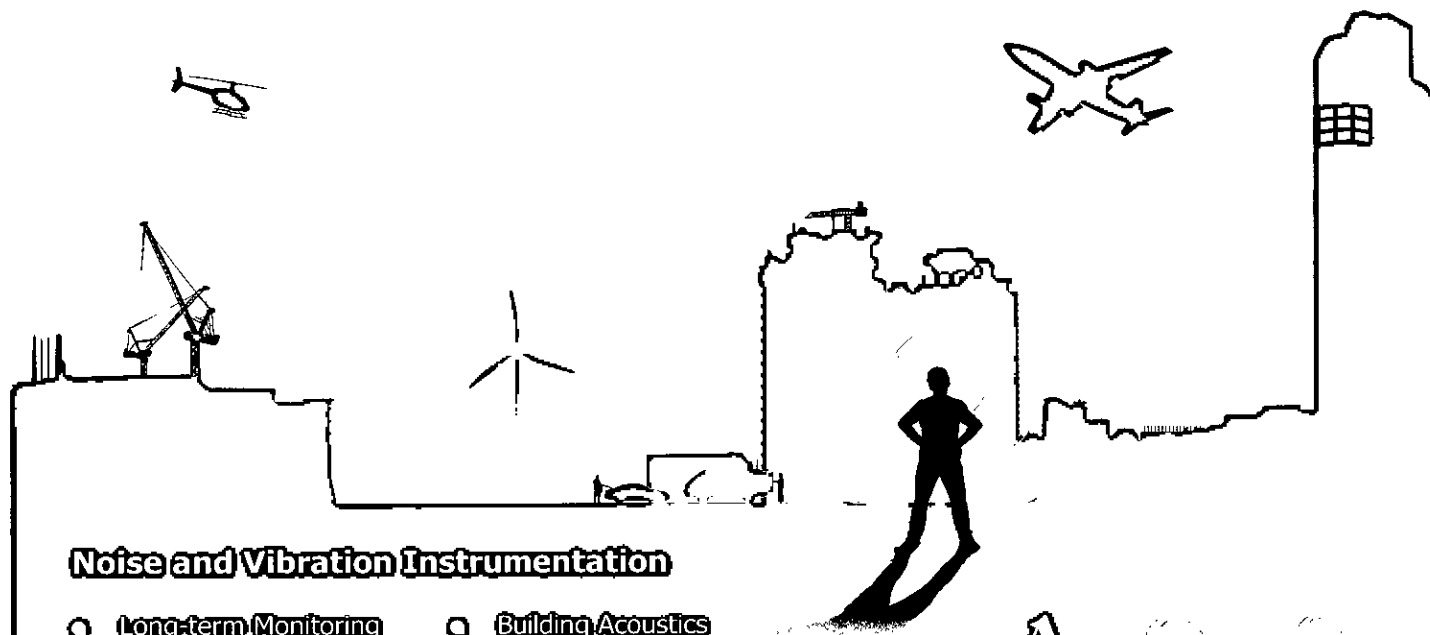
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Published and produced by:

The Institute of Acoustics,
3rd Floor St Peter's House,
45-49 Victoria Street, St Albans.

Design and artwork by:

oneagency.co London
81 Rivington Street
London, EC2A 3AY
e-mail: london@oneagency.co
web site: www.oneagency.co

Printed by:

Newnorth Print
College Street
Kempston
Bedford MK42 8NA



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Annual subscription (6 issues) £120.00
Single copy £20.00

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Vol 40 No 1 January/February 2015

Institute Affairs	6
Brum beats the drum for IOA as it celebrates its 40 th anniversary	6
Reproduced Sound 2014: 'entertaining, intensive and worthwhile'	18
Institute award winners receive their honours at Birmingham conferences	23
Six more member achievements in sustainable practice	35
Instrumentation Corner:	
The dummy microphone is no longer alone	40
General News	41
Researcher goes in search of 3D sound reproduction	41
Ultrasound creates objects that can be seen and felt	42
Technical Contributions	43
BS 4142:2014 Methods for rating and assessing industrial and commercial sound	43
An elephant named uncertainty	50
Industry Update	52
People News	54
Product News	54
Institute Diary	
Conference programme 2015	5
Committee meetings 2015	58
List of sponsors	58
List of advertisers	58

Front cover photograph:

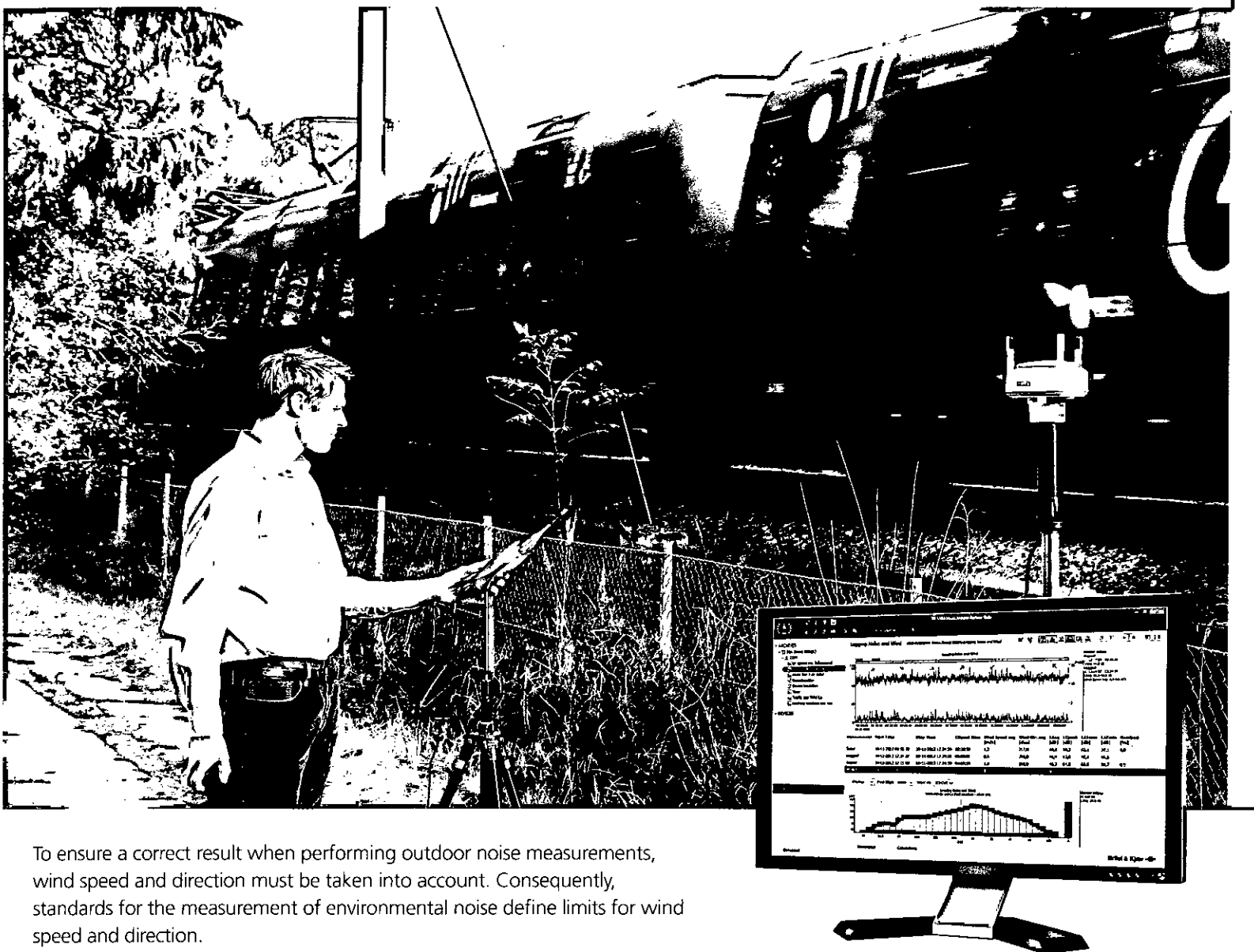
Leo Beranek delivers his keynote lecture at the 40th Anniversary Conference.

The Institute of Acoustics is the UK's professional body for those working in acoustics, noise and vibration. It was formed in 1974 from the amalgamation of the Acoustics Group of the Institute of Physics and the British Acoustical Society. The Institute of Acoustics is a nominated body of the Engineering Council, offering registration at Chartered and Incorporated Engineer levels.

The Institute has over 3000 members working in a diverse range of research, educational, governmental and industrial organisations. This multidisciplinary culture provides a productive environment for cross-fertilisation of ideas and initiatives. The range of interests of members within the world of acoustics is equally wide, embracing such aspects as aerodynamics, architectural acoustics, building acoustics, electroacoustics, engineering dynamics, noise and vibration, hearing, speech, physical acoustics, underwater acoustics, together with a variety of environmental aspects. The Institute is a Registered Charity no. 267026.

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and Speech and Hearing Groups
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and the enjoyment
and performance of music**
London

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Organised by the Underwater
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**Seabed and sediment acoustics:
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Bath

27-30 September

Organised by the Galpin Society
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**Musical instruments
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Cambridge

29-31 October

Organised with support from the
French Acoustical Society (SFA)
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Paris

10-12 November

Organised by the
Electro-acoustics Group
Reproduced Sound
Moreton-in-Marsh

Please refer to
www.ioa.org.uk
for up-to-date information.

Dear Members

I wish you all a happy and prosperous new year and hope it brings us all what we strive for. The new year is a time to review 2014 and look forward to 2015.

Since my last letter we have run the successful 40th Anniversary Conference at the NEC. I was extremely proud of the organisation by all to make it such a triumph. We welcomed many visitors from overseas and it was a pleasure to have them participate. Our opening keynote speaker, Leo Beranek, had celebrated his 100th birthday a few weeks before, but defied his age when giving an up-to-date presentation, holding the audience's attention and then demonstrating his extensive current knowledge in a Q&A session. He graciously gave the after dinner speech, which captivated and delighted the audience.

The range of topics and applications throughout the event were extensive, which is a true testament of the wide variety of members' interests and contribution they make to society as a whole. The presenters engaged the audience with high quality entertaining presentations, displaying depth of knowledge and expertise.

As part of our strategy to promote acoustics, we have been continuing to build closer links and attend events with many other institutes and societies. My thanks go to all the volunteers who graciously give up their time to go to these events and foster good relationships. Jo Webb and Simon Kahn attended the Royal Academy of Engineering and the STEM Alliance respectively. David Watts attended the Institute of Physics event. I was privileged to attend the Noise Abatement Society's John Connell Awards and present the innovation award, which we sponsored. This went to Network Rail for a scheme to design and build quieter rail repair equipment. It also gave us the chance, as a team, to discuss current topics with two ministers, a peer and other MPs. Likewise, Peter Rogers has been developing closer links with Government by attending the Parliamentary and Scientific Committee meetings to ensure we demonstrate a scientific approach to the various bodies.

However, in ensuring we promote acoustics, it has been interesting to read in the Press the continued debate on wind farms and we at the Institute have received many letters from various lobbies. Interesting because, with us publishing the Good Practice Guide, it seems that the public and press have incorrectly assumed we set the policies



and noise limits. Our role was to create a guide (not standard) to aid those who are applying the policy set by Government to ensure good, robust methodology. We have published a response on our website to the various comments and we will continue to maintain the scientific and professional approach expected of a professional body.

We continue to drive the strategic purpose of the Institute and have recently set the goals for 2015 on a number of initiatives commenced in 2014. One of the key reviews will be education and how the IT infrastructure will integrate to support the future vision.

It is also worth mentioning the fascinating fact that the IOA now has more than 7,000 members in its LinkedIn group, which suggests there are thousands of potential Institute members out there. This, in turn, raises the question: can/should Institute members do more to promote the many benefits of membership to colleagues and fellow acousticians they come across in the course of their work? There is obviously a huge professional interest in the subject and it is something we as the Institute need to look at to see how we can tap into more effectively.

I would also like to draw to your attention when renewing your membership to the request to complete the equality and diversity questionnaire. The information given is collated to identify overall how we are represented across all sections of community and will feed into the Royal Academy of Engineering Diversity Concordat. As a nation we have a major shortfall in engineers and the data will be used to monitor the success of measures to encourage more minority groups into engineering. ■

William

William Egan, President

Brum beats the drum for IOA as it celebrates its 40th anniversary

Full conference round-up

All roads led to Birmingham for IOA members last October as they celebrated the Institute's 40th anniversary with a highly successful two-day conference at the NEC. Almost 300 people attended, some travelling from as far as Canada and the US as well as seven European countries outside the UK.

Overlapping on the first day with Reproduced Sound, it featured keynote lectures, plenaries and medal lectures as well as a series of parallel technical sessions organised by all the Institute's specialist groups.

Two stand-out presentations for many delegates were the keynote lectures delivered by two of the acoustics world's most revered figures: Leo Beranek (*Concert hall design: new findings*), who a month earlier had celebrated his 100th birthday at his home in the US, and Herman Steeneken (*Forty years of speech intelligibility assessment*) who came from Holland to speak.

The social highlight was a reception and dinner at the end of the first day at the adjoining Hilton Metropole Hotel, during which a series of presentations were made to award winners (see pages 23-28 for full details). A full report of Reproduced Sound appears on pages 18-22.

Institute President William Egan, who opened the conference by formally welcoming delegates, said afterwards: "I was extremely proud of the organisation of the event by all concerned to make it such a success.

"The range of topics and applications was extensive, which is a true testament of the wide variety of interests of our members and the contribution they make to society as a whole.

"The presenters engaged the audience with high quality, entertaining presentations, displaying a huge depth of knowledge and expertise.

"We were particularly pleased to welcome many visitors from

overseas and it was a pleasure to have them participate."

Plenary lectures

By Hilary Notley and Bridget Shield

Leo Beranek

Before he started his lecture, Leo was congratulated on his recent 100th birthday and presented with a special issue of the Rayleigh Medal (see page 23) and a certificate to mark the occasion. He then delivered a stimulating lecture in which he summarised his own research on concert hall ratings and gave brief descriptions of some of the most popular halls around the world. In addition to his own data, obtained through many years' research, Leo presented the latest findings in concert hall research, concluding with proposed optimum dimensions and seating capacities to ensure good acoustics. Everyone in the audience considered it a privilege to have the opportunity to hear Leo speak so eloquently on the subject of concert hall acoustics, particularly in his centenary year.

Herman Steeneken

The second invited keynote speaker was Herman Steeneken, famous as the joint author, with Tammo Houtgast, of the Speech Transmission Index. Herman's lecture consisted of an overview of the past 40 years of speech intelligibility testing, and compared various subjective methods that have been developed over the years in different countries. He described the changes in the applications of the testing, from telephone and military communications in the early days to today's areas of use such as classrooms, hearing aid testing and public address systems. He also summarised the objective measures and standards that have been developed for measuring and specifying speech intelligibility, showing how advances in technology have influenced the



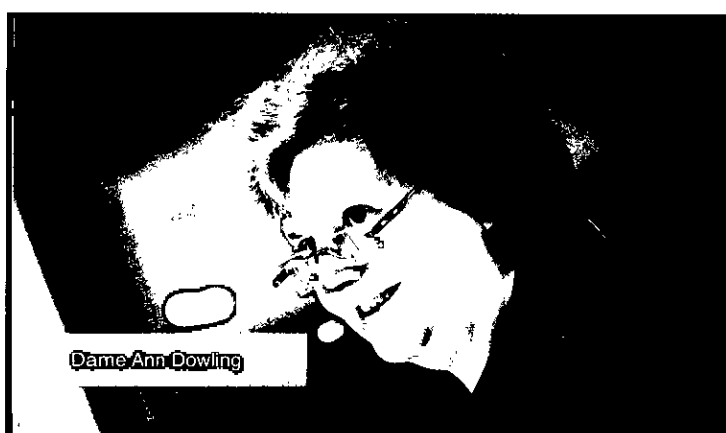
William Egan, IOA President



Stephen Turner



Leo Beranek



Dame Ann Dowling

■ methods available and suggesting that more sophisticated and accurate methods will be developed in the future.

Stephen Turner

Stephen Turner gave a review of the development of UK noise policy and management over the past 40 years, although he started his talk somewhat earlier with a quote from *The Bible* regarding construction noise. After a brief consideration of other historical examples, Stephen commenced his review by looking at the standards, guidance and regulations which were already in place in 1974. He then focussed on planning and noise and transportation noise, showing how the various guidelines have been extended and amended in the past 40 years, and suggesting how they might develop in the future.

Ann Dowling

Dame Ann Dowling was awarded the 2014 Engineering Medal (see page 25) and gave her medal lecture on the subject of the reduction of jet noise. The traditional methods of reducing jet noise in aircraft lead to an increase in fan noise, such that the latter is now approximately equal to the jet noise. Dame Ann's research team has therefore been investigating other methods of reducing the jet noise. She described their theoretical approach to predicting the noise reduction which can be obtained by introducing chevrons or corrugations around the lip of the jet pipe. A prediction model has been developed which can be used to examine the effects of different geometries in order to optimise the noise reduction at the design stage and enhance understanding of the source mechanisms. The model captures the effects of chevrons and microjets. The techniques developed can also be used to examine other ways of reducing jet noise.

Tim Leighton

Tim Leighton, the 2014 winner of the Rayleigh Medal (see page 28), gave a fascinating Rayleigh Medal lecture describing the importance of bubbles and his many years' research into their behaviour and developing applications. His lecture was illustrated with informative slides and videos, including several of hapless researchers getting wet in the process of their investigations! Examples of applications which Tim and his research team have developed included using counts of bubbles in the ocean to estimate the amount of carbon transferred between the sea and the atmosphere, which is making an important contribution to the understanding of climate change; investigation of the feeding patterns of whales and dolphins; detection of underwater explosives; and seabed applications such as identifying leaks from underwater gas pipelines. Other applications, on dry land, include searching for mobile phones and hence their owners in disaster areas; bio-medical uses; and cold water cleaning.

Keith Attenborough

Keith discussed the principles underlying the acoustic performance of sonic crystals, which makes them of use in certain sound reduction applications, and described recent developments in their use for noise and vibration control. He showed the theory

behind the performance of different arrays of sonic crystals and illustrated their practical use by presenting data on the insertion losses provided by sonic crystal barriers of different designs, materials and array configurations. He also showed how, when using a sonic crystal barrier, attenuation provided by the ground effect is enhanced, and presented results of recent research aimed at increasing the attenuation provided by the ground by introducing roughness to a surface.

Trevor Cox

Trevor gave an entertaining talk on some buildings with strange acoustic phenomena, which he had come across as part of his research for his book and sound tourism website *Sonic Wonderland*. These included the abandoned spy station at Teufelsberg, Berlin where the domes provide a variety of interesting sound effects; the Emanuel Vigeland Mausoleum in Oslo, with a reverberation time of 18 seconds at low frequency; a warbling station booking office, also in Oslo; and a disused Second World War oil tank in Scotland which Guinness considers has the longest RT in the world (of 75 s!). As well as providing acoustic data to illustrate the effects, Trevor gave examples of musicians playing in some of the spaces to utilise the strange acoustic effects.

John Seller

John gave an overview of developments in the measurement of sound over the past 40 years. This included both changes in instrumentation over that period, and the introduction of new acoustic parameters and metrics over the years, such as statistical levels. In the early days the Building Research Station was at the forefront of research on building acoustics and noise, and John illustrated his talk with many interesting photographs from the BRE archive. In the late 1940s, "portable" equipment for field measurement meant a large van filled with instrumentation! John concluded his lecture by making some observations on the importance of subjective testing and suggestions regarding factors that should be considered in order to improve its accuracy and reliability in the future.

Stuart Rosen

Stuart Rosen, Professor of Speech and Hearing Science at UCL, gave a plenary lecture on the difficulty of understanding speech in background noise, and discussed recent research which is advancing our understanding of the mechanisms behind such difficulties. He described in particular the distinctions between the different types of masking which occur in the auditory pathway, illustrating these concepts by explaining how they affect people of different ages and hearing abilities.

Stephen Dance

Stephen Dance gave the 2014 Tyndall Medal lecture which described his work with the Royal Academy of Music over the past few years, bringing together the worlds of music and acoustics education. Stephen gave an amusing account of how he encourages the music students to engage with acoustics, and in particular with the potential risks to their hearing. A programme ■ P8 ■



Tim Leighton



Keith Attenborough

◀P7▶ of audiometric testing of music students has led to the development of a large database of audiometric data. Stephen also showed results of investigations into the noise exposure of players of different instruments, and discussed mitigation methods that have been developed for students and professional musicians.

Building Acoustics

By Carl Hopkins and Andy Parkin

The first session, chaired by Carl Hopkins, started with a paper by Professor Sean Smith on *Airborne sound insulation in buildings – the conundrum of extending to lower frequencies*. This paper reviewed research and proposals that had been made in recent years to include frequencies down to the 50Hz one-third octave band. It was noted that emphasis on lower frequencies in single-number weightings may lead to sound transmission issues at mid and high frequencies. For this reason, dual parameters might be required, the sound insulation standard based on 100Hz could be increased or a revised weighting-curve could be developed.

The second paper was by Fiona Smyth on *A centenary of architectural acoustics: Hope Bagenal and Wallace Clement Sabine*. In 1914, a series of letters on the topic of architectural acoustics was exchanged between British architect Bagenal and Harvard physicist Sabine. Fiona discussed their correspondence which marked the introduction of Sabine's advances in acoustics to applied design in British architecture, and the emergence of Bagenal as Britain's first independent acoustic consultant. Fiona discussed the context within which the letters were written and made another centenary link with Bagenal's life during the First World War.

The third paper was presented by Christina Higgins and Raf Orłowski and was authored with Luis Gomez Agustina on *An investigation into the Helmholtz resonators of the Queen Elizabeth Hall, London*. Raf introduced the paper with a background to the refurbishment work and handed over to Christina to discuss the details of the investigation into the performance of the 2,300 Helmholtz resonators in the hall which control the reverberation at low frequencies. A bank of replica resonators was constructed and the absorption was measured with and without foam in the neck and with acoustic curtains in front of the resonators.

The fourth paper was by Jack Harvie-Clark on *Reverberation time, strength and clarity in school halls: measurements and modelling* and discussed school rooms where the absorption is mainly on one surface as these can be difficult to predict due to non-linear decays. Jack explored the potential to use Strength and Clarity to describe the acoustic response of the spaces, and the correlation of these with the conditions that the users require. These can be predicted as a function of distance, mean absorption coefficient, and geometry such that signal level between a talker and listener can be predicted from Strength, and speech intelligibility from Clarity even when the measured reverberation time varies.

The second session, which chaired by Andy Parkin, started with a paper by Daniel Lurcock of the University of Southampton, who spoke on *Predicting groundborne railway noise and vibration in buildings: a comparison of measurement methods*. Daniel

discussed the pros and cons of various assessment methods: empirical predictions tend to be generalised and simplistic in their output; computational predictions are costly and time consuming (they are also not always properly validated). When carrying out measurements on site, it is found that vibration magnitudes vary between floors (indeed some radiate whilst others attenuate); theoretical models are not always "clever" enough to predict this behaviour. The most accurate theoretical model, having the best correlation with site measurements, is Finite Element (FE) modelling with parametric capabilities, which may be the way forward, but this is even more time consuming and costly than other computational methods. Comparing FE models with site measurements, it is found that: empirical and basic computational models are too inaccurate; FE models do not need too much detail to be accurate, but can take a day or so to run!

Stephen Dance from London South Bank University talked about *The development of vacuum isolating panels for noise control applications*. Sound cannot pass through a vacuum, therefore vacuums should be the ultimate attenuator, in theory. However, in practice this is very difficult to achieve due to the physical loads required on a system to maintain a vacuum. A number of experiments have been carried out to see what can be achieved (before structural failure occurs in the panels). Findings show that, in panels approaching internal vacuum, low frequency attenuation is increased, but high frequency actually decreases. The conclusion was that vacuum panels are not currently physically or economically viable in noise control.

Helen Butcher of Arup closed the session talking about *Temporary theatres: challenges and expectations*. Arup has been involved in a number of temporary theatre installations, including a naturally ventilated timber frame "Shed" at the National Theatre and The Tent in Chichester. External façade attenuation is one of the biggest challenges for the lightweight structures, both in terms of noise break-in and break-out. Achieving adequate natural ventilation is a real challenge, especially when considering the conflict of requirements between attenuation and pressure loss. Rain noise can also be an issue, although clever use of damping and insulation can make this manageable. Key findings from these installations included: making services plant especially quiet so they do not affect internal noise levels; using highly directional sound reinforcement systems to minimise disturbance to residents; using dressing rooms (in shipping containers!) and other solid objects as barriers to protect residents; and use heavy drapes internally to supplement external façade attenuation.

Environmental Noise

By Colin Cobbing and Steve Mitchell

The first presenter of the first session (chaired by Steve Mitchell) was Paul McDonald of Sonitus Systems who described his project for Dublin City Council, monitoring the sound of a city. Paul described a noise monitoring system he has provided in response to the Environmental Noise Directive, with the following main aims: to validate noise mapping; to improve communication with the public; and to check the effectiveness of actions taken to affect noise in the city. Twenty monitors were installed in parks and other areas that warrant noise management and data is reported online (www.Dublincitynoise.ie). Paul described some of the data capture challenges that has been overcome and how, because the audience was multileveled, the data was presented in different ways. He reported some noise reductions of 1-2dB through 2012-2013, possibly due to city initiatives to control noise. Eight areas had been designated as Quiet Urban Areas. The next steps were to extent the number of sites and to integrate the programme with the Smart Cities Plan.

The second speaker was Phil McIlwain of Westminster City Council who spoke about identifying and protecting urban tranquillity. Phil's presentation followed on the theme of urban noise and protecting certain areas, but moved away from monitoring to policy and protection mechanism. Westminster City Council declared a policy to protect tranquil areas in 2009. A study identified 20 sites and 10 were looked at in more detail, in particular to understand their quality and value to health. The work was multi-faceted, for example ▶P10▶



Fiona Smyth

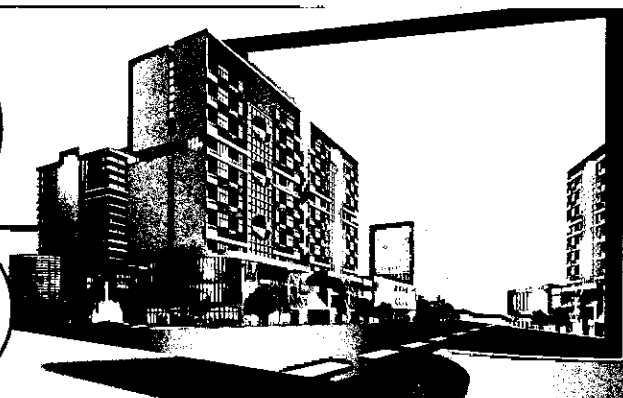


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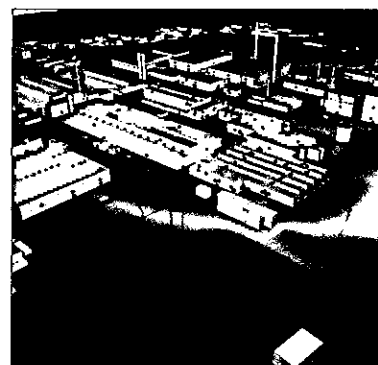
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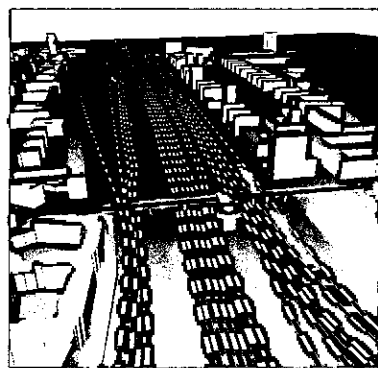


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P8 considering historic value, and it adopted the Tranquillity Rating scoring system. Noise levels even in the centre of parks were high, but they are highly valued. As a result, 23 spaces are protected by local policies that not only restrict noise emissions from development within the spaces but also adjacent to them.

The final speaker in this session was Greg Watts of Bradford University who spoke on factors associated with tranquillity in the Scottish Highlands and Dartmoor National Park. Greg's talk took the audience from the hubbub of Dublin and Westminster to the peace and tranquillity of some of our most remote unmanaged countryside. The objective of his work had been to see how to rank tranquillity in such areas, to see if the Tranquillity Rating (TR) scoring worked well in these places and to understand what were the main factors making these areas so tranquil. Research had told us that tranquil areas create feelings of being relaxed. Greg's survey work confirmed this with a close correlation in the subjects studied. He played some of the video clips used in the research and demonstrated how adding man-made noise changed the feelings evoked. Questions such as "how wild" or "how natural" had been asked. Features such as the percentage natural features and percentage wild land had been quantified. Strong correlations between the Tranquillity Rating score and scores on feelings of pleasantness and calm were found. It was concluded that the Tranquillity Rating method worked well in remote locations.

In the second session, chaired by Colin Cobbing, Bernard Berry of BEL- Environmental and Diana Sanchez of Anderson Acoustics gave a presentation on *The economic valuation of aircraft noise effects: a critical review of the state of the art*. They explained the different effects of aircraft noise on human health, dose-response relationships and the strength of evidence for each type of effect. They then described the different methods for monetisation and explained why the recommended UK monetary cost per Disability Adjusted Life Year (DALY) is £60,000. Estimates for Heathrow, Gatwick and Stansted were presented, although they were at great pains to explain that these were only indicative and that no definitive conclusions could be drawn on the absolute costs of health effects. It was estimated that the cost of the health effects (acute myocardial infarction, sleep disturbance and annoyance) associated with the three airports was between 4% and 17% of the total cost of environmental noise in England, which had been estimated to be approximately £7 billion.

The next presentation was given by Professor Jian Kang of the University of Sheffield on *Sound source recognition technique for construction noise control*. Recordings were taken of construction activities around London Bridge Station during its redevelopment. He explained the automatic recognition methods that were applied to identify and detect different types of construction noise from the general ambient noise. The results obtained using the method were impressive given the variable nature of the construction noise and the general ambient noise around the station. The accuracy was 90% for reversing alarms fitted to construction vehicles, 78% for demolition, 94% for piling, and 86% for heavy trucks, demonstrating real potential for practical applications of automatic detection methods in environmental noise.

Next was Dani Fiumicelli of Temple Group who talked about *Aviation noise impacts on the historic environment*. The presentation was based on the joint paper between the Temple Group and Cotswold Archaeology, derived from work they had carried out on behalf of English Heritage to develop a methodology to analyse the noise impacts of airport expansion in the south-east of the UK on the historic environment. Dani explained that an extensive literature and web-based search had revealed no established methodologies; but highlighted that consideration of the noise impacts on cultural activities and heritage assets was found in a significant minority of Environment Statements for EIA schemes. Consequently, the project has taken an EIA-based approach which focused on the importance of the setting of heritage assets and how the impacts of noise on this could be assessed. The presentation described how the method used GIS techniques to identify the spatial scope of the study by overlaying airport noise contours on digitised data sets of the distribution of heritage assets. Dani highlighted that there is no fixed relationship between a heritage assets' designation e.g. listing status

and its noise sensitivity, and therefore it was critical to screen heritage assets in terms of their sensitivity to noise impacts; based on four categories created as part of the project. He then went on to describe how the method applied to detailed assessment of noise sensitive heritage assets based on quantitative acoustic data and qualitative non-acoustic information, taking care to emphasise the need to incorporate justified professional judgement as part of the process as slavish application of the methodology was discouraged. A useful insight of the method was provided by particular consideration of a few cases, including examples where heritage assets were rated as being significantly affected and not significantly affected by aviation noise.

The last presentation was given by Chris Skinner of URS who spoke on *Focused noise monitoring 2013*. He reported the findings of the work carried out on behalf of Defra to undertake a noise monitoring programme over eight days at 77 properties in England. Addresses were selected to revisit those from previous surveys, some dating back to the 1960s, to allow an investigation of trends on noise levels over periods of 50 years. An acoustic version of the Time Team Analysis of those sites where data exists dating back to the 1960s showed significant decreases in LA10 and LA90 (no LAeq data was available from the 1962 survey). A small proportion of the change may be attributable to differences in measurement procedures and locations. However, the full magnitude of the change can only be explained by a real reduction in noise which is a powerful validation of the historic policy interventions that have been implemented since the early 1960s.

Measurement and Instrumentation

By Ian Campbell and Mark Dowie

The first session was opened by Ben Piper of NPL who has been researching the use of light to measure sound. Based on Doppler modulation of lasers, two methods were described for quantifying sound. These already allow visual mapping of sound fields and eventually to defining the acoustic Pascal without relying on microphones. Although currently expensive and time consuming, the prospects look encouraging and research continues. The discussion, initiated by Jamie Angus, covered the demise of reference standards and the prospects for sound field microphones.

A review of instrument standards from the 1960s given by Richard Tyler of AVI explained how the IEC was structured and described the work of the specialist committees who produce them. The ensuing standards are then promulgated as National and EN documents. As the SLM and calibrator standards are up to date, work is concentrated on the filter and noise exposure meter standards. Questions followed from Roger Thompsett regarding the costs of standards work and the prospects for funding the specialists who have to undertake the work.

Tools and machinery used at work must be accompanied by a Noise Declaration. Emma Shanks of HSL reported work undertaken by the HSL into their adequacy. Some 80% were inadequate, often due to the complex nature of the regulations. Directives and associated Test Codes are not always clear nor relate to real use risk. Work is continuing to provide recommendations for a framework that will encourage manufacturers to reduce noise emissions of their products and to report noise emissions in a meaningful way. Stephen Turner suggested combining the different Directives into one document as this may make it easier to enforce.

The final paper, by David Robinson of Cirrus Research, concerned the evolution of the SLM. From measurements taken in the 1920s by the New York Noise Abatement Commission, he charted the development of the modern instrument. From the advent of the transistor in the 1960s portable instrumentation became practical, although the whole system was still analogue. With the advent of digital circuits in the 1970s the analogue display became digital; with each passing decade the AD converter moved nearer to the microphone; now they are all digital. The final section of the paper related to mobile phone apps; this prompted comment on the performance of the microphones in phones as well as the question of legal metrology.

The second session started with Richard Barham from NPL whose presentation looked at the development of MEMS **P12**

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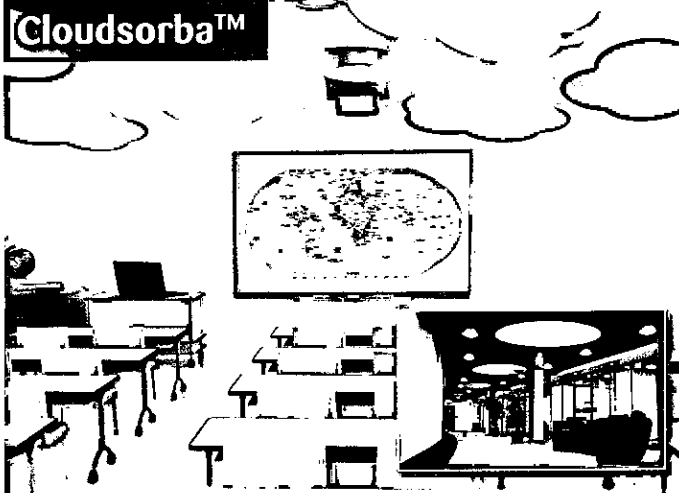
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►P10 microphone technology for use in the measurement and instrumentation field. With some adaption and correction Richard and his colleagues have successfully corrected the very low-cost, mass-produced MEMS microphone to meet IEC 61672 class 1 tolerances. With a noise floor of 41dB, they may not yet be suited to all traditional applications but the potential for MEMS microphones to be embedded into almost any device opens a broad range of new possibilities.

The convenience of the balloon means that it is commonly used as an impulse source for reverberation tests. Kenneth Liston questioned how effective it was compared with the more repeatable starting pistol and loudspeaker methods, and he found there had been very little research to date. Applying each of the three methods in a lecture theatre, a concert hall and a church, Kenneth was able to measure the effect of using the balloon. It was only in the less reverberant lecture theatre where the balloon impulse produced a significantly different result, with the low frequency bands showing a longer reverberation time than the pistol and speaker methods. In large diffuse spaces, like the church, the balloon produces very similar results to the loudspeaker. This raised the possibility of a standard or calibrated balloon to further improve repeatability.

Ray Browne from SRL presented his method for measurement source data using optimized beam-forming techniques on moving sources for outdoor sound propagation modelling. The original technique, using multiple straight line arrays, was developed for use on helicopters and can produce 3D noise maps to show the most significant noise sources on the helicopter. The technique produced useable results down to 25Hz and could have potential applications for wind turbine noise.

Musical Acoustics

By Lisa Greenhalgh and David Sharp

Professor Murray Campbell of the University of Edinburgh began the first session (chaired by David Sharp) by discussing the question *Why do brass instruments sound 'brassy'?* He explained that the brassy sound has nothing to do with the material of manufacture. Instead it is a result of the nonlinear dynamics of the lip-reed sound generation mechanism and, more significantly, the nonlinear nature of the sound propagation in the bore of the instrument. The extremely high sound pressure levels generated within the instrument during fortissimo playing leads to distortion of the wavefront of the sound propagating along the bore and the formation of a shock wave.

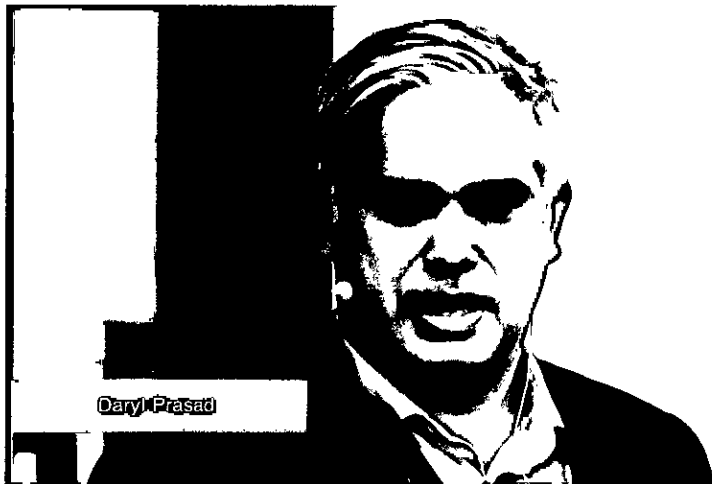
The next paper was delivered by Kuriijn Buys of the Open University who discussed his work on *Developing and evaluating a hybrid wind instrument excited by a loudspeaker*. He described his set-up in which a physical model of a single-reed mouthpiece is simulated on a computer with real-time data acquisition capabilities. The physical model takes into account parameters such as reed stiffness and mouth pressure and calculates a signal which is sent out from the computer and used to drive a loudspeaker coupled to a resonator. The pressure at the input to the resonator

is monitored by a microphone and fed back to the computer, resulting in a real-time adjustment of the generated output signal. A video was shown demonstrating the effect of coupling the hybrid instrumentation to the main body of a clarinet. Adjustments to the fingering applied to the instrument resulted in real-time changes in the notes produced.

The final paper was presented by Ailin Zhang of the University of Cambridge who discussed her experimental investigations on the *Motion of the cello bridge*. She described transfer admittance measurements made on three cellos fitted with different designs of bridge. By striking each bridge at specific points using an instrumented hammer, the response of the bridge to the different impacts was determined using an accelerometer. Processing of the results revealed that the bridge motion can be expressed in terms of a rotation around an instantaneous centre. The motion centre changes with frequency, tending to lie close to the bridge foot near the soundpost at lower frequencies and moving towards the bass-bar foot at higher frequencies (although this behaviour shows some variation depending on the cello and bridge under test).

The second session (chaired by Lisa Greenhalgh) opened with a paper by Richard Seaton of the Open University on *Pitch drift in a cappella western choral music*, and presented the findings of a survey undertaken as part of an ongoing PhD research project. The paper considered 195 responses in total and included differing groups of choirs, ranging from four-part barbershop groups to large choral societies, and from Renaissance to Modern repertoires. The survey also considered the background of the choirs – unauditioned or auditioned amateur, professional or experienced amateur, or all professional. The survey also considered the acoustic properties of the varying rehearsal spaces, the rehearsal time of day, and whether the choir sang standing, sitting, or both. It was found that choirs who recruited unauditioned amateurs reported drifting more regularly than any other group, and whilst all groups reported occasional pitch drift, no professional group reported regularly experiencing drift. It was found that in 80% of the choirs represented that the pitch drifted downwards, and that a significant improvement in maintaining pitch during public performances was experienced. The top three reasons for pitch drift were found to be concentration and tiredness, breath control, and confidence, although a multitude of other factors were also considered as having an influence, whilst posture was indicated as having no significant effect of pitch drift.

The second paper was presented by Owen Woods who discussed *What contribution can acoustics make to organology*. He highlighted both the benefits and limitations of using acoustics and vibration to study musical instruments, and considered the varying standpoints of musicians, luthiers, organologists, and acousticians; and also the different objectives with which these differing disciplines may approach and consider a musical instrument. The paper highlighted the consideration that perhaps what a luthier is seeking to achieve, such as a refinement of the sound of their instrument specialism whilst delivering something that is marketable, is likely to be different to what a musician may seek **►**



■ in an instrument, who may be more focused on both sound and playability. Acousticians will perceive an instrument in yet another different light, and are more likely to be concerned with why a particular instrument sounds like that instrument in particular; whereas an organologist, or ethnomusicologist, may be more concerned with developing designs beyond current limitations or placing an instrument into historical or social context. The paper observes that acoustic analysis can positively contribute to any angle of musical instrument research, so long as it remains contextual, and that the quantifiable nature of acoustic analysis of an instrument may offer benefits not garnered from perception alone. Owen demonstrate such a use of acoustic analysis, presenting the results of an analysis of the bridge admittance of five charangos, a ukulele, a timple, and a classical guitar, and ultimately using this to successfully demonstrate that the charango can be meaningfully considered as a distinct instrument and how this approach was also used to show how and why urban charangos developed from rural charangos.

Carl Hopkins of the University of Liverpool presented research carried out with colleagues at the University of Liverpool and the Royal Northern College of Music on interactive performance for musicians with hearing impairments using the vibrotactile mode. Limits were established for perceiving musical notes via vibration on the fingertips and feet to define a usable dynamic range and a pitch range that can reliably be perceived. Perception and learning of basic relative pitch was investigated with normal and hearing impaired participants. This indicated a high success rate with and without training which implies that everyone has a basic ability to perceive relative pitch although it is difficult to distinguish intervals smaller than three semitones. With training it has been shown to be possible to achieve significant improvements in the assessment of relative pitch.

Noise and Vibration Engineering

By Malcolm Smith and Stephen Walsh

The Noise and Vibration Engineering Group's sessions had a particular focus on vibration transmission in buildings and automotive NVH issues.

In the first session, chaired by Malcolm Smith of ISVR Consulting, the first paper was given by Daryl Prasad of Marshall Day Acoustics who spoke on *Assessment of low vibration techniques in the construction of a diaphragm wall using a hydromill*. An underground station on the Dublin North Metro needs to be constructed adjacent to a hospital, but conventional methods of excavation using grabs would cause high levels of groundborne vibration. A hydromill was proposed instead, and on-site tests demonstrated that this did indeed generate much lower levels of vibration.

The second paper was *Possible approaches for assessment of industrial noise by emphasis on different standards and guidance*. Tim Britton of URS Environment & Infrastructure described the guidance and planning policy that applies when performing a noise impact assessment for new residential developments near existing industrial sites. A case study highlighted how different

conclusions can be reached by using alternative standards and guidance. Tim pointed out the potential for disagreements between consultants and for storing up environmental noise problems into the future.

The final paper returned to the topic of vibration in hospitals, this time caused by the blade passing frequency of helicopters landing on the roof of the Karolinska Institute in Stockholm. Adam Fox of Mason UK Ltd explained the technical difficulties of shielding the building from this very low frequency source, and the particular structural requirements of the landing pad.

At the end of the session the chairman noted that the lively discussion on the transmission and control of vibration in hospitals suggested scope for a more general meeting on related topics.

Stephen Walsh of Loughborough University chaired the second session, which opened with a paper by John Smethurst and Richard Sullivan of Anderson Acoustics entitled *Crossrail western running tunnels and caverns – managing groundborne noise and vibration*. This highly topical presentation described how ground-borne noise and vibration from construction of the Crossrail tunnel were predicted, monitored and managed. Measured data from the tunnel boring machines were presented, along with design measures taken to minimise the impact of a temporary construction railway.

Next, Bernard Challen of Shoreham Services presented a personal and highly entertaining reflection on automotive NVH developments over the last 40 years, complementing an article in the September-October 2014 issue of *Acoustics Bulletin*. This covered the development of government legislation on permitted vehicle exterior noise levels as well as the development of NVH tools to measure and predict vehicle interior and exterior sound.

The NVH theme was continued by Stephen Walsh with a paper entitled *Sound source contributions for the prediction of vehicle pass-by noise*. It was explained how the orifice noise and shell noise from an exhaust silencer were modelled in order to predict their contribution to pass-by noise. The predictions were validated experimentally in the anechoic chamber at Loughborough University, involving a specially constructed source on a trolley to replicate exhaust orifice noise, and a reciprocal approach to determine noise radiation from the shell.

Orla Murphy of Jaguar Land Rover gave the closing paper entitled *2D or 3D surround sound in an automotive environment? Preferences of the untrained listener*. The author presented a very interesting report on listener preferences between 2D and 3D surround sound in a vehicle cabin. The 3D surround sound involved speakers in the roof lining of the vehicle in order to raise the sound stage, and the subjective listening trials were carried out on 84 untrained listeners. A statistical analysis of the results showed that the preference for 3D was related to both the musical genre and the content of sample.

Physical Acoustics

By Shahram Taherzadeh

The Physical Acoustics Group had two sessions, the main **P14**



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EP13 theme being the use of metamaterials and complex surfaces to improve sound attenuation properties of materials and surfaces.

The first session, which was attended by about 25 people, featured three presentations. First, Victor Krylov of Loughborough University gave a talk on *The applicability of Kramers-Kronig relations for guided and surface waves*. This was followed by a talk given by Logan Schwan of the University of Salford on *Sound propagation in presence of locally-resonant surface: an analytical model*. The last talk of the session was presented by Dmitri Smirnov of the University of Salford on *Tunable resonator arrays-transmission, near field interactions and effective property extraction*.

The second session, which also attracted up to 25 people, started with a presentation by Shahram Taherzadeh of the Open University on *Sound propagation through periodic and non-periodic arrays of cylinders near ground surfaces*. This was followed by a presentation by Haydar Aygun of Southampton Solent University on *Propagation of sound in a duct with a Helmholtz resonator at one end and incorporating a temperature gradient across the duct*. Ho-Chul Shin of the Open University gave a talk that described a technique for *non-invasive deduction of soil strength by acoustic-seismic measurements*. Finally, Giulio Dolcetti of the University of Sheffield presented *Model measurements on acoustic waves backscattered by rough surface of a shallow water flow*.

Speech and Hearing

By Graham Frost and Gordon Hunter

The sessions, chaired by Graham Frost and Gordon Hunter, attracted papers on a wide variety of topics, ranging from speech perception and intelligibility, through speech privacy and security and audiometry to signal processing and assistive speech technology.

Nick Durup of Sharps Redmore Acoustics and London South Bank University presented a paper updating delegates of progress on his PhD project regarding links between vocal stress experienced by school teachers and poor acoustics in the school teaching rooms. The main focus was the design of an online questionnaire for teachers, and the findings of the results obtained so far. His questionnaire included 57 questions relating to teachers' perceptions of classroom acoustics and how this affected their vocal stress, wider health and any therapy they had sought. Their experience of formal voice training (if any – 57% had received none) was solicited, along with their views on whether this should be included in teacher training courses (94% thought so). Of the respondents, 77% of primary teachers and 57% of secondary teachers reported having experienced some form of voice problems, with this being about twice as common in women teachers as men. Around 27% of respondents reported some level of hearing problem with noise from projectors and air conditioning systems being cited as the main causes.

On a related topic, Chris Barlow of Southampton Solent University described work carried out in collaboration with Strategic Audiological Services on developing and evaluating a novel hearing screening system, implemented on a tablet PC, and thus highly portable. He noted how the ageing population across the developed world was highly likely to result in ever increasing problems relating to hearing impairments, with associated costs.

However, many people only have their hearing problems diagnosed once they have already become quite severe, due to inadequate screening. Where screening does take place, it normally requires specialist staff and is expensive, yet often makes use of headsets originally designed for use by aircraft pilots in the 1940s! The proposed system was low cost, but made use of high-quality modern headphones, giving excellent attenuation of ambient noise. The system was evaluated using a standard audiometric test procedure on 10 subjects, in comparison with a MAICO MA51 standard and two other audiometers. It was found that the performance of the new system deviated less from the MAICO standard than did that of the other audiometers.

Gordon Hunter of Kingston University presented some initial findings of a study on the production of vowels of Standard Southern British English (SSBE) by native speakers of Cypriot Turkish. The subjects had all studied in the UK for between two and six years, but had all lived in Cyprus until early adulthood. Each subject had been required to utter prescribed examples of SSBE b(vowel)d words within a standard carrier sentence, and the formants of the vowels so produced measured. The results indicated that the speakers produced the "best" approximations to the correct SSBE vowel when there was a Turkish vowel with similar formants, but in many other examples tended to produce something with formants closer to a Turkish vowel than should have been the case. These initial results provided some support for the "Perceptual Magnet Hypothesis".

Matthew Hickling of Southampton Solent University described experiments on speech intelligibility measurements in rooms using a head and torso simulator (HATS). He noted that there was currently no standard for rating speech intelligibility using binaural methods. The work he described related to speech intelligibility in rooms under various conditions of background noise, comparing measurements made with a pair of microphones located in the ear positions of a HATS with those from a single omni-directional microphone, where the sound source could be positioned at any angle relative to the orientation of the HATS.

Gordon Hunter of Kingston University gave an overview of work on the *TalkMaths* project, developing and evaluating a system to allow people to dictate mathematical equations and formulae, using relative natural language, into computer-based documents, and have these displayed on the screen, or printed, in convention mathematical notation. The project was primarily designed to be of benefit to people with disabilities, notably groups whose mathematical education and subsequent careers tended to suffer partly as a consequence of their impairments. The system had gone through a number of versions, and is now available as a web-based service. It has mainly been tested and evaluated by students without disabilities, but the small number of disabled students who had tried it out found it useful and beneficial.

Chloe Long (Her Majesty's Government Communications Centre, Milton Keynes) defined and described work on "speech security" and "speech privacy", in the context of both unintentional and deliberate eavesdropping. The work investigated the proportion of speech intelligible to people other than the intended listener who were within earshot of a conversation. ■



■ This was discussed in the contexts of both the speaker and listener's privacy (e.g. during a medical consultation) and in situations where secure information could be compromised.

Soo James and Susan Mercy (QinetiQ) discussed methods through which levels of noise exposure (both from ambient environmental noise and from communication channels) could be reduced whilst maintaining, or even improving, speech intelligibility. Preliminary results of work where speech enhancement algorithms were employed to remove unwanted noise from the essential speech communication signals were presented and discussed.

The papers presented represented a good proportion of the areas covered by the general field of speech and hearing acoustics, and thus provided a good overview of the variety of interests of members of the group.

Underwater Acoustics

By Stephen Robinson

These sessions, chaired by Stephen Robinson, were fortunate to include a wide variety of papers from across the field, including high frequency applications, underwater noise measurements and predictions, and bioacoustics.

The session opened with Professor Peter Thorne of the National Oceanography Centre, who presented his paper titled *Sounding out sediment transport: developments over the past two decades*. Peter reviewed the use of high frequency acoustic techniques for detecting and quantifying sediment transport, a technique relevant to determining the mechanisms of coastal erosion, and a field in which he is pre-eminent world-wide.

This was followed by Dr Paul Lepper of Loughborough University who delivered a joint paper titled *Towards standards for measurement of radiated underwater noise from marine energy systems: an update*. The UK has enormous potential resource for marine renewable energy, and the proliferation in developments have presented great challenges for accurate underwater acoustic measurement. Paul described the latest measurement methodologies and the work towards standardisation.

A gap in the programme caused by an unavoidable late withdrawal was filled gallantly by Professor Victor Humphrey who presented the work of his student, Michael Wood, who is modelling the noise radiation mechanisms during marine pile driving, a (relatively) poorly-understood source of impulsive noise which has the potential for impact on marine life.

This was followed by Gary Hayman of NPL who presented his paper titled *Characterisation and calibration of autonomous underwater noise recorders*. The advent of commercially available autonomous noise recorders has presented challenges for calibration, and Gary described his work to develop standard methods of characterising their response, including the effect of the recorder body on the frequency and directional responses.

The session continued the following day with Professor Victor Humphrey again taking centre stage as he presented his paper *The EU SONIC project and the measurement of underwater related noise from vessels*. With the increasing concern for the effect of shipping noise on ambient levels in the ocean, it was interesting to learn of the progress in measuring the noise radiated by individual ships, with the focus of Victor's presentation being the onset of cavitation noise at the propeller.

The next paper was a joint presentation by Dr Peter Dobbins of Ultra Electronics and Franca Hoffman of the University of Cambridge, who presented a paper titled *A new robust dolphin whistle detector algorithm*. After a fascinating introduction to the work by Peter, Franca gave a thorough description of the algorithm for detecting and classifying dolphin whistles and showed the results of successful application to finding whistles in the presence of noise.

Dr Richard Hazelwood of R&V Hazelwood drew the session to a close with his paper *How "loud" is underwater noise compared with air noise*. This was a thought-provoking paper which covered the misunderstandings commonly encountered when expressing acoustic levels in air and in water, and then focused on the rough equivalence of the hearing threshold of the cormorant in air and water when expressed in terms of acoustic intensity. ■



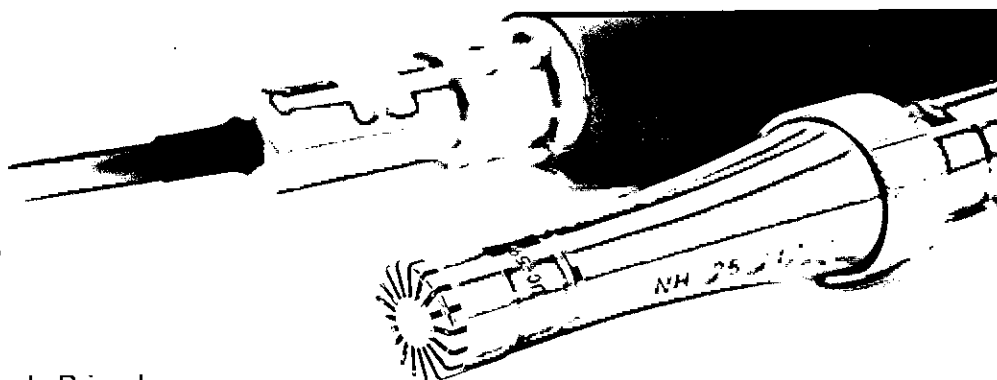
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2/324



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2/342



2/177

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Reproduced Sound 2014: 'entertaining, intensive and worthwhile'

By Bob Walker

Reproduced Sound 2014 was held on 14-15 October at the NEC, Birmingham. This year, being the 40th anniversary of the Institute and the 30th anniversary of RS, as a special feature the conference was held in association with the Institute's annual conference. The two programmes were scheduled to overlap, with a common day on the 15th. This report is only on RS. The annual conference and the plenary sessions are reported separately (see pages 6-15).

The Institute's thanks and appreciation again go to Paul Malpas for chairing the Electro-Acoustics Group and the conference organising committee and to all the members of the committee for their contributions in organising the event. Thanks also go to the venue staff, who were always efficient and helpful, greatly helping the smooth running.

All meeting rooms had also been equipped with advanced audiovisual systems, organised and managed by John Taylor of d&b audiotechnik, assisted by professional operators. The conference organising committee gratefully acknowledges the great effort put in by many people in setting up the excellent technical support.

The contributions of the exhibitors to the success of the conference are also gratefully acknowledged. Several exhibitors also included sponsorship as part of their exhibition package.

The technical presentations took place in a meeting room, with the adjoining atrium area being used by the exhibitors and for the refreshment and lunch breaks. Evening activities, including the conference dinner, took place in the adjacent Hilton Metropole Hotel.

The conference theme continued from previous years, with its focus on developments in perception, sound fields, room acoustics and modelling, cinema sound and intelligibility. In addition to two keynote lectures, one invited paper and the Peter Barnett Award lecture, 17 other technical papers were presented in six sessions. There were also five posters. This made for a very busy and intensive programme, fully occupying both days.

The conference was well attended, with 107 registered delegates, of whom 16 were students, plus 10 exhibitors. The committee was again pleased to see a number of faces new to RS, as well as the large complement of students.

The delegates certainly appeared to have had an enjoyable and worthwhile conference, though there were some comments about the intensity of the programme and the shortage of time for informal discussions. Overall, the committee was very satisfied with the response to the programme and the smooth running and friendly atmosphere. Subject to confirmation, it is proposed to hold the 2015 event at the Fire Service College at Moreton-in-Marsh in the Cotswolds on 10-12 November, which will represent a return to the popular "residential format" that is usually a feature of RS.

The conference programme

The conference was formally opened by Paul Malpas, who welcomed the delegates. He said that the conference had been well supported, with many papers submitted and excellent attendance numbers. In fact, so many offers had been received that not all could be accepted as papers. Some of the authors had agreed to contribute to the poster session instead, which delegates were encouraged to view throughout the conference.

His welcome address was followed by the keynote lecture *Developments in electro-acoustics over the past 40 years* by Peter Mapp, followed by the remaining technical sessions of the day. Afterwards, there was a short break until a reception, followed by the conference dinner. After dinner there were informal presentations of two systems for room acoustic modification – *Crowd*

enhancement in stadiums using electro-acoustic enhancement systems by Mattius Winther of Audile Electro-Acoustics, Sweden and *In-line vs. regenerative acoustic enhancement systems* by Ron Bakkar of Yamaha Commercial Audio, Europe.

The second day started the keynote lecture *Concert hall design* by Dr Leo Beranek, who had recently celebrated his 100th birthday. That was followed by the first plenary session and the Electroacoustics Group AGM. RS then resumed with further technical sessions until lunch, which was followed by a plenary session, including the Rayleigh Medal Lecture on *Bubble acoustics: from whales to other worlds* by Professor Timothy Leighton.

The RS conference resumed after the plenary with an invited lecture on *Intelligibility enhancement of speech in noise* by Cassia Valentini-Botinhao of the University of Edinburgh and one more technical session. The second day's proceedings ended with the presentation of the Peter Barnett Memorial Award to Professor Malcolm Hawksford (see page 25). Afterwards, there was the annual conference reception and dinner, for which a number of RS delegates stayed to attend. Notable guests were Roy Lawrence and Cathy Mackenzie, who together had been so instrumental in starting the RS conferences at Windermere 30 years previously.

Technical sessions, 14 October

The conference began with the keynote lecture *Developments in electro-acoustics over the past 40 years* by Peter Mapp. The presentation consisted of an entertaining revue of many aspects of the subject. Peter covered historical aspects of microphones, loudspeakers, Public Address systems, recording media and **P20**



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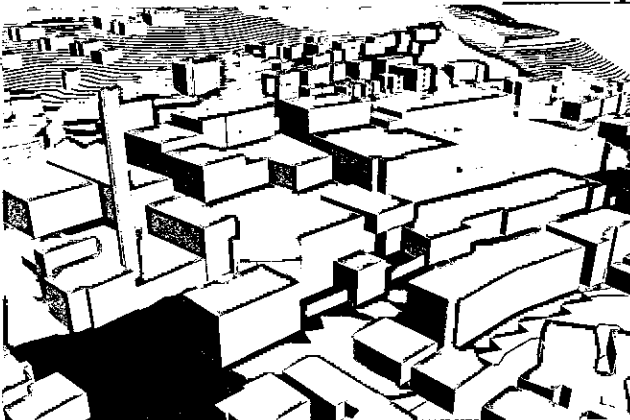
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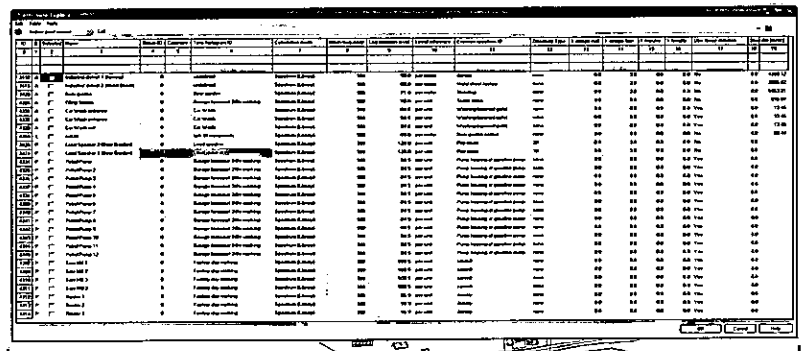
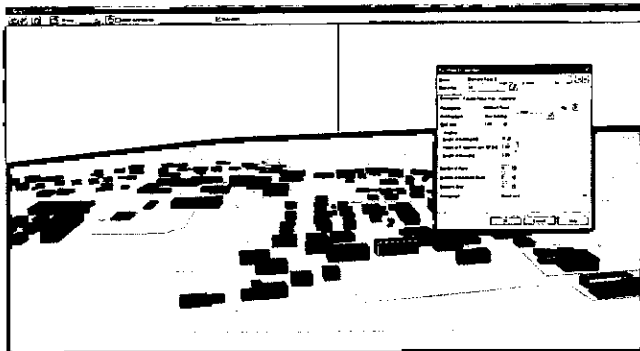
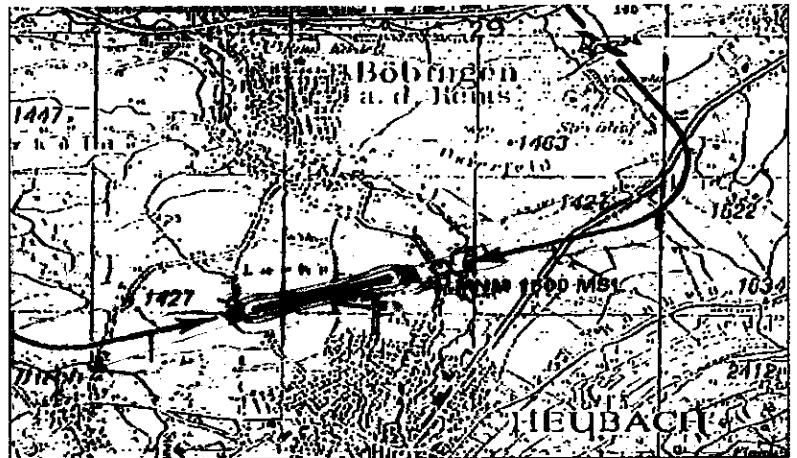
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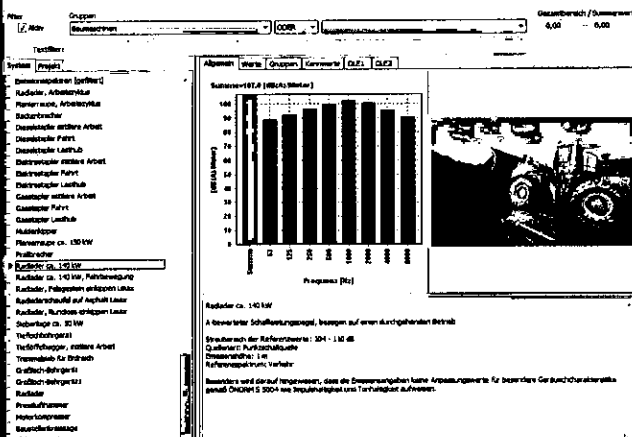
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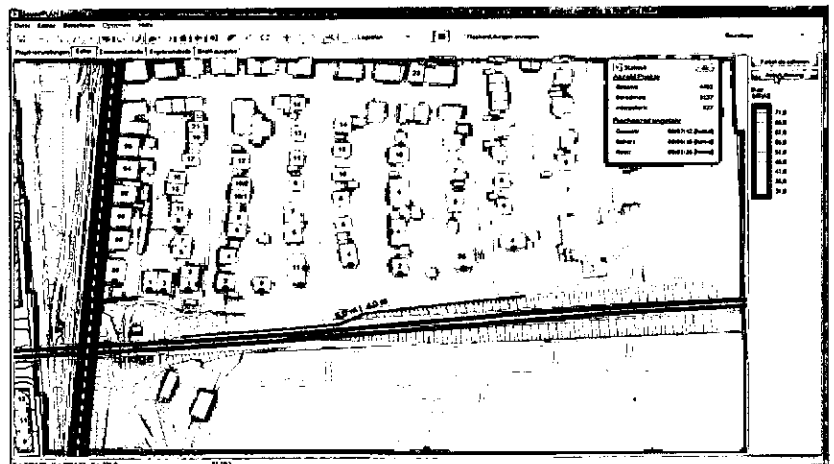
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IP18 equipment, audio coding, "HiFi" furniture and components, measurement and instrumentation and room equalisation. He had collected a large number of pictures of old equipment and related some reminiscences of his personal experience with some of them.

Session 1, Perception 1, Chairman – Adam Hill

The first paper of the session was *Efficient compact representations of head related transfer functions* by Jo Sinker (University of Salford). The presentation consisted of a highly detailed comparison of decomposition methods for reducing the data to a manageable quantity using a set of orthogonal basis functions and parametric methods often associated with speech processing. This allowed convenient and unambiguous interpolation and a significant reduction in the number of stored functions required to generate a continuous auditory space. It was also suggested that the method might be useful in developing efficient schemes for custom HRTF capture.

The second paper was *The psycho-acoustic effects of stimuli plausibility on headphone externalisation* by Bruno Fazenda and Jamie Newton (University of Salford). It was presented by Bruno and described tests on externalisation and the effects of modifying the subject's expectations using apparently accidental cues in the preparations leading up to the actual tests. Subjects had, apparently inadvertently, been made subconsciously aware of unrelated stimuli before the test started. Subsequent exposure to those same stimuli greatly increased their ability to localise. This demonstrated that plausibility had a profound positive effect on the ability to externalise auditory cues with headphones.

Session 2, Measurement and modelling, Chairman – Bob Walker

The programme continued with *Short time acoustical measurement using maximum entropy* by Jamie Angus (University of Salford). The paper continued the work described last year on a method for reducing the artefacts generated in time-domain limited measurements as a result of using the usual 'time windows'. Jamie began with a discussion of the entropy of an audio signal and how truncation actually adds information by imposing order. Jamie then showed how, by mathematically maximising the entropy of the data, the effects of the truncation

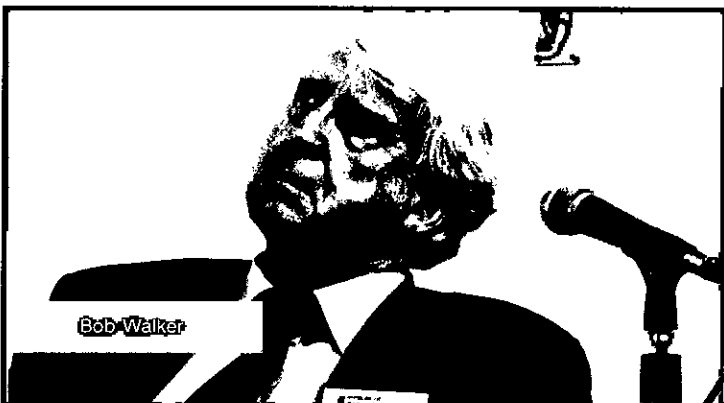
could be reduced and the low frequency resolution of the measurement improved.

The second paper was *Modelling loudspeaker cabinet diffraction* by George Perkins (KEF Audio). The presentation discussed some of the historical work on diffraction by Olsen more than 65 years ago and how those results are still used as guidelines. He then described an investigation using boundary element methods using conceptual secondary sources to obtain more accurate results. He discussed the optimisation of the secondary source strengths and directionality and showed examples of both good and poor cabinet designs. He also demonstrated the adverse effects of the common 'half-roll' loudspeaker surround and the improvements made by a "Z-fold" alternative.

The final paper in the session was *Acoustic realism in the story space of stage and audio drama* by Paul Malpas (Engineered Acoustic Designs). The paper discussed the many components that go into creating a sound scheme for dramatic productions. They included dialogue, character effects, sound effects and atmosphere. For each one, the different factors that have to be considered by the sound designer were described. The underlying physical acoustics also needed to be considered, but sometimes modified or even ignored to achieve the final dramatic effect. In addition, Paul described how the other requirements of the production and the director's intentions needed to be considered in order to create the final acoustic results.

The session was followed by lunch and then by a poster session. The posters on display were:

- In *Setting the tone: considerations for educating the next generations of sound reproduction professionals* by Paul Thompson and Benjamin Mosley (Leeds Metropolitan University) the authors presented their experiences in developing the curriculum for sound reproduction topic in an undergraduate music technology course. The poster also included some approaches to delivering sound reproduction themes and additional ways of addressing the needs of the industry.
- Investigating headphone driver modelling using the finite/boundary element method* by Kelvin Griffiths (ElectroAcoustic Design) and Rowan Williams (Woox Innovations). The poster described the inaccuracies of electrical analogues for modelling headphone performance and the potential improvements from simulating the structure and surrounding air using finite element methods. Some current modelling methods of modelling a 40mm driver were presented. The method also included non-linear loading and a fully-coupled vibroacoustic analysis. A case study of the effects of differing numbers of stiffening ribs formed into the diaphragm was also included.
- Three-dimensional tissue-conducted sound fields* by Ian McKenzie, Peter Lennox and Bruce Wiggins (University of Derby). The poster showed how multiple cranial transducers were used to achieve auditory spatial perception via bone and tissue conduction, bypassing the peripheral hearing system. This could be useful in cases of peripheral hearing damage and some other situations. Discrete signal, stereo and first-order ambisonics were used to investigate the possibilities for control of externalisation in direction, range and spaciousness. **D**



■ Possible development paths were also presented.

- d) In their poster entitled *Passive pre-microphone acoustic filters with gain*, Graham Bank (Deben Acoustics) and Peter Cochran (University of Hertfordshire) showed how close-coupled acoustic filters arranged before the microphone could overcome some of the extreme physical effects on the microphone diaphragm caused by loud sounds. Those included non-linearity and dynamic range limitation. By filtering out the unwanted acoustic energy before the microphone, significant improvements in wanted performance could be achieved, together with small but useful amounts of gain. Some prototypes and sample test results were also presented.
- e) *ReS (Resonant String Shell), the design of an acoustic shell for outdoor chamber music* by Serafino Di Rosario (Buro Happold). The poster described the development of an acoustic shell for outdoor chamber music performances at Villa Pennisi, Acireale (CT), Italy. The specification called for a shell that was easily erected and dismantled and made entirely of wood cut on site. Not only that, it also had to be made of cheap materials. The poster presented the design steps and the final result, with analysis of the impulse responses made on site and the subjective impressions of the musicians. The design is continuously under development, tested again every year during the music festival.

Session 3, Perception 2, Chairman – Glenn Leembruggen

After the lunch break, Adam Hill (University of Derby) presented *Subjective evaluation of an emerging theory of low-frequency sound-source localisation* by himself and Malcolm Hawksford (University of Essex). The paper discussed source localisation at low frequencies and the potential for stereophony at those frequencies. Subjective tests had been carried out to assess localisation accuracy with sine and square waves using tone bursts. It was found that distances corresponding to eight wavelengths uncorrupted by reflections were necessary for accurate localisation.

The next paper was *Why is good speech intelligibility in mosques a challenge?* by Wolfgang Anheer and Emad El-Saghir (ADA-AMC), presented by Wolfgang. It discussed some aspects of both the cultural influences requiring clear articulation and the commonly extremely reverberant nature of typical mosques. Historical methods of overcoming the inevitable difficulties using 'niches', elevated speaking platforms or even relays of helpers along the length of the space were described. The problems associated with some modern sound systems were also described. The use of electronically steerable loudspeaker arrays, together with carefully selected carpet and underlay combinations as remedial controls were also presented.

In the final paper before tea, Peter Mapp (Peter Mapp Associates) presented *The acoustic and intelligibility performance of assisted listening systems* in which he described the benefits that the 10-14% of the general population affected by a noticeable degree of hearing impairment could obtain from some form of hearing assistance. Unfortunately, many of the systems actually installed fail to provide the help that they should. The paper described investigations into the acoustic and intelligibility requirements for such systems and examined a number of microphone scenarios for their potential quality and intelligibility. The results of testing in a number of venues were presented, together with some recommendations, performance criteria and "rules of thumb" for microphone placement and system testing.

Session 4, Sound fields, Chairman – Sam Wise

After the tea break, *The history of active acoustic enhancement systems* by Stuart Gillian (Soundscape Audio Consultancy, Scotland) was presented by Ron Bakkar. After giving a brief summary of the history of enhancement systems, he described how improvements in capabilities of dsp systems could allow the hardware infrastructure to be significantly reduced whilst maintaining adequate acoustic performance. That resulted in improved reliability and reduced costs. Systems are now available for a wider range of venues at more affordable costs. The paper was supported by an informal demonstration after the conference dinner.

The second paper in the session was *Circular loudspeaker array for personalised audio* by Mincheol Chin, Filippo Fazi, Philip Nelson (ISVR, Southampton), Simone Fontana and Lang Yue (Huawei European Research Centre, Germany). The paper was presented by Mincheol. He described how an array of 32 loudspeakers arranged in a circle could be electronically steered to provide an individual listening position. The performances of two algorithms were compared using computer simulations and experiments using the real loudspeaker array mounted on a rigid cylinder. The presentation included a comprehensive mathematical analysis.

The next paper was *Numerical comparison of sound field control strategies under free-field conditions for given performance constraints* by Fernando Olivieri, Filippo Fazi, Philip Nelson (ISVR, Southampton), Simone Fontana and Lang Yue (Huawei European Research Centre, Germany). The paper was presented by Fernando. The paper covered the same topic as the previous one, but with the emphasis on the dsp strategy. A number of sound field control algorithms were compared using numerical simulations under free-field conditions and using a linear loudspeaker array. Constraints on directivity and permitted maximum loudspeaker input power were applied. The algorithm performances were quantified in terms of array efficiency and acoustic contrast. The results showed similar low-frequency performances but with significant differences at high frequencies.

The final paper was *How to see sound waves in motion* by Richard Jockett (NPL). That was different! Richard and his team had been using a laser doppler vibrometer to observe surfaces in motion. One of the issues with the method is the distortion caused by transient irregularities in the air path. They realised that the instrument could be used without a moving target to observe deliberately-introduced distortions in the air density/temperature (aka sound waves) in motion. Several movies were shown of sound waves radiating from a loudspeaker, with interference between the high and low drivers. Cabinet edge diffractions could also be seen. Also shown were waves reflecting from various surfaces, including a "diffusor". The method did take quite a long time – overnight for a single measurement – and the loudspeaker expired during one run because of the high levels needed. **P22 ▶**



CIP211

Technical sessions, 15 October

Session 5, Sound quality, Chairman – Keith Holland

The day started for Reproduced Sound 2014 at 12:30, after the Plenary Sessions, with *Profiling the distortion characteristics of commercial music using amplitude distribution statistics* by Alex Wilson and Bruno Fazenda (University of Salford). The paper was presented by Alex. He described the various characteristics of CD recordings with different types of distortion. By analysing the statistical distribution of sample values much can be determined about the distortion profile. Today, many CDs contain hard and/or soft clipping. Some show traces of their recording history through several different stages. Subjective testing had shown that listeners can perceive differences in these profiles. Extending the methods to higher numbers of bits required a different methodology because the number of “bins” could be so large that only a few samples fell into each one, making the statistical analysis more difficult.

The second presentation was *How important is audio quality to usage of online recordings?* by Trevor Cox, Bruno Fazenda, Iain Jackson, Paul Kendrick and Francis Li (University of Salford). The paper, presented by Trevor, began by discussing the highly variable quality of downloadable audio on the internet. The possible use of metadata, such as the frequency of downloads or the “views per day” as measures of quality were proposed. Two experiments had been carried out to explore the relationship between such metadata and the subjective quality. Where there was a discernible relationship, the number of downloads was found to be the best predictor of audio quality. However, overall, using metadata was found to be a poor predictor of online audio quality.

The third paper of the session was *Applications of the fast multipole boundary element method to the audio industry* by Patrick Macey (PACSYS). In his paper, Patrick described a number of uses of BEM for electro-acoustics, for example analysis of driver radiation, enclosure diffraction and the acoustics of the room. However, direct solution of the resulting large set of linear equations often became impractical. Patrick showed how the fast multipole method of iteration was capable of significant speed increases, extending the size of problems that can be solved in reasonable times. Some results were presented for room acoustics and a line array model. Also discussed were issues associated with coupling the method to structural finite elements.

The session was followed by a break for lunch and the second plenary session after which Reproduced Sound then re-convened for the final session.

The first event was an invited lecture *Intelligibility enhancement of speech in noise* by Cassia Valentini-Botinhao. It consisted of an extensive study of the effects of pre-distorting artificial speech signals to improve their intelligibility, using as guidance the behaviour of real listeners and speakers in adapting to difficult communication conditions. Modifications such as increasing level, spectrum modification and improved articulation were modelled. Project LISTA is intended to develop the scientific foundations needed for the next generation of spoken output technologies. An extensive series of listening experiments had shown that intelligibility gains of up to 4dB could be achieved without increases in intensity.

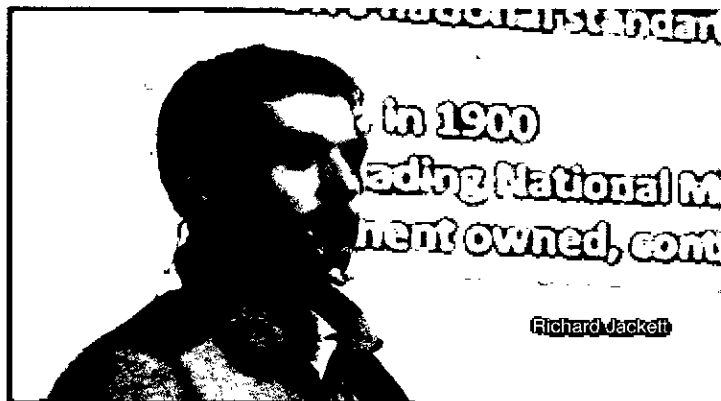
Session 6, Cinema sound, Chairman – Paul Malpas

The first paper of the session was *Room response estimation using microphone averaging* by Philip Newell (Consultant, Spain) and Keith Holland (ISVR, Southampton). The paper was presented by Philip and presented an investigation into the variability of measured low-frequency room responses with microphone position. A large number of positions had been used to illustrate how smaller arrays or positions, using perhaps only four or eight, can easily produce poor estimates of the average room response.

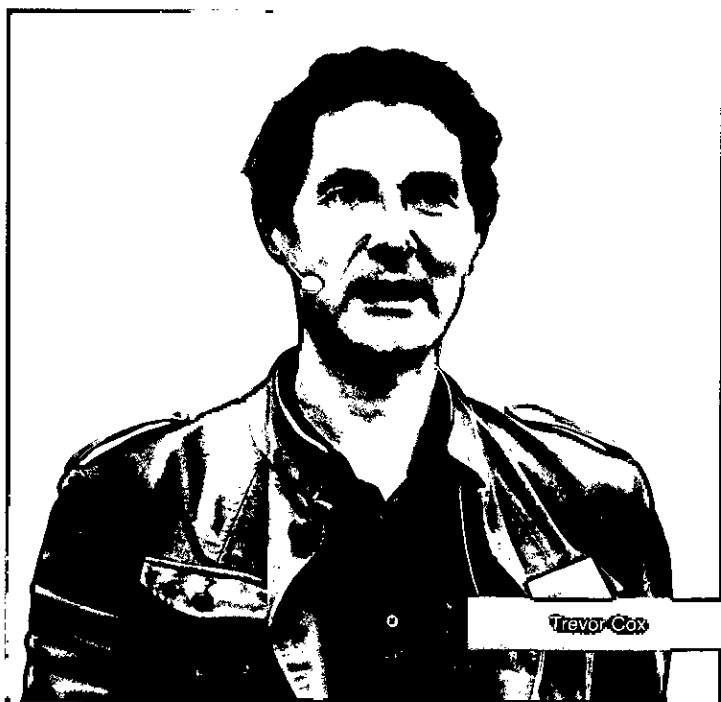
The final paper of the session was *The audibility of comb-filtering due to cinema screens* by David Elliot, Keith Holland (ISVR, Southampton) and Philip Newell. The paper was presented by David. A model of comb-filtering had been created and used to

simulate representative examples of the types of distortion caused by the loudspeakers being located behind a projection screen. Numerous samples were assessed using subjective tests, particularly the effects of varying the screen-loudspeaker distance. Overall, the effects were found to be at worst barely audible. It was concluded that comb-filtering was probably not as significant a problem as had been previously thought.

The session was followed immediately by the presentation of the Peter Barnett Memorial Award to Malcolm Hawksford by the Institute President William Egan. In his lecture immediately following the award, Malcolm treated the audience to an entertaining review of more than 43 years in working in many audio and electro-acoustic disciplines. He began by describing the homemade tape recorder that he had constructed as a teenager and which had been described in *Wireless World* at the time. He went on to describe his life-time's work in educating, encouraging and developing a large number of students over his career as a university lecturer and ultimately professor at the University of Essex. Malcolm's list of successful PhD students was very long. The total number of undergraduates had been lost count of. He then described briefly aspects of technology with which he had been involved (and which this author might dare to say has made substantial contributions). They included the early attempts at dpcm, as well as analogue audio circuitry, power amplifiers, loudspeaker systems, ADC and DAC systems, spatial audio, digital signal processing and computer modelling. Altogether, a very worthy recipient of the award, which was partly instigated to recognise contributions to education in electro-acoustics. ■



Richard Jackett



Trevor Cox

Institute award winners receive their honours at Birmingham conferences

Presentations were made to several Institute award winners at the 40th Anniversary Conference and Reproduced Sound at the NEC, Birmingham. Another award, to John Bowsher, was presented subsequently. Here are summaries of the citations.

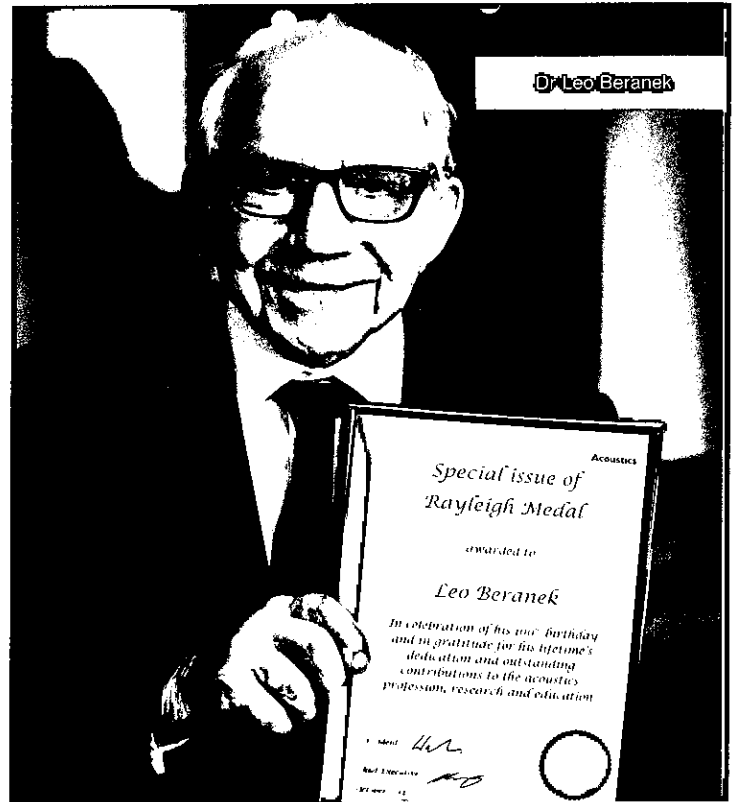
Dr Leo Beranek

Special issue of Rayleigh Medal

For three-quarters of a century Leo Beranek has been at the forefront of acoustics, as a consultant, researcher and writer. Everyone in this room will have been influenced by some aspect of his work. An early interest in repairing radios led to Leo studying at Harvard where he was awarded his doctorate in 1940. During the Second World War he was the Director of the electro-acoustics laboratory at Harvard where significant work was done on improving voice communications in military aircraft. After the war he was appointed as professor of Communications Engineering at Massachusetts Institute of Technology, and also helped to found the world leading acoustic consultancy Bolt, Beranek and Newman, of which he was president from 1952 to 1971.

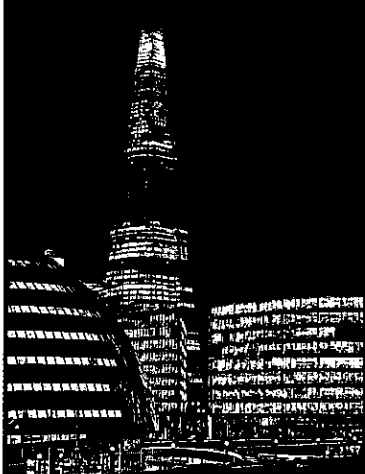
In 1948 Leo paid his first visit to Europe, to determine what acoustics research had been carried out during the war. During this trip he visited England and attended the first Summer Symposium of the Acoustics Group of the Physical Society, which had been set up the previous year, and was a forerunner of the Institute of Acoustics. Leo opened the proceedings with a paper on Sound Transmission through Partitions. At this meeting he made lifelong friends among the European acoustics community, including Peter Parkin and Bill Allen.

Three years later Leo was invited to comment on the **P24**



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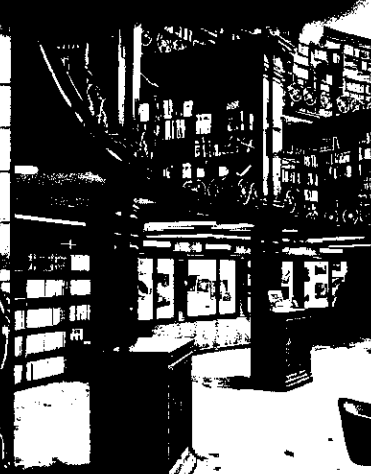
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[1923] design of the recently opened Royal Festival Hall, and through this he became friends with Hope Bagenal, the UK's leading architectural acoustician at the time. Since then he has been a frequent visitor to the UK, exchanging opinions with UK acousticians, giving invited lectures and papers, and visiting many of our concert halls partly as research for his book *Music, Acoustics and Architecture*, first published in 1962 and heavily revised and extended in 2004.

As well as his books on architectural acoustics Leo wrote a seminal text book *Acoustics* in 1954, which was revised in 1986 and again only two years ago, in 2012. He has also edited classic textbooks on noise and vibration control.

Leo has also published – and continues to publish – many papers, particularly on auditorium acoustics and concert halls, and continues to act as a consultant on concert hall and theatre design throughout the world.

In addition to receiving many awards and honours throughout his long career, Leo has been president of the Acoustical Society of America; of the Audio Engineering Society; and of the International Institute of Noise Control Engineering. He has also been Chair of the Board of the Boston Symphony Orchestra, of which he remains a lifetime trustee.

As well as celebrating Leo's many well-known achievements in the professional and academic world of acoustics, and to wish him a very happy birthday, on this occasion we also particularly want to thank him for his interest, support and participation in the acoustics field in the UK, especially during the 40 year history of the Institute.

Therefore, to recognise his 100th birthday; to celebrate his many and significant contributions to acoustics as a consultant, researcher, teacher and writer; and to thank him for his continued support over the years, the Institute of Acoustics is proud to present a special issue of its most prestigious award, the Rayleigh Medal, to Dr Leo Beranek.

John Bowsher

Award for services to the Institute

John Bowsher's responsibilities in and for education in acoustics started with his appointment as lecturer in acoustics at the University of Surrey. He played a major part in the establishment of the physics with modern acoustics degree and the famous "Tonmeister" MSc course at the university. John has supported the Institute of Acoustics for many years, being a member of Council from 1978 to 1986, Vice President and Chairman of the Membership Committee and organiser of several IOA conferences. In 1986, the Institute awarded him an Honorary Fellowship for contributions to musical acoustics.

John has also made major and important contributions to the educational activities of the Institute, being deputy chief examiner for the Diploma in 1986 and chief examiner from 1988 to 2000. During John's period as chief examiner, work started on a tutored distance learning version of the Diploma, and an education review

initiated by Council resulted in 12 recommendations including the appointment of an education manager, Peter Wheeler being the first incumbent in 2000. Since retiring as chief examiner, John has been responsible for the typesetting, proof reading, printing and distribution of IOA examination papers. His meticulous reign in this capacity has included devising of rubrics, font types and conventions and formula sheets. He has also often acted as an important final checker of proofs. At the end of 2014 he decided to step down from this latest role and he will be sorely missed since he has set standards for the production of IOA examination papers that will be hard to follow.

In recognition of his distinguished record of contributions to its educational activities the IOA is pleased to make an award for services to the Institute to John Bowsher.

Sam Daintree

Best performance in the IOA Diploma in Acoustics and Noise Control

Sam Daintree, of Sandy Brown Associates, was presented with award for the best performance in the Institute's 2013 Diploma in Acoustics and Noise Control. In achieving it, he received a merit in general principles of acoustics, building acoustics, noise and vibration control engineering, project and laboratory module. Sam, aged 25, is a graduate of the University of Huddersfield, where he obtained a first class degree in creative music technology.

Stephen Dance

Tyndall Medal

Dr Stephen Dance has worked at London South Bank University since 1989, as a post graduate and postdoctoral researcher assistant, lecturer and now Reader in Acoustics. He is also responsible for the teaching, research and consultancy activities of the Acoustics Group and is Course Director of the MSc in Environmental and Architectural Acoustics, as well as acting as a visiting lecturer at various institutions including ISVR.

Following a first degree in computer science, Stephen's post-graduate and postdoctoral research involved developing fast, efficient and accurate computer models of the behaviour of sound in and around buildings. He continues to update, apply and disseminate his work in this area.

During his career at LSBU Stephen has continued to engage in innovative research, and now leads a research team, much of whose work is supported by Enterprise funding in collaboration with industry. Recent projects involve research related to speech intelligibility, including the improvement of public address systems on the London Underground, the development of low noise systems for use in measuring speech intelligibility, and investigations of STI.

Another major development has involved working with music students, performers and venues on projects aimed at preventing hearing loss among orchestral performers and improving the acoustic environment for musicians in practice, rehearsal and performance. ■



■ In addition to his research projects, Stephen encourages students to undertake interesting and original Masters projects. Ten of his students have been awarded the Acoustical Society of America Newman prize in recent years. In 2007 Stephen received the ASA Schultz Grant for the Advancement of Acoustical Education for the development of a web-based image source model, and in 2012 he was presented with the ASA Student Mentoring Award. He was also elected to the advisory board of the ASA Newman Fund.

Stephen has also been an enthusiastic contributor to the university's outreach programmes aimed at encouraging young people to consider engineering as a career.

For his achievements throughout his career in the modelling of sound, and his recent innovative developments in room acoustics, noise control and hearing protection, plus his continual encouragement of acoustics students, the Institute of Acoustics is pleased to award the Tyndall Medal for 2014 to Dr Stephen Dance.

Ken Dibble

Honorary Fellowship

Ken Dibble's interest in acoustics was brought about whilst running a touring sound and installation company during the late sixties and seventies. Noting that even whilst using state of the art equipment, this did not guarantee consistent sound quality in different buildings, he concluded that it must be the effect of the buildings and the performance space having an effect. As a result he started studying acoustics. Almost entirely self-taught in the discipline, Ken achieved full membership of the Institute in 1977.

Whilst Ken has enjoyed a varied career in acoustics, it is in the areas of entertainment related issues that he has specialised and gained a reputation as an independent consultant. Apart from electro-acoustic work, designing audio systems and venues to work together, this has involved a great deal of research and case work in the field of entertainment noise control. His understanding of the needs of the performance, be that live music or in nightclubs, has given him a unique approach to achieving the balance between a successful venue and content neighbours.

Ken ran the first study into the noise dose experienced by entertainments venue staff on behalf of the British Entertainments and Discotheque Association, and through this spent some time looking at the differences between noise induced and music induced hearing loss, a contentious issue in the late 1980s.

An active contributor to the work of the IOA, Ken presented many papers at Institute meetings and has also chaired many conference sessions and provided technical facilities to many meetings and conferences. He was chairman of the Reproduced Sound conference committee from 1990 for many years, and sat for many years on the IOA Meetings Committee.

Despite holding no formal academic qualifications, Ken was registered as a chartered engineer through the IOA in 1993 through a study into the development of a then unique audio system design deployed at Coventry Cathedral. He was elected a Fellow of

the Institute in 1995, and his contribution to the Institute was acknowledged through a distinguished service award in 2002.

The Institute of Acoustics is delighted to award an Honorary Fellowship to Ken Dibble for his exceptional service to the Institute of Acoustics.

Ann Dowling Engineering Medal

Ann Dowling is a Fellow of the Royal Society, Royal Academy of Engineering and is a Foreign Member of the US National Academy of Engineering and of the French Academy of Sciences.

She is an Honorary Fellow of the Institution of Mechanical Engineers and the Institution of Engineering Designers and a Fellow of the Royal Aeronautical Society and of the Institute of Acoustics. She has honorary degrees from Imperial College London, Trinity College Dublin and the University of Kent.

Ann Dowling is Head of the Department of Engineering, Professor of Mechanical Engineering and Deputy Vice-Chancellor at the University of Cambridge.

Dame Ann started her career as a mathematician but always wanted to pursue applied mathematics and did her PhD in engineering acoustics with Prof John Ffowcs Williams FREng, who led pioneering noise-reduction research on Concorde. She now leads research on efficient, low emission combustion for aero and industrial gas turbines and low noise vehicles, particularly aircraft and cars.

Her work in aeronautics and energy has been recognised by fellowships of the Royal Society and Royal Academy of Engineering, and foreign associate membership of both the US National Academy of Engineering and the French Academy of Sciences.

Dame Ann led the Cambridge MIT Silent Aircraft project, which published its radical new design concept SAX-40 in 2006 with the aim of raising aircraft industry aspirations.

She also chaired the agenda-setting and widely respected joint Royal Society/Royal Academy of Engineering report *Nanoscience and nanotechnologies: opportunities and uncertainties*, published in 2004, which highlighted the need for responsible regulation and research around the use of materials at an extremely small scale – only a few millionths of a millimetre.

Dame Ann is a non-executive director of BP and a panel chair for the Research Excellence Framework. She was nominated in BBC Radio 4 Woman's Hour power list 2013 as one of the 100 most influential women in the country.

For her pioneering work in acoustical engineering, the Institute of Acoustics is proud to award the Engineering Medal for 2014 to Dame Ann Dowling.

Malcolm Hawksford

Peter Barnett Memorial Award

Professor Malcolm Hawksford has contributed enormously to the field of electro-acoustics over the past six decades, primarily at the University of Essex. His contributions can be traced back to **P26**



CP25 a publication in the June 1963 issue of *HiFi News*, in which a 15-year-old Hawksford described the design and build of his very own console tape recorder. This early contribution set him on course to provide an on-going stream of advancements to state-of-the-art electroacoustic engineering.

Malcolm began his academic career at Aston University in 1965, enrolling in one of the first electrical engineering courses in "light-current electronics" rather than power electronics. Upon graduation, he was awarded a BBC Research Scholarship to investigate methods to improve transmission technology for colour television, but he quickly shifted to audio and acoustics research.

After completing his PhD at Aston in 1972, Malcolm took up a lecturing post at the University of Essex. He has been an Emeritus Professor at Essex since retiring in 2012, but continues to teach and remains research-active.

Malcolm has specialised in projects involving loudspeakers, analogue and digital crossover networks, audio amplification, high-resolution audio, signal transmission and room acoustics. His research has gained him recognition and respect among professionals, as well as awards from the Audio Engineering Society.

In academia, Malcolm has taught and supervised numerous undergraduate and postgraduate students. He often says that student supervision is a particular passion of his, evident in the fact that many of his former students can now be found in prominent positions at major audio engineering firms and in academic roles at British universities.

Overall, Malcolm has contributed a vast amount towards the progression of electro-acoustics from its later analogue stage through to the digital revolution. He has tackled difficult problems and has never given anything but an in-depth analysis and solution to each. The areas of crossover design for loudspeaker systems, multichannel sound reproduction, analogue-to-digital and digital-to-analogue conversion and system measurement have all greatly benefited by his research efforts.

Professor Hawksford is therefore well-deserving of the Peter Barnett Memorial Award for his sizeable contributions to the advancement of electro-acoustics, his on-going research and for the impact he has had, and continues to have, on generations of audio and acoustics professionals through his passionate teaching and supervision.

Rob Hill

Honorary Fellowship

Rob Hill's introduction to acoustics was via a Bachelor's degree in Architecture awarded by the University of London in 1969. This was followed by further experience in building acoustics and transportation noise by working for a multi-disciplinary consultancy. In 1974 he joined the transportation noise section of the Environmental Sciences Group of the Greater London Council. Rob returned to consultancy work in 1979 by joining Acoustical Investigation & Research Organisation Ltd (AIRO), where he remained for the rest of his career, having become Principal

Consultant in 1992.

Rob's involvement with the Institute has lasted almost 40 years, indeed from its very inception. Having formerly been a Member of the British Acoustical Society, he is one of a select group that attended the two inaugural general meetings in 1974. Rob was elected to Council as an Ordinary Member in 1980 and served as Honorary Secretary from 1983 to 1989. He joined the Membership Committee in the early 1980s, and from 1988 until 2009 he was committee secretary, finally retiring as an ordinary member of the committee last year.

Rob has enjoyed an outstanding career as an acoustics practitioner. He was involved in the noise work carried out in connection with the report of the Urban Motorways Committee and on behalf of the GLC carried out a joint research project with the Transport and Road Research Laboratory to study the effects of traffic induced vibration in dwellings.

At AIRO, Rob managed its specialist section dealing with the noise assessment of highway and other major infrastructure projects. As an acknowledged expert on the subject, he has presented expert evidence in support of the proposed schemes at numerous public inquiries. He has also been a long term member of the British Standards Institution panel considering the effects of vibration on humans, which was instrumental in the development and publication of BS 6472.

Rob was elected a Fellow of the IOA in 1986. His service to the Institute was recognised in 2003 through the presentation of an Award for Distinguished Services.

The Institute of Acoustics is delighted to award an Honorary Fellowship to Rob Hill for his exceptional service both to the Institute of Acoustics and to the profession of acoustical consultancy.

Jian Kang and the Acoustics Group, Department of Architecture, University of Sheffield

Peter Lord Award

The Peter Lord Award has been introduced in the Institute's 40th year in memory of Professor Peter Lord, a founder member and former President of the Institute and a hugely influential figure in UK acoustics.

The award is made for a building, project or product that showcases outstanding and innovative acoustic design. It has been awarded to a team at the University of Sheffield which has produced an innovative design for a window system to reduce noise from outside whilst allowing natural ventilation and maximising daylight penetration. The design is based upon the innovative use of transparent micro-perforated absorbers which allow optimum use of the window area for its main function of providing adequate light ingress as well as allowing the attenuator to occupy the whole window area. It thus negates the need for placing conventional fibrous silencer elements in the ventilation path or in a separate silencer penetrating the building facade. It is a design that not only addresses growing concerns about



■ sustainability which has been proven not only theoretically but also in both laboratory and field tests.

The team developed an integrated acoustics, ventilation and lighting test facility between a semi-anechoic chamber and a reverberation chamber to simulate as closely as possible real world conditions and has also investigated the effectiveness of the design using finite element methods by considering the effects of opening size, air gap, louvers, hood and absorbers.

The team involved was the Acoustics Research Group in the Department of Architecture at the University of Sheffield, who were led by Professor Jian Kang. He was the principal investigator for the development stage, with research associate, Dr Martin Brocklesby, carrying out experimental and analysis work and research student, Z M Li, the simulation work. Ian Ward advised on the ventilation side and Peter Tregenza on the lighting side.

The project itself is one that Peter Lord would have fully appreciated. Not for him the grand design but something small and useful that could be used by many.

The Peter Lord Award for outstanding and innovative design in acoustics for 2014 is awarded to Jian Kang and his team from the Acoustics Research Group in the School of Architecture at the University of Sheffield.

Alex Krasnic

Promoting acoustics to the public

Alex Krasnic is a Corporate Member of the Institute of Acoustics. After obtaining his BEng (Hons) in Aerospace Engineering he took an MSc in Environmental and Architectural Acoustics. Alex has gained considerable experience over the last 13 years, working for a range of acoustic consultancies and he now runs his own consultancy, ASK Acoustics. (Editor's note: Alex has recently joined Vanguardia – see page 54)

He has used his expertise on the IIA Building Acoustics Group and Education Committee, together with the CIBSE Technical Review Committee for Part B4: Noise and Vibration. He has also published or contributed to several papers.

As a STEM Ambassador, Alex has brought acoustics directly to potential future acousticians. This major Government-backed scheme provides an opportunity to show school pupils that STEM subjects can be fun, interesting, challenging and provide a rewarding career.

In addition to presenting acoustic STEM activities at numerous schools, engineering festivals and similar events, Alex has worked to raise the profile of STEM Acoustic Ambassadors amongst IOA members, encouraging others to become involved.

Alex has made a significant and sustained effort for a considerable number of years to raise the profile of acoustics outside the profession to both the general public (specifically pupils and students) and also to people working in other disciplines who may interact with acoustics.

To this end, Alex has also contributed to promoting acoustics as an engineering discipline to the wider community, by **P28**



Alex Krasnic

ANC

THE ASSOCIATION OF NOISE CONSULTANTS

The ANC has represented Acoustics Consultancies since 1973. We now have over one hundred member companies, including several international members, representing over seven hundred individual consultants.

Members of the ANC can also apply to become registered testers in the ANC's verification scheme, recognised by CLG as being equivalent to UKAS accreditation for sound insulation testing.

We are regularly consulted on draft legislation, standards, guidelines and codes of practice; and represented on BSI & ISO committees.

We have Bi-monthly meetings that provide a forum for discussion and debate, both within the meetings and in a more informal social context.

Potential clients can search our website which lists all members, sorted by services offered and location.

Membership of the Association is open to all acoustics consultancy practices able to demonstrate the necessary professional and technical competence is available, that a satisfactory standard of continuity of service and staff is maintained and that there is no significant interest in acoustical products.

To find out more about becoming a member of the ANC please visit our website (www.theanc.co.uk) or call 020 8253 4518

CP27 assisting the Construction Industry Council (CIC) in the role of 'Construction Ambassador'. Notable involvements include filming a short interview for the CIC about "Working in the construction industry."

Another valuable contribution is the dynamism, enthusiasm and positive 'can do' outlook that he has consistently brought to all of this work. Not only has he made a very significant contribution directly to the promotion of acoustics to the public, but he has made a significant contribution to the promotion to other acousticians of 'the promotion of acoustics to the public', so that they may then make greater contributions to this essential activity.

For all of these reasons the Institute of Acoustics is proud to present the award for Promoting Acoustics to the Public to Alex Krasnic.

Timothy Leighton Rayleigh Medal

Gas bubbles injected underwater are powerful sources of sound – the smaller the bubble, the higher the pitch. As an undergraduate at Cambridge, Tim Leighton was the first to use this relationship to measure the size distributions of bubbles generated in the natural world. It is through an academic career focussed on the acoustics of gas bubbles in liquids, and through related innovations in a diverse range of applications, that he has achieved international distinction.

His undergraduate studies resulted in the award of a double first class honours degree in physics and theoretical physics. Tim stayed at Cambridge to study for a PhD and his interests progressed naturally to looking at the potentially hazardous effects when bubbles are driven with ultrasound.

In 1988 Tim was appointed as a Research Fellow at Magdalene College, Cambridge and was awarded an SERC Postdoctoral Fellowship. In 1992 he was appointed to a lectureship in the Institute of Sound and Vibration Research at the University of Southampton, and shortly afterwards, at the age of 28, he published *The Acoustic Bubble*, a monograph that is now the most cited work in the field.

Since then, in over 120 journal papers, he has presented research based on these principles, and as a result, delivered a remarkable



number of real-world applications. To mention just two, they include the development of needle-free injectors to treat migraines (with sales of over 1 million), and dramatically improved kidney stone monitoring for hundreds of patients to date.

Tim was made Professor in ISVR in 1999 and currently serves as Associate Dean for Research in the University's Faculty of Engineering and the Environment. His work has already been recognised by many learned societies, with the award of numerous medals and prizes.

In addition to being a prolifically productive scientist and innovator, Tim is an outstanding science communicator. His research has been used in extensive public engagement, including 15 TV/video shows that include broadcasts by David Attenborough and Richard Hammond, and in 24 radio shows.

In an academic career of great distinction, Timothy Leighton has made outstanding contributions to science, innovation and public engagement in the field of acoustics. There can be no doubt that he is a worthy recipient of the 2014 Rayleigh Medal. ■

Amplitude modulation comes under Institute working group's spotlight

The Institute's Amplitude Modulation Working Group held a workshop meeting in London in November. The group's aim is to agree a metric for assessing amplitude modulation (AM) in wind turbine noise. Currently there are several methods in use around the world, each giving a different result and clearly some standardisation is needed. The meeting was fully subscribed with environmental health officers, consultants and developers present. Gavin Irvine, group chairman, introduced speakers from the group who each gave a short presentation.

Matthew Cand, Hoare Lea, began by summarising the RenewableUK report on AM published in 2013. Matthew drew the distinction between "normal" AM, which is caused by the moving blades and the directivity of the trailing edge noise heard relatively close to the turbine, and "other" AM, which is primarily caused by transient stall on the rotor blade as observed at residential distances. This is primarily a downwind, low frequency effect characterised by a "whoomphing" or thumping noise at the blade passage frequency, typically just less than once per second.

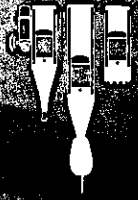
The next speaker was Robert Davis who had the unenviable task of summarising around 30 scientific papers on the subject. Of particular interest were those which included subjective listening tests to establish a dose-response relationship. Researchers have proposed different ways of rating AM. Many have taken a Fast-Fourier Transform (FFT) of the time series as represented by short L_{Aeq} or L_{pA} values, e.g. in 100 millisecond samples. By using the FFT,

the modulation frequency appears as a spectral peak in the frequency domain and the periodicity of the amplitude modulation can clearly be seen. The power spectral density of the fundamental can be related to the peak to trough value of the AM. One advantage of this approach is that false positives can be reduced as those with a modulation frequency outside of the expected range can be ignored. However, in Australia, Cooper and Evans used the FFT method only to find the modulation frequency and then used this to select peaks and troughs within a window defined by the modulation frequency again reduces the influence of the spurious results. The outcome is the depth of the modulation, albeit with some averaging depending on the chosen time period. Other methods used included impulsiveness, fluctuation strength and the DAM index proposed by Tachibana's group in Japan.

Jeremy Bass from RES and David Sexton from West Devon Borough Council then described the long-running Den Brook Wind Farm saga from the developer's and local authority's perspectives. Den Brook is one consented wind farm which has an AM planning condition which states that the AM is deemed "greater than expected" if it exceeds 3dB, subject to certain other qualifications. Jeremy described the difficulties with this condition in that general environmental noise, well away from wind turbines can also fail the condition. A way out of the planning quagmire was thought to have been found with the planning authority's discharge of the so-called Condition 21 scheme developed by RES and agreed **P30**



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CP28 with the local authority's noise consultants, ISVR. However, this has been challenged in the courts and even though the case was recently lost, an appeal has been lodged. The saga continues... Tom Levett from Hayes McKenzie then presented some analysis work of AM from wind farm sites. The RenewableUK rating system has been shown to underestimate the level of AM as represented by the mean peak to trough level. However, the agreement can be improved by taking into account the second harmonic of the modulation frequency. Other techniques analysed included a representation of Evans and Cooper's method, the DAM rating and taking a band-limited time series, say 100 Hz to 500 Hz and using this to determine the modulation frequency by the FFT technique. An advantage of the band-limited method is that it better discriminates wind farm AM which occurs at low frequencies, from spurious sounds such as high-frequency bird noise.

The last speaker was John Shelton from ACSoft who discussed instrumentation and wind shields. John highlighted the fact that sound level meters are nowadays digital instruments and therefore

Network Rail wins IOA-sponsored noise 'Oscar'

A flash butt welder designed by Network Rail National Supply Chain (NRNSC) to minimise noise nuisance has won the IOA-sponsored innovation category in the Noise Abatement Society's annual John Connell Awards.

The award was presented by William Egan, Institute President, to representatives of the organisation at a ceremony at the House of Commons.

The welder is the first piece of equipment designed by NRNSC with a specific sound power target of under 85 dB as part of a policy to protect nearby residents from noise while it carries out track repairs and maintenance, which are often performed at night.

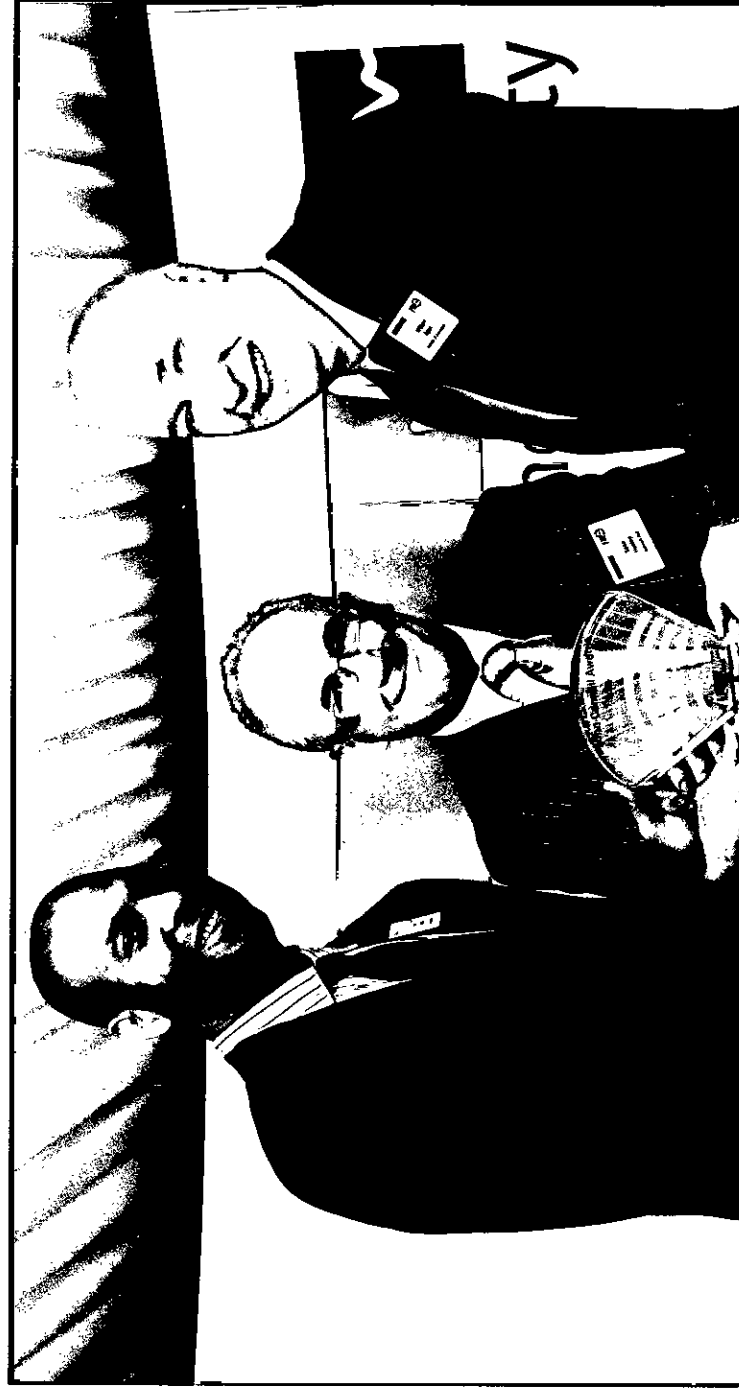
Highly commended in the innovation category was Rockwool for

its range of acoustic products which protect against noise and fire. Jian Kang, an IOA Fellow and a former Council member, was presented with a lifetime achievement award for "unstinting work in promoting the science of acoustics in the urban realm and for his continual drive for innovation and the standardisation of the emerging science of soundscape management".

He is Professor of Acoustics and Director of Research and International Development in the University of Sheffield School of Architecture. He was previously Senior Research Associate at the Martin Centre, Cambridge University, a Humboldt Fellow at the Fraunhofer Institute of Building Physics; and a lecturer at Tsinghua University.

Jian, who received his award from Stephen Turner, outgoing Head of Noise and Nuisance Technical and Evidence team at Defra, was awarded a John Connell Award in 2011 for his work in soundscape design of the waterscapes for the regeneration of Sheffield City Centre.

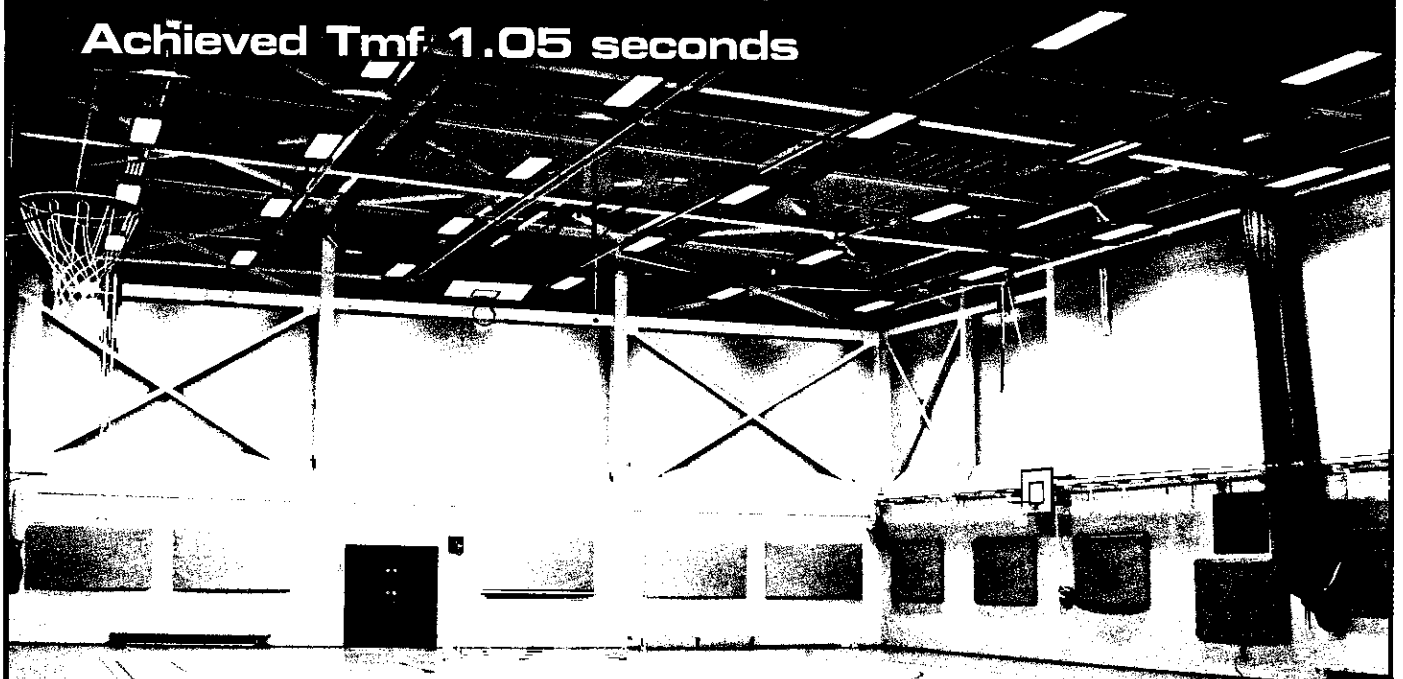
Known as the industry's "Oscars", the awards are named after the NAS's founder and aim to recognise organisations and individuals who have made outstanding contributions to reducing noise pollution. ■



Okey Ngoka (left) and Sean Heslop of NRNSC receive the innovation award from William Egan

The Complete Sports Hall Acoustic Solution

Achieved Tmf 1.05 seconds



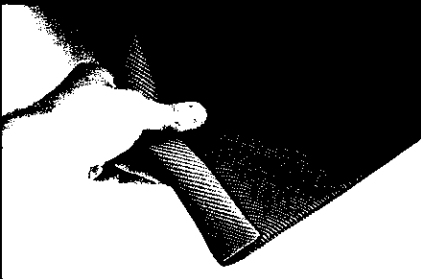
The Oscar Evo-Panel:

- Kinder on human impact than a concrete wall
- Sport England specification compliant
- Easy & quick installation - typically within 1 day
- Each can be removed & replaced within 20 seconds
- Stylish in a range of customisable colours
- Meets fire rating Class 0 to BS476 Part 6

SonaSpray onto roof liner:

- Can be applied directly onto standard galvanised deck
- Saves time & money over perforated liner systems
- Higher performance than perforated systems
- Meets fire rating Class 0 to BS476 Part 6
- Recycled finishes contributing to project LEED points

Bedford Academy - 800m² sports hall. SonaSpray onto galvanised deck, 28 Oscar Evo-Panels at low level. Estimated £25-30k saving to contractor over standard solution. Passed with Tmf 1.05 secs (in-house testing).



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ACOUSTICS

Seventy-three candidates successful in Diploma in Acoustics and Noise Control

By Keith Attenborough, Education Manager

In 2013/2014 the IOA Diploma in Acoustics and Noise Control was centre-based at five institutions (Derby University, Leeds Beckett University, Southampton Solent University, NESCOL and London South Bank University) and offered through five tutored distance learning (DL) centres (St. Albans, Trinity College

Dublin, Bristol, Edinburgh Napier University and Cornwall). After two "probationary" years as a tutored distance learning centre Southampton Solent now offers the Diploma as an autonomous centre and London South Bank University has resumed offering the Diploma after a gap of 17 years. Sadly however, the University of Salford no longer offers the Diploma and Colchester Institute was unable to recruit enough candidates.

1. Formerly Leeds Metropolitan University

The General Principles of Acoustics (GPA) Module ▶

Centre Name	GRADE	GPA	PROJECT	LAB	BA	NVCE	RA	EN
DL (Bristol)	Merit	4	2	4	2	1	0	3
	Pass	3	4	3	3	3	0	2
	Fail	1	2	1	2	1	0	0
DL (Cornwall)	Merit	0	0	0	0	0	0	0
	Pass	1	0	1	0	0	0	0
	Fail	0	1	0	1	0	0	1
DL (Edinburgh)	Merit	5	1	2	4	0	0	5
	Pass	5	6	7	5	2	0	1
	Fail	1	6	1	0	2	0	3
DL (St Albans)	Merit	6	3	1	3	2	0	2
	Pass	1	7	7	6	3	1	2
	Fail	4	6	2	5	3	1	1
DL (Dublin)	Merit	4	4	5	0	0	1	3
	Pass	2	2	1	3	2	1	2
	Fail	0	0	0	0	0	0	0
Leeds Beckett University	Merit	13	4	9	2	0	0	10
	Pass	3	12	7	10	6	3	4
	Fail	1	4	1	3	3	0	0
London South Bank University	Merit	7	4	7	4	4	0	0
	Pass	4	7	8	7	6	0	0
	Fail	4	5	0	4	5	0	0
NESCOL	Merit	4	2	3	0	0	2	3
	Pass	0	3	2	0	0	3	2
	Fail	1	0	0	0	0	0	0
Southampton Solent University	Merit	1	1	1	0	0	1	3
	Pass	5	6	6	4	4	0	1
	Fail	2	1	1	1	2	0	0
University of Derby	Merit	4	2	17	0	0	0	5
	Pass	16	14	3	6	3	6	9
	Fail	2	4	0	5	3	6	1
Totals	Merit	48	23	50	15	7	4	34
	Pass	40	61	45	44	29	14	23
	Fail	17	29	6	22	20	7	6

IOA Diploma Results Chart for 2014

■ examination Part A questions concerned calculation of sound levels from peak sound pressures, standing waves and room modes, vibration indices, definitions and examples of absorption, diffraction and refraction, noise generation mechanisms, underwater sound waves, the hearing mechanism and propagation. At all centres, GPA part A questions were answered well enough for the average score to be above 50%. The questions on the hearing system and calculations of sound pressure level from sound power level were answered consistently well. On the other hand, the questions on VDV, noise sources and underwater sound were answered relatively poorly. Part B questions on the GPA examination paper were about room acoustics, microphone performance and sound power measurement, vibration and noise in the workplace, vibration isolation and railway noise and its reduction. The questions on room acoustics, workshop noise and vibration and railway noise were most popular and answered well. The question on microphones and sound power determination was least popular and answered poorly. The GPA assignments in 2013/14 were about the acoustical measurement of distance and supermarket delivery noise, the latter being more popular and answered better than the former. The mean GPA exam and conflated marks in 2014 were near the average of those gained on the GPA since 2000.

It was found necessary again to moderate some centre marks for the laboratory module to bring them into line with those for DL candidates. The laboratory module continues to have a high percentage of merits (52% this year).

At the moderation meeting for the 2014 marks a criterion based on the means and standard deviations was used to decide whether or not to moderate marks for the specialist modules. The raw mean written exam mark for the Regulation and Assessment of Noise (RAN) module in 2014 was just below the seven-year average – two Standard Deviations' leading to a relatively high number of fails. It was agreed to raise all of the exam marks to

make the mean exam mark in line with the mean mark from the last seven years. The number of candidates opting for the RAN module continues to fall.

Compared with previous years, the 2014 Noise and Vibration Control Engineering (NVCE) written examination and conflated means were low and correspondingly the percentage of fails was relatively high. The NVCE assignment concerning a building acoustics design involving a standby generator was considered to be hard and marked harshly. At the moderation meeting borderline marks were given close scrutiny and if the raw aggregate mark was close to but below the pass threshold, the CW marks were adjusted to give a pass.

As in previous years, a merit threshold of 70% was applied to the written paper and the conflated GPA mark. The examination scripts of candidates satisfying the conflated mark threshold but gaining between 67% and 69% on the written paper were examined at moderation, re-marked where appropriate, and judged individually as pass or merit. However, even if these criteria were satisfied, a merit was not awarded if the assignment mark was carried over from a previous year. To obtain a merit grade on the specialist modules, candidates were required to have conflated mark and written examination marks of at least 70%. No merit was awarded if it depended on a deferred score.

The numbers of candidates who gained merits (M), passes (P) or fails (F) in each module are shown for each centre in the table of results overleaf. The 'fails' include those who were absent from the written examinations. The results of seven appeals (only one of which was successful) are included also.

There were 106 candidates (including four from overseas) entered for the General Principles of Acoustics (GPA) written paper in 2014. This is less than last year (113) and well below the peak of 216 in 2006. There were 25 candidates for Regulation and Assessment of Noise (RAN), 56 for Noise and Vibration **P34**

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P33 Control Engineering (NVCE), 81 for Building Acoustics (BA) and 63 for Environmental Noise Measurement, Prediction and Control (EN). Out of the 113 registered for the project module, 29 candidates, listed as having failed the project in the table of results, did not submit and will have to repeat the project module next year.

The prize for best overall Diploma performance (based on the total marks awarded for five merits (GPA, BA, NVCE, Project and the Laboratory Module) is to be awarded to Jen Taylor (London South Bank University). Special commendation letters, offering congratulations on also achieving five Merits, have been sent to

Jemma Jones (LSBU), Scott Castle (NESCOT), Alex Foster (DL St Albans), Gareth Thompson (DL Dublin), Simon Harry and David Johnston(DL Bristol). Gareth Thompson will also receive the prize for the best overall Diploma performance by an Irish student.

I would like to thank all tutors and examiners and Hansa Parmar in the IOA office for their contributions. Special thanks to go to Rupert Taylor who has resigned as one of the NVCE examiners, after five years' service in this capacity, due to pressure of work. Rupert's input has been excellent and it will be hard to maintain the variety and challenge of the assignments he has set. **o**

Institute of Acoustics Diploma Bulletin Pass List 2013-14

Diploma awarded after written exams August 2014 (carried over Project pass)

Distance Learning (Bristol)	Distance Learning (St Albans)	Southampton Solent University
Ferris D	Veerasamy R	Williams T J

Diploma awarded in December 2014 (including 2014 projects)

Distance learning Dublin	Distance Learning Edinburgh	Macleod K J D
Barry P	Champion J N	Mohammed R M S
Donegan D G	Corey J	Skingle S C
McFarland L	Inglis B G	Veerasamy R
Quirke K A	Joyes K	
Sheridan B J	Kelly I R	
Thompson G	Neilson G L M	
	Petrie M	
Distance Learning Bristol	Distance Learning St Albans	
Allard R J	Crabtree L A	
Ferris D	Cueto I	
Green D	De La Osa Enriquez A	
Hargreaves S G	Foster A	
Harry S J	Grady R M	
Johnston D N	Kinsman D A	
Morgan A	Lewis S	

University of Derby	NESCOT	University of Derby
Dent J	Castle S A	
Dominy C J	Meakins A C	
Draper M	Monk D J	
Fellows A J	Vincent T I	
Gerard D J		
Gibbs S		
Griffith S		
Javed R		
Large J		
Last C J		
Patel A		
Slater J A		
Symons A K		

London South Bank University	Southampton Solent University
Sills A	Atkley D J
Storey C R	Bennett N S J
Whitaker R J	Carda G M
	Davison L G
	Green D J
	Williams T J
	Yule L

London South Bank University	Southampton Solent University
Bateman M S	Atkley D J
Capps E	Bennett N S J
Harper S	Carda G M
Jones J	Davison L G
Markwick M	Green D J
Nicholson W	Williams T J
Pigrem J	Yule L
Taylor f	
Wade W C	

Sixty-seven more applications for membership approved by IOA Council

Sixty-seven applications for membership were approved by Council in November following the recommendations of the

Membership Committee. Of these, 41 were for new or reinstated membership, the rest were for upgrades. **o**

FIOA	Mark Hinds	Ion Tofts
Patrick Allen	David Ives	Samuel Williams
Henrik Moller	George Kouritis	Allen Woolley
	Derek McLaughlin	
MIOA	Martin McVay	AMIOA
Peter Akhurst	Chiara Morbelli	James Allen
Jose Andreu Medina	Louise Morris	Peter Barry
Graham Aveyard	Ronan Murphy	Steven Barry
Adam Bamford	Paul Newbery	Sam Daintree
Thomas Barnsley	Sofia Patricia	Jason Dent
Charles Bradfield	Spyros Polychronopoulos	Giovanni De Rienzo
Matthew Bronka	Allan Robinson	Rebecca Edwards
Janine Dickinson	Georgia Rodgers	David Elliott
Philip Duncan	Daniel Sissons	Dunstan Ferris
Daniel Harrison	Christian So	Tim Fox

Francis Goodall	James Smith
Lewis Herd	Lewis Stonehouse
Jack Latham	Kristoffer Tsiontas
Victor Lindstrom	Matthew Tuora
Kirsty Maple	Leo Weber
Moreno Robles	Ashley Walke
Charlotte Morrison	
Jack Naumann	
Camilla Nelson	
Benjamin Phillips	
Punyakom Prayoonsakul	
Benjamin Reed	
Juan Rioperez	
Luis Ruivo	

Affiliate	Tech
Andrew Pidsley	Gavin Bache
	Thomas Clarke
	Christopher Hisk
	David Johnston
	Chloe Miller
	Olubukola Olose

Spotlight falls again on excellence in sustainable acoustic practice

By Richard Cowell and Peter Rogers, of the Sustainable Design Task Force

In the May-June 2014 Bulletin we introduced six good examples of sustainable acoustic practice, illustrating the wide range of existing achievement by Institute members.

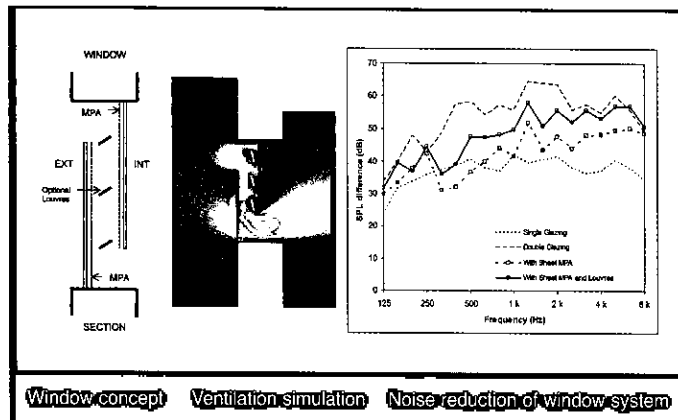
As before, we hope that the following examples encourage more attention to the valuable contribution that we can make as professionals through our acoustic practice.

Energy efficiency: holistic window design improves scope for natural ventilation in noisy environments

[Awarded the IOA Peter Lord award for Good Acoustic Design and Innovation]

To allow natural ventilation, attenuation is not normally possible within the opening of the windows, due to the obstruction of daylight and use of fibrous material in attenuation paths is not welcome on health grounds. In this project, staggered window openings are lined with transparent micro-perforated absorbers (MPA) which is spaced away from the glass to form a resonant system. An integrated acoustics, ventilation and lighting test facility was developed between semi-anechoic and reverberant chambers and various configurations of this concept evaluated. The effectiveness of the design was investigated using finite element method, considering the effects of opening size, air gap, louvres, hood and absorbers. Noise reduction has performed better than closed single glazing. The system has been successfully applied in Hong Kong since 2009.

Contact: Prof Jian Kang FIOA (University of Sheffield) Email: j.kang@sheffield.ac.uk



Design for ongoing legacy use: production quality system for the Olympic Velodrome and Legacy Venue

The Olympic Velodrome was designed and built for the 2012 London Olympics. The permanent sound system was specifically undertaken to meet both the production requirements of the Games (removing the need to rent additional equipment) and the legacy venue, a high quality performance system that could continue to be used there after the Games. After transition works, the Velodrome has now been handed on to the Lee Valley Regional Park Authority.

The VeloPark, as it is now known, has reopened and has hosted public events including the Revolution series, Comic Relief, Newham elections and the Track Cycling World Cup in December 2014. Audio quality and facilities of the installed system allow the production team to provide foreground and background music, video content and live microphones to the seating areas. The coverage can be zoned for flexible usage and various spectator capacities. This legacy provision shows how the building lifecycle is important for acoustic design from the beginning.

Contact: Mark Murphy MIOA (Vanguardia Consulting) Email: mark.murphy@vanguardiaconsulting.co.uk



Social inclusion: exploring use of vibrotactile feedback to facilitate interactive musical performance for deaf musicians

Limits were established for perceiving musical notes via vibration on fingertips and feet, defining the usable dynamic range and a pitch range that can reliably be achieved. Perception and learning of basic relative pitch was investigated with normal and hearing impaired participants. This indicated a high success rate with and without training, implying that everyone has a basic ability to perceive relative pitch, although it is difficult to distinguish intervals smaller than three semitones. Assessment of relative pitch can improve with training. P36

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135 To promote social inclusion and challenge public perceptions of what is possible with a hearing impairment, public engagement activities have taken place with the deaf community. A video, showing musicians performing using vibrotactile feedback, can be found at (<https://stream.liv.ac.uk/kgfyndz4>).

Contact: Professor Carl Hopkins FIOA (University of Liverpool)
Email: Carl.Hopkins@liverpool.ac.uk



A musician using vibrotactile feedback

Recycling/extending life: sustainable acoustic instrumentation use needs a careful mix of recycling and extended life

Advances in electronics and demand for new features (Internet connectivity, colour touch screens, extensive post processing, etc.) make sound level meters obsolete, although microphones are rescued. Our contractors recycle component materials in a sustainable way, in line with WEEE part 6 Clause 48.

The price of increased functionality is power consumption. Modern full specification digital instruments require some 12-16 times the power that analogue instruments need. Slow advance of battery technology means that batteries now drive instrument size. For a simple long term dB(A) time profile in remote locations, where battery power is the only option, the old analogue kit still comes out on top!

The Nor-116 (analogue before the RMS stage) looks almost like the Nor-118 (fully digital after the preamp). Our hire fleet holds the former for these niche measurements, until battery technology catches up.

Contact: Ian Campbell HonFIOA (Campbell Associates) Email: ian@campbell-associates.co.uk



New scheme recycles sound level meters

Cross-disciplinary collaboration: noise modelling for protection of marine life

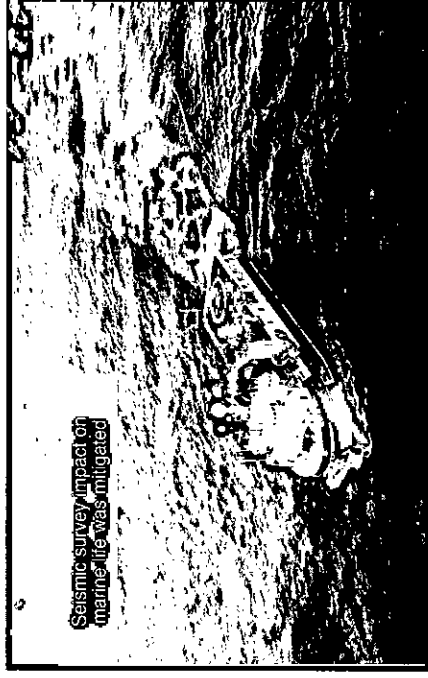
A 3-D seismic survey to be carried out in UK and Norwegian waters threatened an adverse impact on marine life.

Underwater noise propagation from the seismic air gun array was predicted using ERM's Marine Noise Exposure Model, developed to model the specific local marine environment including water temperature, salinity, bathymetry, sea bed absorption and the underlying bedrock characteristics, all influencing propagation or reflection of sound waves. The modelling predicted noise impacts over a wide area, unless mitigated.

Account was taken of the effect of animal movement on accumulated exposure and potential injury. For assessment of likely animal proximity to the airgun array, it was essential that marine biologists and acousticians worked together. As a result, good

mitigation was achieved for the survey to proceed on schedule.

Contact: Steve Mitchell FIOA (ERM) Email: Steve.Mitchell@erm.com



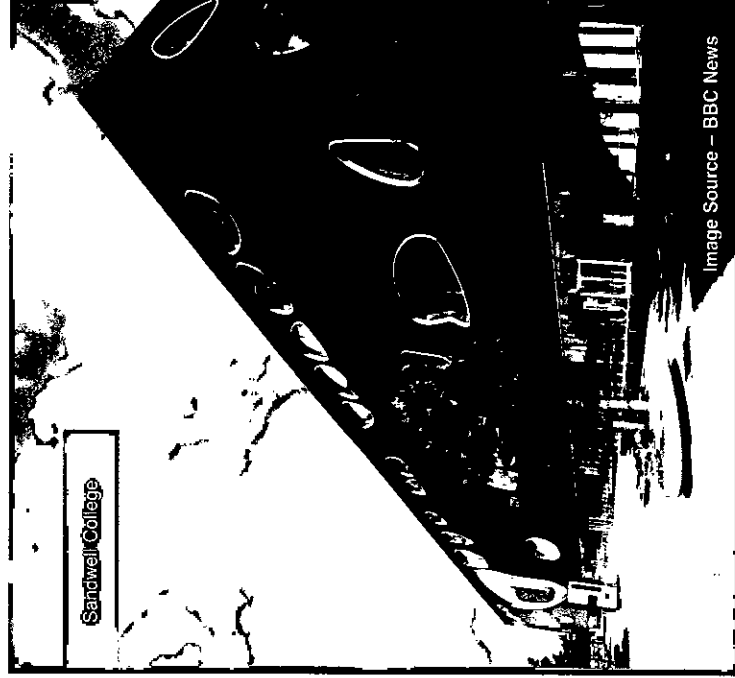
Seismic survey impact on marine life was mitigated

Economic and social benefit: repurposing 'The Public' Millennium Project as Sandwell College Central Sixth Form

In November 2013, the Millennium Project 'The Public' Arts facility in West Bromwich closed due to excessive running costs. Sandwell College, with the local authority, then began work on repurposing the building for its growing sixth form offering. Arup visited the College to consult stakeholders over current building use. Extensive benchmarking assessed the acoustic performance of the fabric of the building and scope for minimum change.

Re-planning involved cellular and open plan teaching, IT, and library spaces, conversion of galleries to lecture theatres and retention and refurbishment of building services. The 'surreal' architecture presented awkward junctions (with roof lights, the façade and internal architectural objects), now detailed to achieve adequate sound insulation. Existing sound absorbing treatments were reused and supplemented only as necessary. This collaborative acoustic design was key to realising the economic and social benefit.

Contact: Cameron Heggie AMIOA (Arup Acoustics) Email: cameron.heggie@arup.com



Sandwell College

Image Source – BBC News

The Sustainable Design Task Force would welcome more example of sustainability. Contacts: Peter Rogers (progers@sustainableacoustics.co.uk) and Richard Covell (richard.covell@arup.com) **Q**

Calling all senior members: your Institute needs you

By Ralph Weston, Senior Members' Group Chairman

Have you considered joining the Senior Members' Group? Set up in 2011, it is open to anyone who is approaching retirement or who has already retired.

Its aims are to use older members' huge wealth of experience to develop the IOA while promoting friendship and networking. In practical terms this means mentoring, assisting in reviewing CPD records, co-operating with the Young Members' Group and organising scientific and social meetings.

Our members have also paid a central role in assisting Geoff Kerry in the monumental task of researching and writing the history of the Institute, which is due to be published early in 2015.

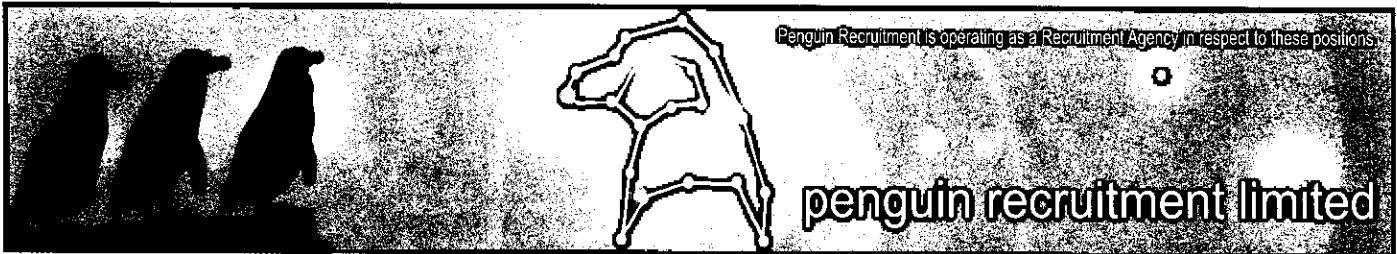
Since our initial meeting at London South Bank University in January 2011 our numbers have grown to 112 and, having been persuaded to serve as chairman for another two years, my aim is to see them increase by another 50 before I finally step down.

Fresh ideas on how we can develop, meetings suggestions and how we can communicate better are all needed, as are more CPD assessors, so do please consider joining us when you come to renew your membership.

There is plenty we can do to progress our group, but we need you to volunteer now. So please contact me at muchpotting@btinternet.com if you can help. ■



Ralph Weston



Penguin Recruitment is operating as a Recruitment Agency in respect to these positions

Penguin Recruitment is a specialist recruitment company offering services to the Environmental Industry

Acoustic Design Engineer – West Yorkshire

£30-40K

Our Client is leading manufacturer of noise control products to the commercial sector, and is looking for an Acoustic Design Engineer to work from their offices in West Yorkshire. You will be responsible for the design of products such as acoustic enclosures, air handling units and ventilation systems. Liaising between clients and other industry contacts you will provide technical guidance from preplanning to completion on projects, and ensure that maximum up selling of the company's products is achieved. You need to have a proven track record in business development within the market, have an up to date awareness of bespoke solutions/competitors and be an excellent communicator. Qualifications required are an MSc or BSc in an Acoustics related discipline, a minimum of 5 years commercial experience with the Acoustics noise control sector and a full clean driving license. On offer is competitive salary, generous bonus structure and flexible benefits package.

Consultant/Senior Acoustician – Birmingham

Circa £25 - 30k

We currently have an excellent opportunity available for a candidate with proven expertise in the UK Environmental Acoustics field to join a large multidisciplinary consultancy in their Birmingham offices. Ideal applicants will have extensive consultancy expertise within the environmental Acoustics sector, with a focus on infrastructure and energy development. They will also hold a BSc or MSc in Acoustics or Noise and Vibration Control, and an IoA diploma, and Full or Associate IoA membership.

Environmental Acoustician – South West

£21 – 26k

We currently have an urgent requirement for an Acoustic Consultant with a background in environmental acoustics to join a leading international engineering and environmental consultancy providing multidisciplinary services to the property, infrastructure, energy and environmental markets to clients in both public and private sectors. Based near Exeter, the successful candidate will have an opportunity to work as part of a well-established, successful team on a wide variety of exciting projects in the regeneration, education, healthcare, property, waste, and energy sectors. Candidates should have a leaning towards Acoustics, but be willing to provide support to other environmental services provided by the team, such as Environmental Impact Assessment.

Senior Acoustic Consultant – London

£30 - 40K

A fantastic opportunity exists for a Senior Environmental Acoustic Consultant to join an extremely successful and highly recognised multidisciplinary engineering consultancy with an enviable reputation as being one of the world's leading engineering and development consultancies. Due to an increase in workload they currently require a highly experienced and skilled environmental acoustician with a proven track record of project work. Qualifications desired include: a degree in acoustics/vibration related field ideally with a post graduate certificate in a relevant subject. Reporting to the principal consultant, you will provide technical expertise and assist with the management of a number of innovative projects across the UK.

Acoustic Noise Consultant – Surrey

£22 - 30k

A well-established environmental engineering company based in Watford currently have an urgent requirement for an Acoustic Noise Consultant. They pride themselves on the quality of their work and the service they provide to their clients and also have a thriving noise control product division. The ideal candidate will hold an acoustics or related degree and have prior experience working within the acoustics sector particularly undertaking environmental noise assessments with knowledge of relevant legislation. This role will involve both office and field work and as such a driving license is advantageous. The successful candidate will receive a competitive salary and benefits package and will work in a friendly management team who support professional development and further training.

Building Acoustic Consultant – Berkshire

Circa £30k

Our client is a small specialist niche building acoustic company based in the Berkshire area. They offer a friendly and professional service all around the UK and are looking for a Building Acoustic Consultant to join their team. The ideal candidate will have excellent technical skills and will be able to explain complicated reports in simpler terms to clients to help them understand what is required. You will be required to travel independently to different clients' sites around the country undertaking noise assessments and sound insulation testing. The starting salary for this role is flexible depending on your level of experience.

**We have many more vacancies available on our website.
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Interested in our current Acoustic job opportunities? Please do not hesitate to contact Amir Gharaati on 01792 365 101 or alternatively email amir.gharaati@penguinrecruitment.co.uk

Scots look to future as they celebrate IOA 40th anniversary with event to remember

By Alistair Somerville, Scottish Branch Chairman

As professional institutes go, we are relatively new kids on the block. RIBA, CIOB, RICS, REHIS and CIEH have been around for about 130 to 180 years. Nevertheless, in the last 40 years, the IOA has developed into a professional body representing some 3,000 members working in an extremely diverse range of acoustics disciplines, with nine specialist interest groups and local activities organized by regional branches. It has an internationally recognised professional qualification, a range of professionally recognised courses and a programme of regular meetings and events.

So, despite our youth, we have a lot to celebrate when we look back over the past 40 years. It was particularly appropriate that the Scottish Branch organised an event in Edinburgh as it was here that the Institute first set up an office, based at Heriot-Watt University.

Although it was good to celebrate, it is also important to look forward to the future and we therefore took the opportunity to invite fellow professionals and significant representatives from organisations which will provide opportunities for collaboration, organisational development and expanding spheres of influence into the future. Guests included those from Scottish Government (planning, pollution and building standards functions); the Royal Environmental Health Institute of Scotland, the Scottish Environmental Protection Agency and ClimateXChange.

The celebration took place at Edinburgh Napier University's Craiglockhart Campus, which proved to be an excellent location for both the afternoon technical conference and the celebratory evening dinner. Thanks are particularly due to Sean Smith and Nicola Robertson for much of the organisational leg work and on-site facilitating.

In all, 54 attended and in terms of looking to the future, it was great to see a significant number of young members there.

The technical conference featured three presentations.

Professor Sean Smith (Edinburgh Napier University Professor of Construction Innovation and Director of the Institute for Sustainable Construction) began with *Future global developments in sound insulation, classification systems and low frequency issues*.

His presentation discussed the recent developments for sound insulation through European networks TU0901 and ISO standards and the potential influence on future building acoustics. He discussed findings from the 32 countries involved in a four year network programme and looked at possible future developments. Interlinks with sustainability standards and variations across countries were also presented.

Next came Dr Laurent Galbrun (Heriot-Watt University), who spoke on *Soundscape design for the built environment*.

He considered the context of studies carried out in the last 10 years which have shown that decreasing noise levels and eliminating noise sources are insufficient for improving the acoustic quality and comfort of both outdoor and indoor spaces. Soundscape studies go beyond basic concepts of noise level and annoyance and, in particular, rely on considering physical characteristics as well as mental perception of the aural environment. It promotes the use of pleasant sounds to improve acoustic comfort. He gave two examples of research carried out at Heriot-Watt University. Firstly, the audio-visual and perceptual analysis of waterscapes used for road traffic noise masking, and secondly, the analysis of multi-lingual speech intelligibility in enclosed spaces, in relation to the particular issue of cross-cultural communication.

Andrew Bullmore (Hoare Lea Acoustics) concluded the presentation with *Scottish wind farms: case study review of noise impacts of onshore wind farms – progress report*.

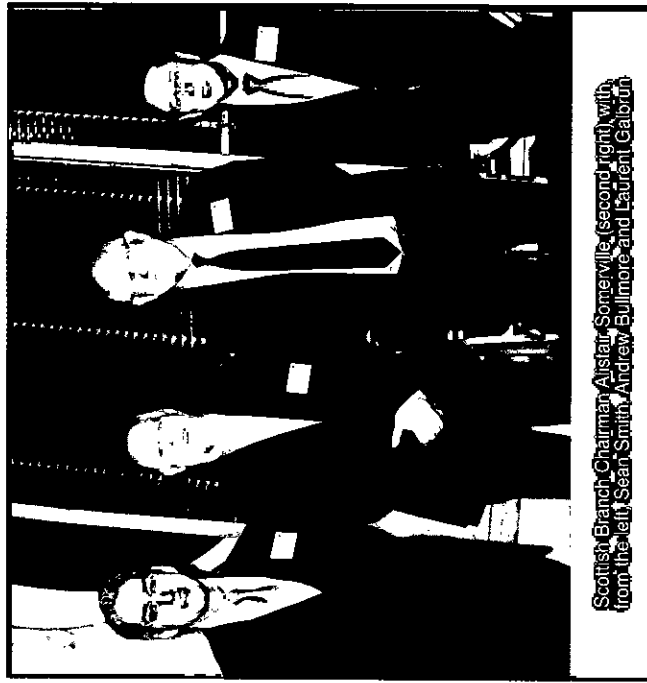
He described the scope, measurement methodology, challenges and progress of a study designed to compare the predicted versus actual impacts (noise, visual and shadow) of operational wind farms. The predicted impacts were those contained in Environmental Statements or other documentation submitted with the planning application. The study was requested by Scottish Government and is being managed by ClimateXChange. The study is examining 10 onshore wind farm developments across Scotland, measuring their operational impacts through a combination of field assessments and local resident surveys. The study will contribute evidence to inform guidance to wind farm developers on how they should measure the potential impacts of their wind farms, and how they should communicate this to planning authorities and those likely to be affected.

All presentations were extremely well received and provoked numerous questions. Our thanks go to the three speakers.

At the end of the presentations a DVD of Leo Beranek's after-dinner speech at the Institute's 40th anniversary conference in Birmingham was shown, with all marvelling at the stamina and wit of this 100-year-old "giant" in the world of acoustics.

Following a drinks reception, the dinner took place, the highlight of which was a speech by Professor Robin Mackenzie, who gave an account of the Institute's beginnings and the development, significant events and notable individuals linked to Scottish Branch activities. Currently Professor of Acoustics and Vice Principal (Research) at Edinburgh Napier University, he is a Fellow and past member of Council of the Institute and was the first chairman of the Building Acoustics Group.

The feedback from members and guests was extremely positive: they thoroughly enjoyed the event and said it was a very fitting way to celebrate our anniversary. On behalf of everyone I would like to thank our Institute for their administrative and financial support, Edinburgh Napier University for hosting the event and the branch committee for planning it. ■



Scottish Branch Chairman Alistair Somerville (second right) with from the left Sean Smith, Andrew Bullmore and Laurent Galbrun

Cheers! Sell-out attendance as South West Branch members toast 40 years of the IOA

By Dan Pope, South West Branch Chairman

South West Branch celebrated the Institute's 40th anniversary with a visit to the At-Bristol Science Centre with a record sell-out attendance for a meeting of the branch of 50 people. The organisations represented ranged from consultants to local authority, from manufacturing to equipment suppliers, and we were pleased to welcome a number of new and non-members.

Those attending enjoyed access to the science centre's exhibits, and in particular were guided to the acoustic-themed installations such as the whisper dishes, hearing range test, musical pipes, visible vibrations strings, models of human vocal apparatus creating vowel sounds, and a demonstration of hearing through bone conduction, among others.

Four technical papers were presented, including two from young members. Miguel Blanco of Mach Acoustics presented on investigation into real world and modelled performance of partially opened windows and showed 3D models of potential acoustic mitigation through different opening types and screens. Georgia Rogers of Max Fordham presented on the recently adopted BS 12913-1 Soundscapes and its influence on acoustic design. Branch chairman Dan Pope of Atkins presented on the Future Sound of Cities, the paper previously presented as a poster session at the IOA 40th Conference at the NEC, providing a potted history of the influence of urban planning on soundscape, giving examples from Atkins acoustic design tools for urban areas.

Our keynote speaker Bernard Berry of Bel Acoustics and an ex-IOA President, then gave a detailed presentation on the latest **P40**



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- | | |
|------------------|--|
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| IRC297666 | Graduate Acoustics Consultant / Acoustics Consultant, Bristol |
| IRC297808 | Graduate Acoustics Consultant / Acoustics Consultant, Birmingham |

We are also interested in expressions of interest from senior practitioners based across Scotland, England and Wales.

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P39 research on the effects of noise on human health. In particular he categorised the evidence for various effects using the International Agency for Research on Cancer four point scale for categorising medical evidence as either sufficient, limited, inadequate or lacking.

Attention was brought to the EEA Technical Report 11/2010 *Good practice guide on noise exposure and potential health effects* which compares results of various previous studies on the number of people annoyed by different noise levels, and shows that the levels

at which the percentage of people are highly annoyed increases post-1990 when compared with pre-1990 studies. As far as he is aware no assessment has used these revised thresholds as yet.

Following this there was food and drink provided, with thanks to ANV for their support on this. (Perhaps free food is a key factor in the increased attendance?) We retired to the pub afterwards to discuss issues both acoustic and non-acoustic over a social drink. The branch thanks all who presented and attended and looks forward to the new year. ■

The dummy microphone is no longer alone

By Ian Campbell

Measurement of low level noise has long been a feature of environmental noise surveys, yet it is one of the aspects of instrumentation that has not been given much attention. Statistical parameters are normally used for these determinations, yet in the long-awaited revision of the sound level meter specification there is no mention as to how they should be measured. It appears you can choose the sample rate, bin size and time constant to suit your own, or the instrument designer's needs. To be fair however, as most instruments are now little computers in their own right they have all the processing power necessary and the solutions offered by manufacturers are usually more than adequate for the task. So it comes down to determining the lowest level that the instruments can measure; traditionally this has been verified during the periodic verification (calibration) by the measurement of the instruments self-noise, which is duly reported on the calibration documentation. This measurement has to date been made as a measurement of the preamplifier self-noise by replacing the microphone with a dummy microphone and noting the level indicated on the meter. These dummy microphones place a similar load on the preamplifier as a real microphone but do not have any active microphone element so you can see what the meter would indicate if the microphone diaphragm was fixed and could not move.

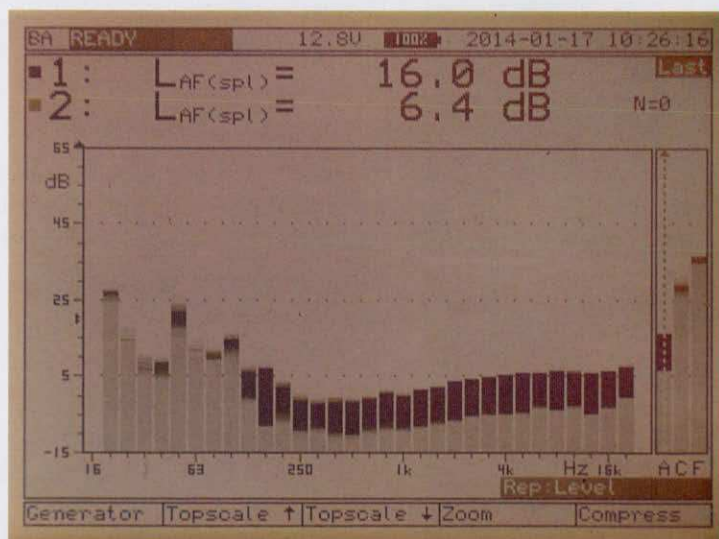
In the good old days the electrical noise of the preamplifier was normally the controlling factor but over the years electronics has improved and now it is not uncommon to find instruments returning self-noise figures of less than 8 dB(A). But this does not mean we can measure statistical levels down to these values as the microphone element itself has an inherent self-noise that is significantly above this level. This microphone self-noise is due to the random movement of molecules within the microphone and varies depending on the type of microphone and the degree of damping they use to produce the required frequency response. For a standard half-inch 50 mV free field measurement microphone the microphone self-noise will be around 15 dB(A). These two numbers will combine to give an effective noise floor for the instrument of 16 dB(A) so any measurement of less than 26 dB(A) has to be treated with some caution.

Fortunately, the standards have now recognised these problems and in the new version of the instrument verification standards the self-noise has to be measured with the microphone present. This is a measurement of just the dB(A) value with the other weighting networks being verified in the conventional manner. For the calibration laboratory this means that a test area has to be constructed that has a noise level ideally of less than 8 dB(A) and an instrumentation system that can measure these low levels. Fortunately, it does not have to be very large so an enclosure about a metre cube constructed with dense materials and good vibration isolation can achieve this and a special low noise monitor microphone is used to verify the levels present when the

microphone and associated instrument are being checked. It gets a little more complex when you have to consider the different configurations of instrument that are presented for calibration. Some have extension cables so just the microphone has to be in the "quiet zone", but in some cases the complete instrument has to be in the test box. Then of course the problem is being able to see the display so a bit more complexity comes into play. We have even seen instruments that themselves produce noise levels due to the coils or display drivers emitting tones that are audible in the test enclosure! You soon get to the stage where you need a dual channel real time analyser to check the results; the characteristic spectrum of the microphone and preamplifier self-noise are well defined and hence measurement artefacts soon show up. Experience has shown that noisy microphones are one of the main causes of problems where L90 values have been questioned, so hopefully these problems should be captured in future before the instrumentation gets out on site.

So if your meters are calibrated to the new BS EN 61672 standard there should be an extra line on the calibration report that gives the dB(A) self-noise for the microphone in addition to the electrical noise on all the frequency weightings. Then for sure you know how low you can go.

Ian Campbell is Technical Director of Campbell Associates and a committee member of the Institute of Acoustics' Measurement and Instrumentation Group. ■



Microphone self-noise measurement

Channel 1 is the device under test and channel 2 the monitor microphone verifying the noise level in the test chamber. Results <250 Hz are preamplifier/ambient break through noise and > 250 Hz are microphone noise

Researcher goes in search of 3D sound reproduction

A University of Huddersfield researcher aims to bring sound reproduction into the 3D age with a new system that would allow not only horizontal but also vertical distribution of sound.

It could mean that in the near future, filmgoers, music lovers and home cinema enthusiasts will more easily be able to experience three-dimensional recorded sound. This is perceived vertically as well as on the horizontal plane – horizontal being the sole plane with conventional 2D sound – leading to an experience that completely envelops the listener.

Dr Hyunkook Lee, a senior lecturer in music technology in the university's School of Computing and Engineering, has been awarded a grant of £100,000 by the Engineering and Physical Sciences Research Council (EPSRC) for a two-year project entitled *Perceptual rendering of vertical image width for 3D multichannel audio*.

"If you are at a live concert you hear sounds from everywhere, including reverberation and reflection from the ceiling," explained Dr Lee. "But conventional surround sound systems are limited because they are effectively two-dimensional. 3D means you have an additional height dimension."

The new, two-year, EPSRC-backed project aims to arrive at a psycho-acoustical understanding of how the human brain perceives vertical sound.

"We know how we perceive sound horizontally very well, because we are so used to stereo and surround sound, but the height dimension is the new thing," said Dr Lee.

He aims to develop software that renders the characteristics of 3D sound. It would be an "upmixing" system, so that studio engineers or home listeners could convert 2D recordings into 3D.



Dr Hyunkook Lee

But first, Dr Lee must conduct a series of tests, so that he can arrive at a greater understanding of how humans perceive vertical sound. To do this, he has secured the services of one of the world's top experts to design a critical listening room that will be installed at the university and equipped to the highest audio industry standards.

Once it is complete – by the spring of 2015 – a panel of trained and selected music technology students will act as the "ears" of Dr Lee's project.

Installed in the listening room, they will hear recordings of music, assess the quality of the sound and provide perceptual patterns that can be analysed by Dr Lee, who will be assisted by a postgraduate researcher for the project.

Dr Lee is convinced that there will be a burgeoning demand for 3D audio – and there are systems capable of playing it – but there is a need for more content, so that sound catches up with vision. His research aims to speed up this process.

"The 3D version of Avatar is very popular, but its audio is still 2D, so we need some new technology for making 3D audio." ■

Road traffic noise 'still a major health issue for tens of millions of Europeans'

Noise from road traffic still heavily affects Europeans' health, according to the latest edition of the European Environment Agency's annual report on environment and transport.

Although only about 40 % of the expected data has been reported for 2012, it is clear that at least 110 million Europeans are exposed to daily average road traffic noise levels that are detrimental to health, according to the indicator on annoyance (> 55 dB Lden), it states.

The total numbers of exposure to rail and aircraft noise are lower, "but not inconsiderable".

Europeans collectively travelled 6.4 trillion kilometres in 2012, according to the *Transport and Environment Reporting Mechanism (TERM) 2014*.

While car transport made up more than 70 % of this distance, it has continued to decline since 2009. In contrast, air transport has increased very fast over recent decades. One factor behind this pattern may be changing consumption habits. ■

New industry group set up to tackle noise and vibration risk in the workplace

The Health and Safety Executive has formed a partnership group with industry bodies, specifically in the energy, extraction, manufacturing and construction sectors, to increase awareness of the risks associated with noise and vibration in the workplace and promote effective management and control.

The main aims are

- to reduce the incidence of noise induced hearing loss and hand-arm vibration syndrome in workers by further raising

awareness, using pictorial images i.e. posters and a calendar, of the risks of exposure to noise and vibration in the workplace

- to improve workers' knowledge concerning exposure to noise and vibration in the workplace
- to share, promote and encourage good control practices in the workplace
- ultimately to bring about a change in attitudes and behaviours to workplace noise and vibration. ■

No link between wind turbine noise and health problems, new study finds

There is no evidence to support a link between exposure to wind turbine noise and health problems, a study by the Canadian government has found.

However, the study did demonstrate a relationship between increasing levels of wind turbine noise and annoyance towards several features associated with wind turbines, including noise, vibration, shadow flicker and aircraft warning lights atop them.

Health Canada, which carried out the study in collaboration with Statistics Canada, said it was important to note the findings did not provide definitive answers on their own and must be considered in the context of a broader evidence base.

The \$2.1 million study was conducted in south west Ontario and Prince Edward Island and included 1,238 households living within

various distances from 399 separate wind turbines in 18 wind turbine developments.

It found no link between wind turbine noise and ill-effects including:

- symptoms such as dizziness and migraines
- chronic illnesses such as heart disease, high blood pressure and diabetes
- measures of stress levels, such as heart rate, blood pressure and cortisol
- self-reported or measured quality of sleep.

"While some people reported some of the health conditions above, their existence was not found to change in relation to exposure to wind turbine noise," Health Canada said. ■

Ultrasound creates objects that can be seen and felt

New research, using ultrasound, has developed an invisible 3D haptic shape that can be seen and felt.

The research, led by Dr Ben Long and colleagues Professor Sriram Subramanian, Sue Ann Seah and Tom Carter from the University of Bristol's Department of Computer Science, could change the way 3D shapes are used. The new technology could enable surgeons to explore a CT scan by enabling them to feel a disease, such as a tumour, using haptic feedback.

The method uses ultrasound, which is focused onto hands

above the device and that can be felt. By focusing complex patterns of ultrasound, the air disturbances can be seen as floating 3D shapes. Visually, the researchers have demonstrated the ultrasound patterns by directing the device at a thin layer of oil so that the depressions in the surface can be seen as spots when lit by a lamp.

The system generates an invisible 3D shape that can be added to 3D displays to create something that can be seen and felt. The research team has also shown that users can match a picture of a 3D shape to the shape created by the system.

Dr Long said: "Touchable holograms, immersive virtual reality that you can feel and complex touchable controls in free space, are all possible ways of using this system.

"In the future, people could feel holograms of objects that would not otherwise be touchable, such as feeling the differences between materials in a CT scan or understanding the shapes of artefacts in a museum." ■

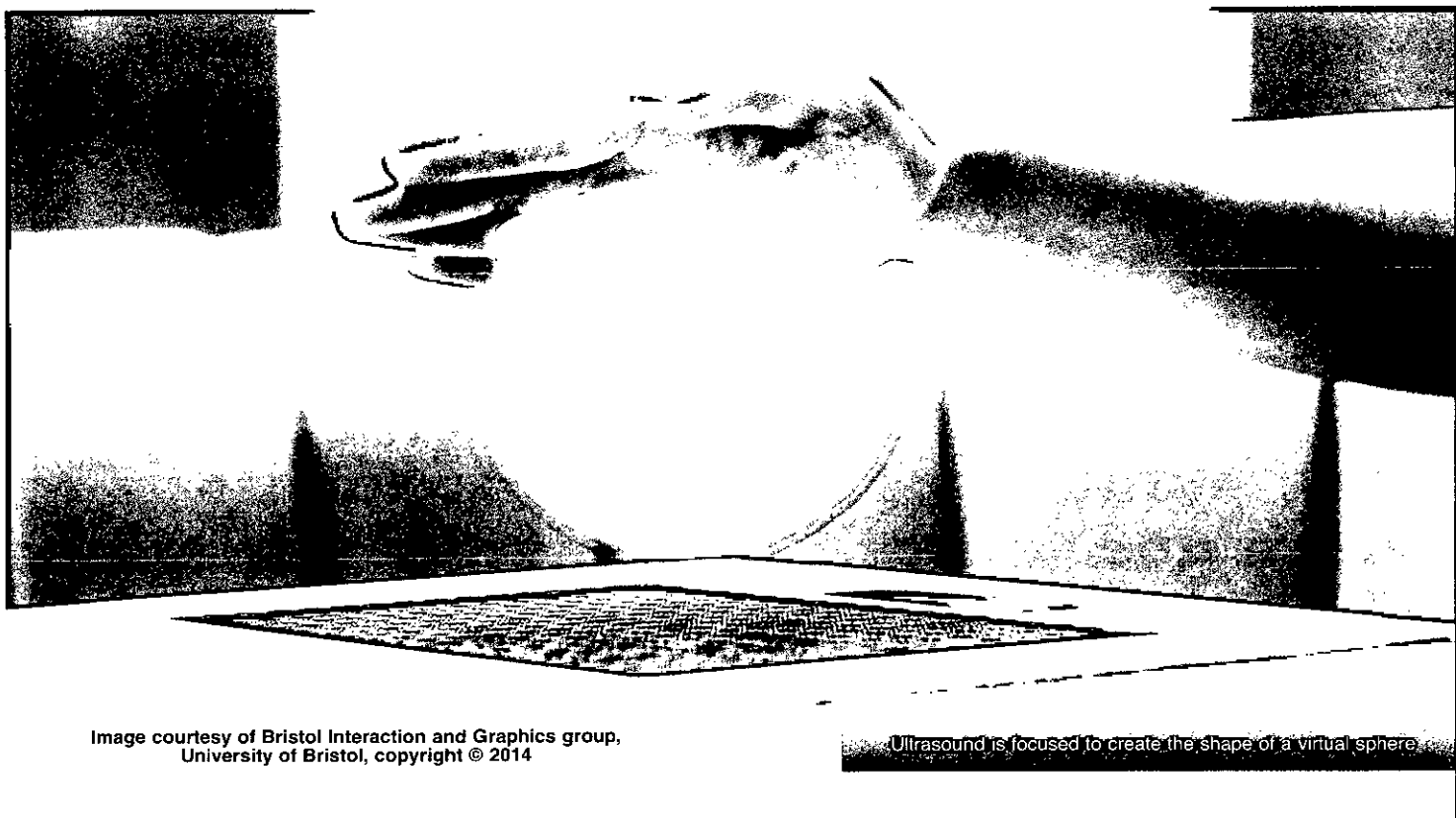


Image courtesy of Bristol Interaction and Graphics group, University of Bristol, copyright © 2014

Ultrasound is focused to create the shape of a virtual sphere.

BS 4142:2014 – revision of the methods for rating and assessing industrial and commercial sound

A revision of British Standard BS 4142 was published at the end of October 2014 and replaces the previous 1997 edition. This article looks at how the current edition came about and then examines the main changes and the implications that arise from them.

BS 4142 first appeared as Appendix XV of the Wilson Report in 1963 although the current standard bears little resemblance to its early origins. The Wilson Report defined noise as “sound which is undesired by the recipient”. For a noise problem to exist, this must involve people and their feelings, and its assessment is a matter rather of human values and environments than of precise physical measurement. Appendix XV was intended as “a quantitative guide to whether an existing industrial noise is likely to cause a complaint from those people, having a normal reaction to noise, who live nearby...”

It then continued to say that it is well known that the actual loudness of a noise is not, by itself, a measure of whether it will give rise to annoyance or complaint. The reaction of the hearer is affected, for example, by the kind of noise, by whether it occurs during the daytime or at night, by the general level of noise already existing, by whether the hearer has become accustomed to it, and so on. Basically the report is describing the concept of “context” which had become lost in the intervening 51 years.

Revision process

In March 1967 Appendix XV became the first separate entity as BS 4142. A second edition was published in November 1990 with the third one in September 1997. In the normal course of events all British Standards are reviewed every five years to decide if a revision will be appropriate. This periodic review is under taken by the BSI Committee EH/1/3 and in May 2012 EH/1/3 decided that a substantial rewrite was required and that the best way forward was a small drafting panel. Work started in August 2012 and in September EH/1/3 decided on the structure of the revision. Stakeholder involvement was essential and a workshop on the revision was held in Birmingham. The purpose was to have the users establish a “road map” for the standard based on experience of using the 1997 edition.

Having established the views of users, work started on the first draft and also considered relevant research from around the world which had accumulated over the previous 15 years. This was in itself a significant task and the first draft was delivered by the drafting panel in November 2012 for EH/1/3 to review and modify to prepare the draft for public consultation. In July 2013 the draft for public consultation was handed over to a BSI Content Developer whose job it was to ensure that it met the requirements of BS0, the standard on how to write standards.

The draft was issued for public consultation in February 2014. The response was quite overwhelming, with 943 public comments. May 2014 saw the start of the process of examining every comment and attempting to resolve them all. The truly excellent involvement of everybody who contributed has ensured that the

standard is “the best it can be”.

The draft standard then had to pass the scrutiny of the EH/1/3 committee and this gave rise to comments that were also considered and the draft modified in response. Then it had to also pass the scrutiny of the parent committee EH/1, a rather intensive review process and it was eventually published at the end of October.

Description of the main changes

The main aim of the standard is to provide an assessment and rating method that is proportionate, sufficiently flexible and suitable for use by practitioners to inform professional judgement. The foreword to the standard clearly states that:

“The execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.”

It does this by providing a method for the determination of:

- rating levels for sources of an industrial and/or commercial nature
- ambient, background and residual sound levels.

An assessment framework is also provided to allow the practitioner to use the rating, ambient, background and residual sound levels determined using the standard for the purposes of:

1. investigating complaints
2. assessing sound from proposed, new, modified or additional source(s) of sound of an industrial and/or commercial nature
3. assessing sound at proposed new dwellings or premises used for residential purposes.

One of the main changes is to the scope and coverage of the standard. The 1997 edition was limited to mixed residential and industrial areas for determining and assessing noise levels from factories, or fixed installations, or sources of an industrial nature. Neither could the method be used when both the background and rating levels were very low. The scope of the standard has now been widened to rating and assessing: *“a) sound from industrial and manufacturing processes b) sound from fixed installations which comprise mechanical and electrical plant and equipment c) sound from the loading and unloading of goods and materials at industrial and/or commercial premises; and d) sound from mobile plant and vehicles that is an intrinsic part of the overall sound emanating from premises or processes, such as that from forklift trucks, or that from train or ship movements on or around an industrial and/or commercial site.”*

It can also be seen from above that the standard explicitly states that it can be used to investigate complaints and has been significantly widened to cover not only new, modified or additional sources of sound, but also the assessment of sound affecting new dwellings or premises to be used for residential purposes.

The standard adds the following limitations and explanations, which are intended to further clarify its application: **P44**



CP43 "The determination of noise amounting to a nuisance is beyond the scope of this British Standard.

Sound of an industrial and/or commercial nature does not include sound from the passage of vehicles on public roads and railway systems.

The standard is not intended to be applied to the rating and assessment of sound from: a) recreational activities, including all forms of motorsport b) music and other entertainment c) shooting grounds d) construction and demolition e) domestic animals f) people g) public address systems for speech h) other sources falling within the scopes of other standards or guidance."

The limitation of the 1997 edition, to exclude very low background and ratings, has been removed.

Like the 1997 edition, the standard provides a method for correcting the specific sound levels so as to account for acoustic features that are present at the assessment location. The approach in the 1997 edition was purely subjective and allowed for a +5 dB correction irrespective of how prominent the feature was or whether there was one feature only or a combination of tones, impulses or other features irregular enough to attract attention. The 2014 edition provides for scaled corrections up to +6 dB for tones and up to +9 dB for impulses, depending upon the prominence of the tones or impulses, as well as +3 dB corrections for:

- other sound characteristics that are neither tonal nor impulsive; and/or
- intermittent features when the sound has identifiable on/off conditions.

The corrections for tones and impulses can be assessed using subjective or reference methods. There is also an objective method for tones, which is based upon the prominence of sound pressure levels in the one-third-octave-band containing a tone in comparison to the sound pressure levels in the adjacent one-third-octave-bands. The objective method however, does not allow for different corrections to be applied for tones differing in prominence as it only allows for a single correction of +6 dB for clearly prominent tones.

The 1997 edition assessed the likelihood of complaints using the difference between the rating level and the background sound level. A difference of around +10 dB or more indicated complaints are likely, a difference of around +5 dB was of marginal significance and a difference of more than 10 dB below the background was considered to provide a positive indication that complaints were unlikely.

The 2014 edition no longer assesses the likelihood of complaints. Instead, it can be used to assess adverse impacts. This change was introduced because the likelihood of complaints is not a particularly appropriate benchmark, especially when it is used in a planning context, and it also aligns the standard more closely with the type of language and benchmarks that are suitable for the assessment of sound at the planning stage for new proposed development. It continues to use the difference between the rating level and the background sound level, although it also introduces the requirement to consider the context and states that:

- "a) Typically, the greater this difference, the greater the magnitude of the impact.*
- b) A difference of around +10 dB or more is likely to be an indication of a significant adverse impact, depending on the context*
- c) A difference of around +5 dB is likely to be an indication of an adverse impact, depending on the context*
- d) The lower the rating level is relative to the measured background sound level, the less likely it is that the specific sound source will have an adverse impact or a significant adverse impact. Where the rating level does not exceed the background sound level, this is an indication of the specific sound source having a low impact, depending on the context."*

The context includes consideration of pertinent factors, such as:

- the absolute level of sound
- the character and level of the residual sound compared to the

character and level of the specific sound

- the sensitivity of the receptor and whether dwellings or other premises used for residential purposes will already incorporate design measures that secure good internal and/or outdoor acoustic conditions.

It can also be seen that the range of the assessment outcomes has been reduced and that it recommends that rating levels equal to the background would indicate a low impact. This is in contrast to the earlier edition which gave indications of the likelihood of complaints based upon differences ranging between +10 and -10 dB.

Field calibration check

As well as clarifying the terminology as a "field calibration check" (not a "calibration", which is a laboratory procedure), BS 4142:2014 also clarifies the acceptable drift as ± 0.5 dB for attended measurements. If the drift exceeds this level then the results should be treated with caution. The drift can exceed ± 0.5 dB for long period monitoring that has been deployed for several days or more, but if the drift exceeds ± 1 dB the measurement chain should be thoroughly investigated.

In practice, modern sound level meters are very stable, and any drift in the field calibration check is likely to be due to environmental changes between successive checks (such as changes in the ambient air pressure, temperature or humidity).

Measurement locations

BS 4142:2014 formalises the use of a 3 dB facade correction factor, and also allows for a 1 to 2 dB facade correction factor for facades that are greater than 1 m away or are not perpendicular to the sound pathway. In practice, if the ambient and residual measurements are taken under the same conditions, the presence of a facade should make no relevant difference to the outcome.

Weather conditions

There is a new focus on recording the weather conditions, including the wind speed and temperature at the measurement location, as well as the cloud cover and precipitation.

Although weather forecasts and public access weather stations can be useful for planning suitable monitoring periods or general weather trends, these cannot replace measurements made at the monitoring location, particularly the wind speed and direction, which are specific to that location.

Background sound level

In the various preceding editions of BS 4142 background noise (sound) level, whilst defined by the L_{A90} index as equating to an underlying level of sound, has never been assigned a definitive measurement time interval for the purpose of reporting $L_{A90,T}$. In the absence of T there has for many years been a common tendency by some practitioners to incorrectly default to the reference time intervals for the specific sound level, which in the 1990 and 1997 editions of the standard were stipulated as one hour for daytime and five minutes for night-time, albeit worked examples were provided utilising periods of 15, 20, 30 and 60 minutes.

The measurement time interval has to be sufficient for the period of interest and should comprise continuous measurements of not normally less than 15 minute intervals that are either continuous or disaggregated, possibly conducted on more than one occasion. By design this is intended to secure greater confidence in producing representative values of the background sound level, though by not stating 15 minutes as a definitive measurement time interval, shorter measurement time periods are not precluded. It is, however, incumbent upon the user of the standard to evaluate the range of background sound levels that prevail, from which a representative level is derived as a whole number, whilst not assuming this to be either the minimum or modal value.

In some applications longer term surveys will produce significant amounts of background sound level data that lends itself to statistical analysis. The level distribution of L_{A90} may offer a

■ means to establishing for a given assessment period what is representative, either as a single value or as a range of values.

Fundamentally, it is important to recognise that there is no single L_{A90} value that can be held as wholly representative of the background sound level either for daytime or night-time. The reality is that it is a highly variable concept that might in part be an indication of relative quietness, governed generally by continuous or semi-continuous sounds, and needing to be examined in a representative manner for any period(s) under consideration. To illustrate this, it can transpire that the middle of the night is distinctly different (and potentially of lesser importance) compared to the start or end of the night for sleep purposes, prompting assessments that relate to a particular context.

In revising the standard efforts have been expressly made to instil an understanding in the user of how to recognise and cater for the need to determine what is typical. In doing so, the user is pointed to key factors that include diurnal patterns and a differentiation between weekdays and weekends which can have a major influence, as can meteorological conditions. It is not therefore simply a matter of measuring the lowest value which can be highly unrepresentative of a broader or other discrete time frame, and is tantamount to misapplication of the rating and assessment method.

The numerous abuses of background sound levels have also included averaging sequential period measurement values, either for a partial period of the daytime or night-time, or for the whole of such periods, yielding a mean average which is then purported to be the background sound level. Whilst in some instances this can indeed be close to or equivalent to a continuous overall period measurement, especially where the ambient sound profile is relatively continuous and does not vary to any great extent, it is nonetheless technically (and statistically) incorrect, as discrete measurement periods should be concatenated if the intent is to determine the L_{A90} value of the total measurement period.

- Application of background sound level as a parameter in rating and assessing industrial and commercial sound is now unrestrained by lower limiting values, other than a requirement to ensure that self-generated and electrical noise within the measurement system does not unduly influence reported values and it is apt to ensure measurements exceed the instrument noise floor by at least 10 dB, extending the scope and use of the standard.

It has been necessary to highlight that industrial and commercial sound sources can form a legitimate component of the background sound level, notably where a new noise-sensitive receptor is introduced or there is a new, modified or additional specific sound source to be considered. This has arisen in part from misuse of the preceding editions of the standard, for example whereby modified or additional specific sound sources have been incorrectly assessed and rated against background sound levels attained when all extant sound sources have been absent, amounting to a misrepresentation of likely noise impact.

Uncertainty

Historically many BS 4142 assessments have incorrectly provided a single numerical result to a precision (not accuracy) of 0.1 dB and then concluded that the assessment provided a definite outcome based solely on this precise value.

The most commonly considered uncertainty is that associated with the instrumentation system, although this is the best controlled and smallest contributor to the overall uncertainty in an assessment. Uncertainty in the levels being measured, the rating level derived from these, and the associated difference between background and rating levels has usually been overlooked, despite this being a large enough value to significantly affect the outcome of many assessments. Additional uncertainty is also introduced with any modelling or calculation of sound propagation e.g. from a measurement location to a receptor, particularly considering how the effects of intervening structures are quantified.

The new edition of the standard makes it explicit that the purpose of any assessment is to consider the likely significance of the impact of the industrial or commercial sound at **P46**



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4P45 noise-sensitive receptors and that this depends upon the context in which the sound is experienced. It should be clear that this must also involve an understanding of uncertainty, both in terms of the significance of the sound, including what is considered to be a suitable rating penalty where appropriate, and the effect that the context may have on the perceived significance of the sound.

As the standard makes clear, it is the responsibility of the practitioner to both minimise uncertainty to an appropriate level, which will depend upon the scale of the proposed development amongst other factors, and to consider the effect that the uncertainty may have on the outcome of the assessment.

This will include the uncertainty in the measured and calculated levels, together with factors that may affect this such as weather conditions. The context, however, is potentially more variable and it is a matter for the practitioner to consider how this may modify the significance of the impact of the specific sound for people who may be affected.

Implications of the main changes to the standard

Overall, the changes to the standard should secure an improvement in the assessment of sound from industrial and commercial sources.

It is envisaged that the increase in the scope will significantly increase its application and utility. For example, the new standard can now be applied to:

- a wider range of commercial sources
- new dwellings or premises used for residential purposes
- situations where the background and rating levels are low.

In addition, the improved definition of the sources that are covered by the standard and the list of exclusions will clarify the sources of sound and the situations where the standard can be applied. The additional clarification to the scope should also overcome some of the apparent ambiguity that existed with the previous edition. This will help to achieve greater consistency of approach and help to prevent the misuse of the standard so that it is not applied to sources of sound or to situations where it is not appropriate to do so. That said, there can be no embargo on applying some of the principles of the standard to other sources of sound which are not covered by other guidance. Nonetheless, if the standard is used beyond its intended scope then it is for the practitioner to properly justify their approach and the conclusions of their assessment.

The standard states that it uses outdoor levels to assess the likely effects of sound on people who might be inside or outside a dwelling upon which the sound is incident. The type of dwelling may include proposed new dwellings or premises used for residential purposes, albeit when it is applied to such situations the context is important. In particular, the standard requires consideration of:

"The sensitivity of the receptor and whether dwellings or other premises used for residential purposes will already incorporate design measures that secure good internal and/or outdoor acoustic conditions, such as: i) facade insulation treatment ii) ventilation and/or cooling that will reduce the need to have windows open so as to provide rapid or purge ventilation iii) acoustic screening."

The sensitivity of the receptor will depend upon its use. For example, a family home or retirement home may be considered to be more sensitive than a hostel used for short-term accommodation. The intent of the guidance on incorporated design measures is that BS 4142:2014 can be used to assess the impact of noise inside and outside new dwellings or rooms for residential purposes if the façade is of traditional construction i.e. with windows that can be opened and reliance on purge ventilation. Alternatively, if the façade is sealed or the building is treated such that it might be reasonable to keep windows closed, then it will only be appropriate to use the method to assess the impact on external areas where commercial or industrial sound is incident and which are proposed to be used for amenity. It follows that the assessment of the impact on external amenity areas should be

carried out during times of the day when the amenity areas are likely to be used. If the circumstances do not lend themselves to the assessment method, such as may be the case for an insulated and sealed building, the standard defers to other guidance and criteria in addition or alternative to BS 4142 that can inform the appropriateness of both introducing a new noise-sensitive receptor and the extent of required noise mitigation e.g. BS 8233.

A number of changes to the standard have been made to improve the quality of any measurements and calculations performed and the resulting reliability of any measured and calculated sound levels which are used to assess sources of sound of an industrial and/or commercial nature. Similarly, the changes to the rating and assessment method should achieve an improvement in the quality of the assessment of sound of an industrial and/or commercial nature.

Adding corrections for both tones and impulses when present and accounting for the differences in the prominence for tones and impulses should ensure that the rating level obtained using the 2014 standard more closely reflects human response to sound containing such features. In addition, the provisions for other characteristics and intermittency should also capture other characteristics that can attract attention and affect human response to the sound that are neither tones nor impulses.

The introduction of the objective and reference methods for assessing the prominence of tones and impulses should ensure greater consistency in the application of the corrections. That said, it is not envisaged that the objective and reference methods will be the normal method of assessment. On the contrary, the standard specifically states that the objective and reference methods should only be used where the subjective methods are not sufficient or are in dispute. This reflects the committee's attempt to make the standard proportionate, flexible and participative. Consequently, the objective and reference methods can be used as a method of last resort if the corrections for the presence of tones and impulses cannot be agreed.

One issue that the committee had to tackle was that of cumulative or additive effects of characteristics where more than one characteristic is present in the sound. It was considered that it was not appropriate to specify precisely how such situations should be assessed and that this was a matter best left to the practitioner to use professional judgement based upon the dominance or influence of each characteristic. In theory, the standard allows for a total correction for the presence of both tones and impulses of up to +15 dB and possibly even +18 dB if intermittency significantly affects perception of the sound. Circumstances where corrections of around 15 dB will apply, for the combined impact of tones and impulses, should however be exceptional. This is because it is likely that any impulsive features will be dominant if the prominence of the impulses is so great as to attract a 9 dB correction. In reality, corrections of more than 10 dB should be atypical. The committee would like to monitor this aspect of the standard and would welcome any feedback on the total corrections that are being applied to sound that contains more than one characteristic.

The new standard should foster better quality of assessments as it now requires the context of the acoustic environment, and all relevant factors influencing the context in which the sound of industrial and commercial sound will be heard, to be considered. The concept of context is not new. Users of the 1997 edition will recall that the foreword stated that:

"The likelihood of complaint in response to a noise depends on factors including the margin by which it exceeds the background noise level, its absolute level, time of day, change in the noise environment etc., as well as local attitudes to the premises and the nature of the neighbourhood. This standard is only concerned with the rating of a noise of an industrial nature, based upon the margin by which it exceeds background noise level with an appropriate allowance for acoustic features present in the noise."

The inference from the above statement is that other relevant factors should be taken into account as part of a wider assessment. So, the key change is not that the new standard has introduced context as a new concept, but rather that it now explicitly

requires the context to be considered as part of the assessment. This should ensure that the assessment is sufficiently comprehensive and that all the relevant factors affecting the impact of the noise on residents will be assessed.

Inevitably, the framework approach will not be to everybody's liking, and some may prefer a more prescriptive approach. The committee felt strongly that the assessment method should not be used to specify definitive assessment outcomes but rather to inform professional judgement through the provision of a framework within which professional judgement can be applied. The provision of a prescriptive method was considered to be simply inappropriate given the range of sources and the situations to which the standard applies. That is why the standard places a clear emphasis on the competencies and expertise of its users.

The new standard no longer indicates that commercial and industrial sound may have an impact when the difference between the rating level and the background sound is negative. The previous advice that complaints were unlikely when the rating level was more than 10 dB below the background has been removed. It was felt that the changes to the rating methods and provisions for correcting for acoustic characteristics would ensure that the method would better reflect the way in which people would perceive and respond to sound such that the consideration of rating levels when they are below the background sound level would no longer be necessary. Consideration of rating levels only when they are equal to or above the background sound level has the additional benefit of reducing the significant uncertainty present when trying to establish specific sound levels that are lower than the background sound level (though this may still be necessary in situations when large character penalties are applied).

Examples

The importance of giving consideration to the context in relation to the outcome of the assessment is demonstrated in the following case studies.

Example 1

This example is of a large waste installation within an industrial estate. There are houses 200 m away, and a road close to the receptor. The installation creates loud cascading crashes as waste material is stockpiled in large heaps. The site noise is difficult to isolate between the car passes. Figure 1, below, shows the 125 ms sound pressure level in red (above), and the five minute L_{A90} in blue (below). The numerous vertical grey lines are pauses for vehicles.

With the vehicle noise removed, the influence of the site is clear, as shown in Figure 2.

The impulsivity of the crashes was assessed using the reference method, which resulted in an impulsivity correction of +6 dB. The overall assessment, assuming it is carried out by removing all vehicle passes when measuring the background sound level, is presented in Table 1.

The site was operating with all practical noise controls **P48 ▶**

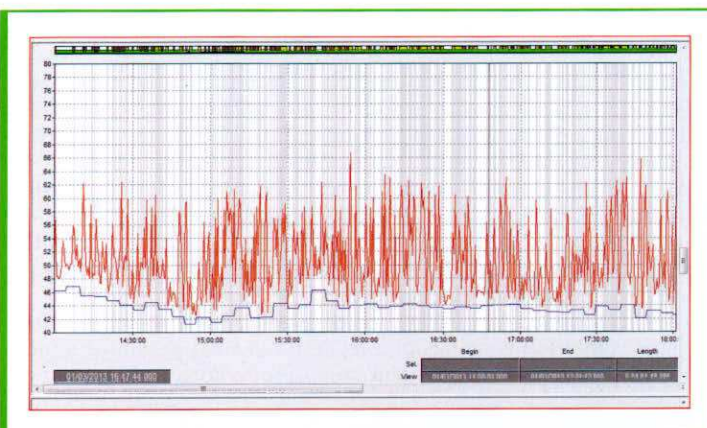


Figure 1: 125 ms sound pressure level and 5 minute L_{A90}

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P47 in place, and although the assessment showed a rating level +16 dB greater than background, this was only measurable by removing the many car passes. The car passes presented similar time profiles and frequency characteristics to the site noise. By removing the car passes the acoustic environment had been fundamentally altered. Furthermore, the context of the (noise) pollution was a large industrial area.

With this in mind, the overall context of the noise pollution from the site diminished the impact such that there was no significant adverse impact or adverse impact, and the operator was considered to be using appropriate noise controls for the site in this location.

Example 2

This example is of a scrap yard immediately adjacent to housing. The yard is creating constant bangs and crashes as well as tonal noise from an angle grinder. A 3.5 hour measurement was taken, which included two hours of site noise, a 30 minute pause as the staff left site, and a one hour residual measurement. The 125 ms sound pressure level and five minute L_{A90} are presented in Figure 3.

The reference method is used to assess the impulses within the first half hour of monitoring, finding impulses of up to +26.5 dB in 0.125 seconds (212 dB/sec). This results in a calculated prominence P of 9.8 and an impulse correction K_i of 8.7 dB. The tonality is assessed using the one-third-octave-band method, which finds that the use of an angle grinder is prominently tonal; as it is not always in use, a penalty of +4 dB is considered appropriate. The assessment is presented in Table 2.

The formal assessment supports the subjective assessment that the noise pollution is unacceptable, and that site operations should cease until suitable noise control measures can be put in place.

Summary

Over the years BS4142 has proven to be a very valuable assessment tool, though when the committee was deliberating the revision to the standard it was apparent that it was often misap-

plied and that a number of practitioners were failing to achieve reasonable standards of assessment and reporting.

It is hoped that the changes to the standard will ensure:

- greater utility of the standard
- a clear understanding of its scope and application
- good quality measurements and calculations that are fit for purpose
- an overall improvement in the quality of assessment of commercial and industrial sound and the impact of that sound on residential receptors.

The changes to the standard should ensure that the assessment better reflects perception and response to commercial and industrial sound and, in so doing, supports practitioners, regulators and others involved in decision making so that people are properly protected from the adverse effects of noise but without imposing unreasonable financial burdens.

The EH/1/3 Committee would welcome feedback on the use of the standard that will help it to review whether the standard is achieving its aims. All feedback should be sent to Phil Dunbavin (philip.dunbavin@gmx.com), who is the chair of EH/1/3.

Finally, the committee would like to thank everybody who responded to the public consultation exercise. The range, depth and quality of the responses were fundamental to the revision process and shaping the new standard.

Contributors

This article was written by the following members of the drafting panel and the EH1/3 Committee: Phil Dunbavin, Chairman, Association of Noise Consultants; Tony Clayton, Environment Agency; Colin Cobbing, Chartered Institute of Environmental Health; Ken Collins, Institute of Acoustics; John Grant, Midlands Joint Advisory Council for Environmental Protection; James McIntyre, Scottish Environmental Protection Agency; Martin McVay, Welsh Government; Patrick Shortt, Association of Noise Consultants; and Jon Tofts, Environment Agency. ■



Figure 2: 5 minute L_{Aeq} and L_{A90} with extraneous noise removed

	dB
Ambient sound level (L_{Aeq} 7.5 hours)	54
Residual sound level (L_{Aeq} 2.5 hours)	46
Specific sound level	53
Acoustic correction feature (impulses)	+6
Rating level	59
Background sound level (L_{A90} 2.5 hours)	43
Rating over background	+16

Table 1

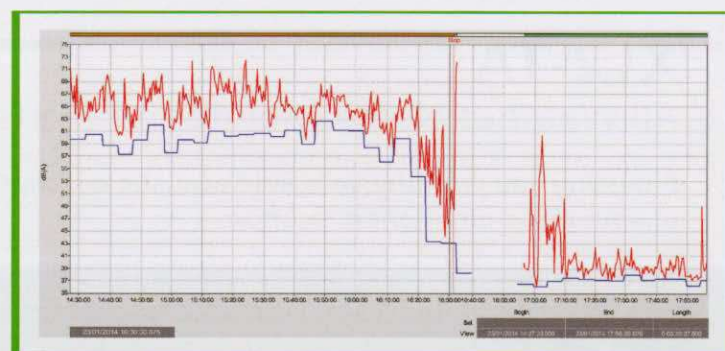


Figure 3: 125 ms sound pressure level and 5 minute L_{A90}

	dB
Ambient sound level (L_{Aeq} 2 hours)	66
Residual sound level (L_{Aeq} 1 hour)	45
Specific sound level	66
Acoustic correction feature (impulses)	+9
Acoustic correction feature (tones)	+4
Rating level	79
Background sound level (L_{A90} 1 hour)	37
Rating over background	+42

Table 2

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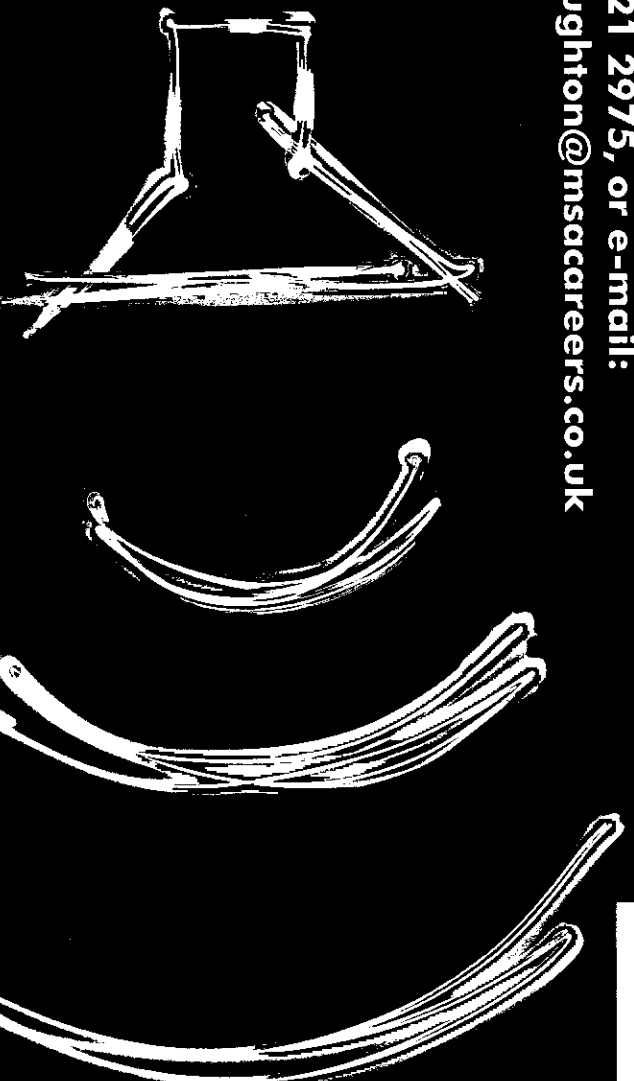
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An elephant named uncertainty

By Richard Collman

This article continues a theme started at the BS4142:2014[1] launch conference last November and expands on the article on the proceeding pages. Although it has been written in conjunction with the launch of BS4142:2014, the principles are relevant to and should be applied to a wide range of other acoustic work. This article, however, has been written individually and expresses the views of the author rather than being collectively written and agreed by the BS4142: 2014 drafting panel, as is the case with the BS4142:2014 article.

Uncertainty is acoustics' "elephant in the room" and is curled up quietly in a corner, having been largely undisturbed for years.

- Uncertainty is definitely grey; it's not black and white.
- A worrying number of people appear totally unaware of it; many people know it's there but ignore it, and a few do actually acknowledge it.
- Its characteristics depend upon which direction you approach it – it may seem fairly small and detailed, or very large and difficult to grasp.
- It usually sits quietly tucked up out of the way so people have no idea how big or small it really is.
- Occasionally uncertainty jumps up, makes a big mess of things and surprises people.
- When it does it can be very big and scary, so most people run away, rather than befriending it.

Back in the dark ages of analogue instrumentation and calibration adjustment by screwdriver that drifted over a short car journey, uncertainty was with you all the time. It was obvious from the needle flicking to and fro that the sound level varied continuously and that, except in laboratory conditions, acoustic measurements were far from precise. Using high quality instrumentation and good measurement techniques helped to minimise the uncertainty. Then digital instrumentation arrived, showing measured (average) levels to a precision of 0.1 dB and the elephant was banished from the room. Or so some people thought – although it really just hid in a corner.

In the intervening years a few people have introduced the elephant to others, most notably Nick Craven & Geoff Kerry's "Good practice guide" [2] (which can be freely downloaded at: <http://usir.salford.ac.uk/20640/>) and more recently Colin Cobbing and Bob Peters' IOA roadshow talk on Uncertainty. However, when people have realised that uncertainty can trample all over their precise measurements, a common reaction has been to run away and hope the elephant remains asleep. This raises two different issues:

- It is our professional duty to provide reliable information and clearly explain its meaning, often in layman's terms, often to help decision makers arrive at the correct outcome and others to understand the process. A failure to consider uncertainty and provide advice about its significance or otherwise, means that the advice is not reliable.
- There appears to be considerable confusion regarding the difference between precision and uncertainty.

The latest edition of BS4142 tackles uncertainty head on, with an explicit requirement to consider it at all stages of the measurement, assessment and reporting process, and to provide advice regarding its potential significance on the outcome of the assessment. Although perhaps frightening for some, this should not be controversial as it simply reflects good practice.

Measurement uncertainty

Traditionally most consideration of uncertainty has focussed on the measurement chain, particularly instrumentation, and to a

lesser extent measurement conditions. A cynical view is that this may be because it is relatively easy to do; specific numbers are available for some of this; the values are not very large so do not usually materially affect measured levels; and there are already specific requirements to do so in some cases e.g. periodic calibration and field checks.

However, there are many other factors which tend to be of far greater significance. These include:

- Complexity of and relationship between specific and residual sounds
- Locations of measurements, sources of sound (both specific and residual) and noise receptors
- Duration, time and number of measurements, together with prevailing conditions such as weather, operation of specific and residual sound sources
- Measurement techniques used, competence of the people involved, data recording methods (clarity, numerical rounding, recorded observations), parameters...

Even when considering measurement uncertainty in isolation, there are several steps that are necessary to properly address uncertainty. These include:

- Minimise instrumentation uncertainty
- Minimise uncertainty and error in measured levels
- Obtain representative measurements
- Understand likely causes, magnitude and significance of measurement uncertainty.

Instrumentation uncertainty can be minimised by careful selection and correct use, including steps to minimise interference. Other factors that can significantly affect measurement uncertainty include:

- Standing waves/ interference that result in significant spatial variation in level, which are likely to be frequency dependent
- Point, line or area sources that affect how the sound level changes with distance depending upon near and far field conditions
- Sound source characteristics such as its configuration, operating condition, height and location (particularly for mobile sources)
- Weather conditions which can interfere with measurements and affect the levels being measured (these are two different effects) The residual sound level is also likely to be affected by a combination of weather conditions at the measurement location and elsewhere which can affect propagation from more distant sources
- Transmission path between all sources and measurement locations including ground effects, barriers and foliage (which may provide some attenuation but can also scatter high frequency sound, for example)
- Receiver/ measurement location characteristics that can affect measured levels or how representative these are
- Survey duration, time, quantity, methods of data recording and storage.

There is also usually significant spatial and/ or temporal variability. It is essential that measurement locations and times are correctly selected to properly control and understand this variability. One technique that can provide a far better understanding is to record the sound level frequently rather than simply recording longer term average values. For example, if measuring for a relatively short period, recording the level eight or 10 times per second can enable specific short duration acoustic events to be identified and accurately quantified; whereas longer periods, such as one second or even one minute, may be appropriate for longer duration measurement periods, whilst accepting that this will inevitably reduce the precision of the information that can be derived from the measurements obtained. Where measurement conditions are very stable and the sound level is very steady, a reliable indication of the ambient sound level can be obtained very quickly. Where the sound level is more variable it will inevitably take longer to gain an understanding of the ambient sound level characteristics. However, in both cases it is important to realise that this is only a reflection of the sound level under those specific conditions and that this may vary significantly not only at different times of the day or night, but possibly to a far greater extent under different weather conditions. ■

■ When preparing for and taking measurements it is important to consider the effects of and appropriately minimise uncertainty, not only in the measurements themselves but also in subsequent use of the measured levels. The steps taken to do this should be appropriate for the scale of the assessment. This means that it will usually be necessary to obtain many more measurements for a major infrastructure development than an individual complaint about steady plant noise. However, there is likely to be greater uncertainty where fewer measurements are obtained and this should be considered as part of the assessment.

Calculation uncertainty

Having taken appropriate steps to control measurement uncertainty, the next step is to consider calculation uncertainty. This can be affected by several factors including:

- Uncertainty in measured levels
- Variability of sound sources (both residual and specific)
- Calculation method and modelling
- Calculation error.

Where a level or result is calculated from measured levels the measurement uncertainty is magnified during the calculation process e.g. the calculated difference between measured background and specific sound levels is affected by the uncertainty in both sets of measurements. A specific sound level is not measured, but is itself calculated from the difference in ambient levels with the sound source off and operating, which can introduce further uncertainty. Where there is a large difference between these levels the uncertainty in the specific level may be virtually the same as the measurement uncertainty in the ambient level with the source operating.

However, where the two levels are similar the uncertainty is greater. For example, if the two levels differ by 4 dB but there is uncertainty of ± 2 dB in each level, the actual difference in levels may be between 8 dB and around 0 dB. A difference of 8 dB would mean that the specific level is close to the ambient sound level with the source operating, but a difference of around 0 dB would indicate that the specific level is much lower than the ambient sound level with the source operating. This means that there may be very significant uncertainty in the calculated specific level. To clarify this, the uncertainty in a level that is calculated from the logarithmic difference of two other uncertain values depends not only on the uncertainty in each of the values but also on the difference between the two values.

This problem is then exacerbated by variability in the residual and specific sound levels, both of which usually change fairly rapidly with time, often by a significant amount. On occasions this has resulted in an ambient level that is lower when the source is operating than when it is not which, whilst frustrating, does at least force some consideration of uncertainty.

The calculation method and associated modelling will inevitably introduce further uncertainty. This can be reduced (but not overcome) by using validated methods such as ISO 9613-2 or ISO 3744. For example, how should a building with a slightly pitched roof be modelled to represent an acoustic barrier? Or what is the likely effect of a slight breeze from noise source to receiver? In many cases it may be appropriate to take additional measurements in order to better understand the results of modelling. This is often termed "validating the model" which may incorrectly imply a false level of accuracy in the model rather than treating this as part of the consideration of uncertainty in the analysis.

In some cases it may be felt to be appropriate to use an alternative non-standard calculation method, in which case the method should be fully described and the reasons for its use should be properly explained.

The use of standard systems can reduce the likelihood of calculation error e.g. by including checks on input values, but does not guarantee their absence. All calculations should be appropriately checked to identify and remove any errors that may be hiding next to the uncertainty elephant.

Assessment uncertainty

The effect of uncertainty is that the outcome of measurements and calculations is likely to be a range rather than a specific value. It is unlikely to have a "normal" distribution due to factors such as wind direction that will skew the uncertainty in a particular direction.

An assessment should indicate the result of the analysis and consider how this may be affected by the likely range of values resulting from the uncertainty in the complete analysis.

Part of this uncertainty will often include the context of the assessment and in many situations how people will respond to the sound (or vibration as these principles apply equally in both cases). The outcome of the assessment should therefore be a conclusion covering the likely significance of the range of numerical results, including the context of the assessment which, if applicable, a decision maker can use to reach an informed decision. Similarly, in many cases it may be appropriate for the assessment to enable a layman to understand the assessment, its (range of) outcome(s) and how this has been arrived at.

Precision and accuracy

Precision often implies and is incorrectly believed to impart a high degree of accuracy. This has been exacerbated by the precision and apparent accuracy of digital acoustic systems. Analysers usually provide acoustic measurements to a precision of 0.1 dB but usually with an uncertainty of several dB. Acoustic modelling systems such as those used to create sound contour plots provide results usually with contours demarking different levels to 1 dB precision, but again with uncertainty of at least several dB. Rather than distinct bands of different colours it may be more appropriate for the boundary between different zones to itself be a band comprising a combination of the colours of the adjacent zones?

Dealing with uncertainty

The first aim should be to identify and appropriately minimise the causes of uncertainty throughout the measurement, calculation and assessment process. This should enable the significance of the inevitable residual uncertainty to be properly understood and considered as part of the assessment conclusion.

Embrace your elephant!

Richard A Collman is managing director of Acoustical Control Engineers Limited and a director of Belair Research Limited. ■

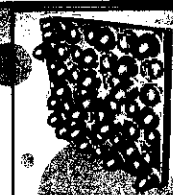
References:

1. BS4142:2014 Methods for rating and assessing industrial and commercial sound. British Standards Institute.
2. Craven, N.J. and Kerry, G 2007, A good practice guide on the sources and magnitude of uncertainty arising in the practical measurement of environmental noise, University of Salford.

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Aecom completes URS acquisition for £2.3 billion

Aecom has completed its £2.3 billion acquisition of US engineering rival URS after the deal received "broad support" from stakeholders of both companies.

Both firms have a significant UK presence after Aecom acquired UK-based consultant Davis Langdon and URS acquired UK-based Scott Wilson, both in 2010.

In the UK the Aecom-URS deal will result in a firm with more than 11,000 staff. Aecom currently has some 4,000 staff and a turnover of £430 million, while URS has around 7,000 staff and £490 million revenue.

The merger has enabled Aecom to leapfrog rival consultant Atkins (9,370 staff) to become the UK's largest consultant by headcount. ■

Starring role for Arup in £80 million revamp of London's National Theatre

Arup provided acoustic consultancy services during the design and construction of the new Dorfman Theatre, which has recently opened as part of the £80 million redevelopment of the National Theatre in London.

As well the theatre, its team was involved in working on the acoustics of the existing foyers, new editing rooms, education spaces and the new workshop areas.

The renovations included opening up the existing theatre and adding a large amount of seating, which had implications for the

acoustics. In order to preserve the same quality of the sound, Arup's designs focused on sound absorption to counteract the new addition of space and make the acoustics reflect their original characteristics.

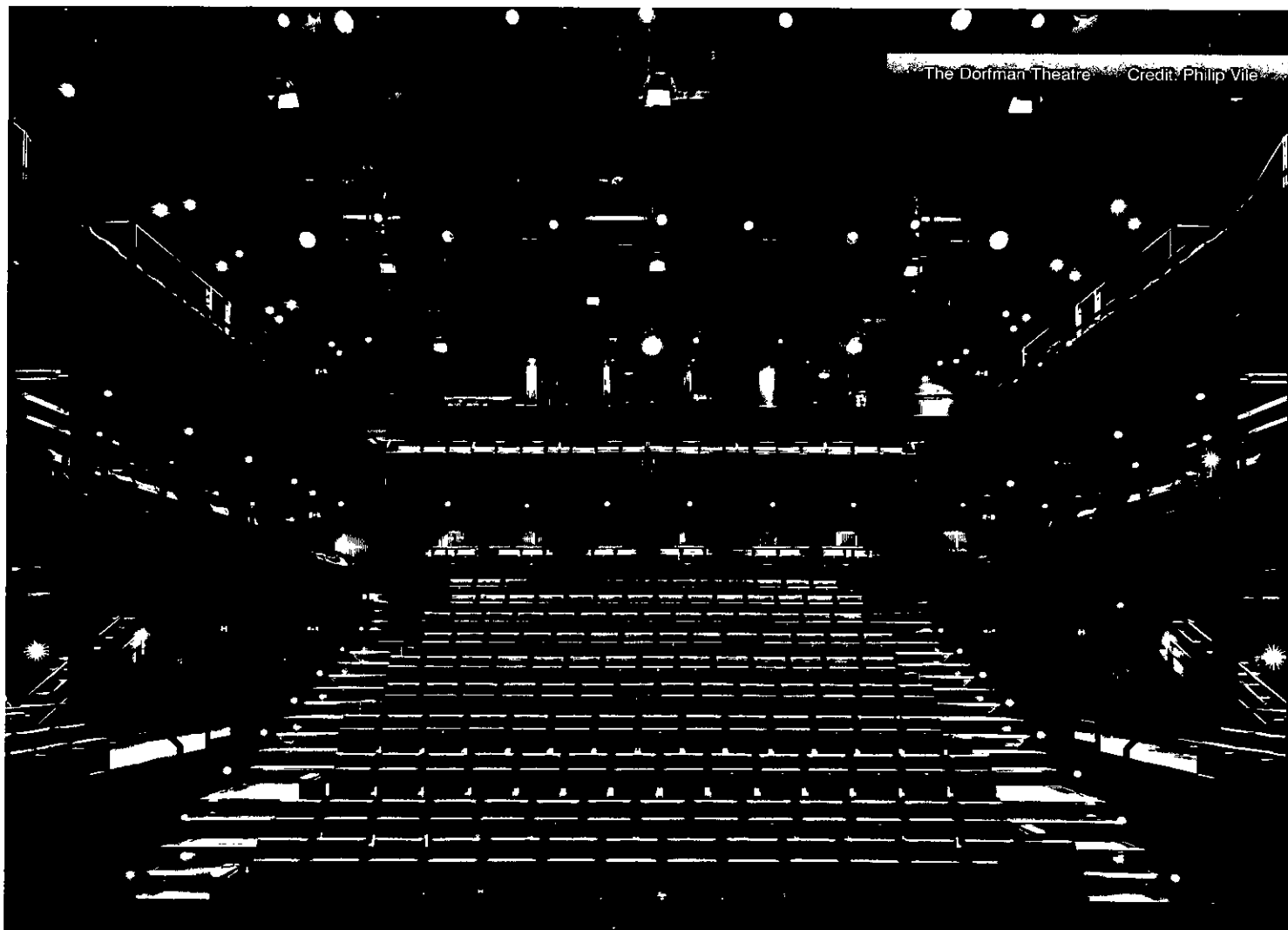
This refurbishment programme was delivered while the building remained in operation and was open to the public, with up to three productions being showcased at the same time.

Helen Butcher, Project Manager, Arup, said: "Working on the acoustics of such an iconic London building as the National brings its

own unique challenges. Listed buildings present a number of practical limitations."

Arup also designed the acoustics for the National's Temporary Theatre, formerly The Shed, which was designed and built in just over one year to provide a third stage during the Dorfman Theatre's closure.

It was initially planned for The Temporary Theatre to be open for 18 months but following its success its life has been extended until spring 2017. ■



The Dorfman Theatre Credit: Philip Vile

New notation aims to cut underwater noise from ships

Bureau Veritas has developed a voluntary notation intend to help shipbuilders and operators cut underwater noise radiating from ships.

The set of standards and measuring services is grouped as NR614 Underwater Radiated Noise (URN). It aims to control and limit the environmental impact on marine fauna of all self-propelled ships and provide a standard and a system to assess compliance with specific vessel requirements for underwater radiated noise.

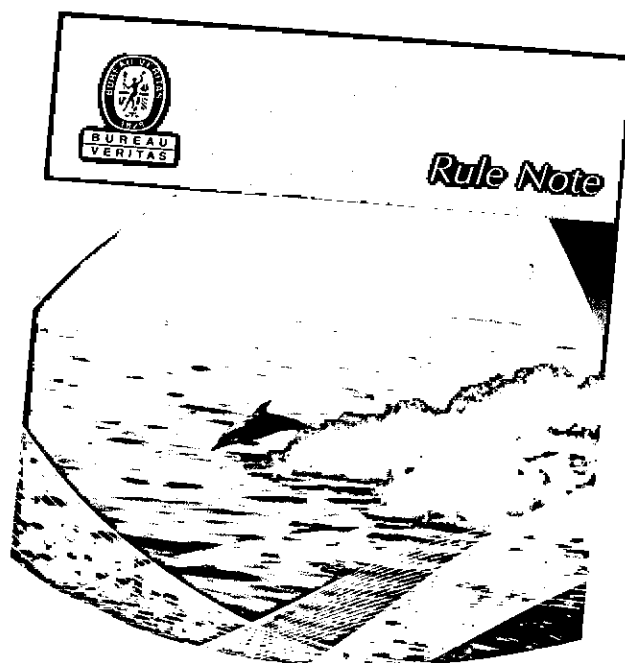
It covers both shallow and deep water conditions, sets out a dedicated comprehensive measurement procedure, explains how to manage measurement uncertainties and sets specific underwater noise level requirements.

Jean-François Segretain, Technical Director, Bureau Veritas Marine & Offshore Division, said: "Underwater noise radiating from ships is acoustic pollution, and there is no doubt that it will be the next big area to be tackled by regulators."

One of the main drivers of the notation is to aid European stakeholders in fulfilling the

requirements of the Marine Strategy Framework Directive. This aims to improve the environmental state of European waters by proposing mitigation solutions to be put in place by 2016, with their efficiency proved by 2020.

The BV notation has been issued in parallel with the European research project AQUO, which is focussed on underwater noise, and includes the work of 13 partners – shipyards, hydrodynamics research institutes and bio-acoustics experts – from eight countries, and an end user committee has been formed to review the project, including BV's notation. ■

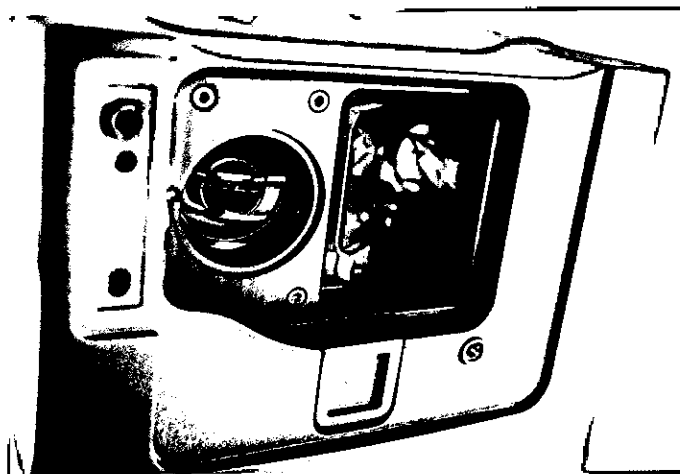


October 2014
NR 614 DT R00 E

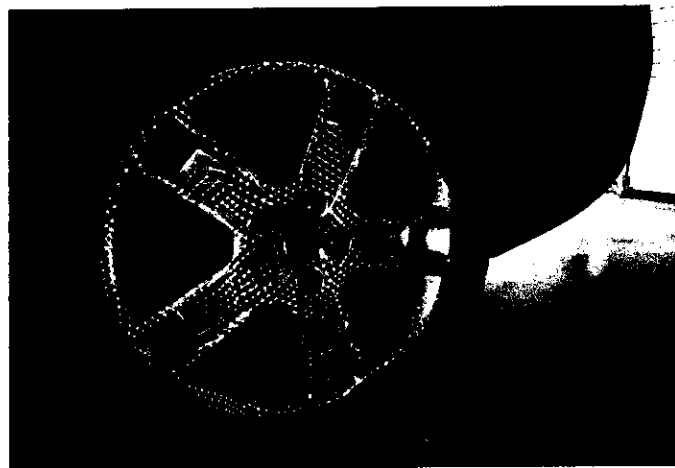
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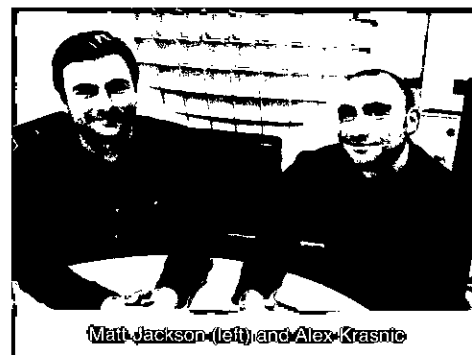
Vanguardia boosts team with two new recruits

Continuing growth at Vanguardia has seen the appointment of Alex Krasnic and Matt Jackson to its acoustics team.

Alex, who comes with 14 years of experience in building and environmental acoustics, was recently awarded the Institute of Acoustics' Award for Promoting Acoustics to the Public (see page 27).

Matt, a graduate from Birmingham City University with a first class degree in sound engineering, will be working on audio visual and acoustics projects.

Vanguardia can now offer clients additional services in transport and street lighting following the appointment of experts in these disciplines. ■



Matt Jackson (left) and Alex Krasnic

'Smart thinking' Will scoops new student acoustics prize

Will Coles, a music studio technology graduate from Southampton Solent University, has won a new award established by KP Acoustics for his work on creating a device for automated acoustic investigation and analysis.

The device was developed in order to create a cost-effective alternative and simplify the existing process of measuring the reverberation time in an enclosed space.

The system entails the use of a microcontroller, an array of ultrasound sensors to measure the dimensions of the test area and a miniature microphone which is used to monitor sound levels.

These measurements are all internally processed and are used in order to determine various characteristics of the test environment such as reverberation time, average absorption coefficient and room modes.

Will was awarded the prize by Lord West, Southampton Solent University's Chancellor, in the graduation ceremony held in November.

The KP Acoustics prize, which aims to promote smart thinking in acoustics, will be awarded annually to BSc, or MSc students at the university for their final projects on the basis of commercial viability and integration of acoustic theory with everyday needs in the acoustics industry. ■



Will Coles receives his award from Lord West

New package from Norsonic to deal with publication of BS 4142: 2014

Norsonic has introduced a package for environmental noise professionals undertaking BS 4142 assessments under the new 2014 version (see page 43).

Revisions in the 2014 version place far bigger penalties on the sound source under investigation for tonal, impulsive and other noise characteristics. The penalties are cumulative and can be added together to give a total penalty of 18dB compared with 5dB in the previous standard.

To assist in applying the penalties Norsonic has introduced a package of options for their meters and PC software, to give the data and answers needed. Tonal assessments are dealt with by measuring 1/3 octave frequency bands, with the source on and off and comparing the difference. BS 4142 also asks for pure tone calculations in accordance with ISO 1996-2; Nor Review software provides this facility to rate the source for tonality, and apply a penalty from 0 to 6dB.

The impulsive assessment requires a fast data logging capability of 25 milliseconds. The Norsonic 140 and new 150 meter provides this facility and also has a new impulse report in the Nor Review software,

which will identify the areas of impulsive activity and run the calculations and grade the impulse, in accordance with BS 4142.

For more details contact hotline@campbell-associates.co.uk or call 01371 871030 ■



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New acoustic troubleshooter makes its UK debut

AcSoft has launched Microflow's 3D Scan and Paint for acoustic trouble shooting and sound source location in the aerospace, automotive and industrial manufacturing industries. The move follows its recent appointment as the Netherlands-based company's exclusive UK distributor.

The system aims to allow easy and accurate visualisation of stationary sound fields in broad frequency range. It is intended for use in environments where anechoic conditions are not applicable, such as within manufacturing facilities, engine bays or car/aircraft interiors.

Using a special particle velocity probe –

the world's first MEMS (Micro-Electrical Mechanical Systems) technology-based sensor – the system enables sound engineers to locate, visualise and analyse sound sources without the need for special acoustic environments such as anechoic chambers. The system uses a single probe to scan an object of interest, which, says AcSoft, means costs are much lower than similar technologies using acoustic camera arrays.

It allows a 3D CAD model to be imported and registered with the 3D camera view. Objects can also be digitised using the probe in the kit which, says AcSoft, is ideal for when CAD data is not available, such as



when benchmarking.

For more information contact Paul Rubens on 01296 682686/ 07815 087905 or prubens@acsoft.co.uk or visit www.acsoft.co.uk □

Icopal Monarfloor ARS aims to prove a sound investment

Monarfloor ARS is a new acoustic resilient product from Monarfloor Acoustic Systems (an Icopal brand). Designed to combat the problem of plasterboard resonance, the membrane is flexible to use and can be applied to any type of plasterboard.

In preliminary tests and site trials, its use has been proven to cause a significant decrease in board resonance, a particular issue in residential build, and improve sound insulation by around 2-3dB.

Before now, solutions developed to reduce the problem of plasterboard resonance have generally involved installing two boards together, which can prove expensive.

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XL2-TA sound level meter wins IEC certification

The XL2-TA sound level meter is the first type approved sound level meter with a certified input keypad for legal noise nuisance assessment.

The Physikalisch-Technische Bundesanstalt (PTB) in Germany confirmed that the XL2-TA in combination with the external input keypad meets the requirements of the standard IEC 61672.

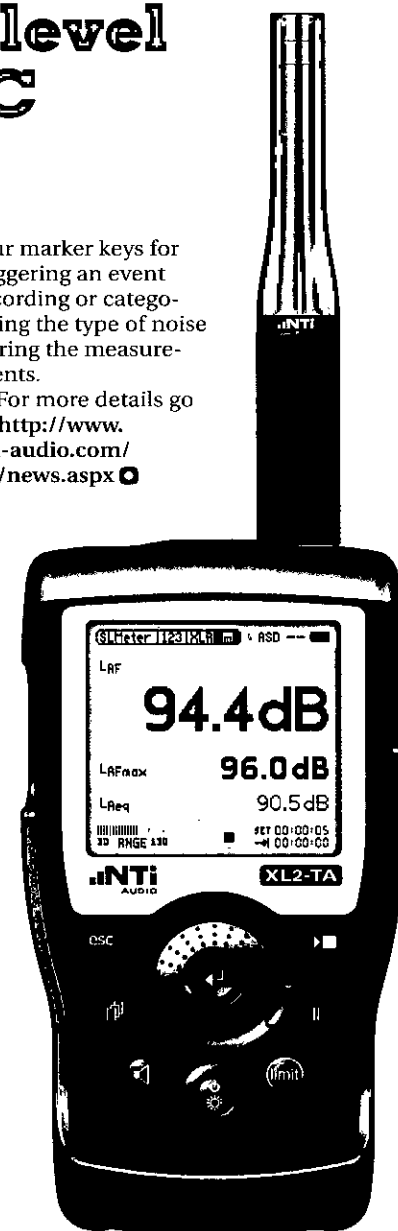
The input keypad forms an extension for the XL2-TA SLM to monitor environmental noise. Any noise event can be marked during the ongoing measurement and audio files recorded simultaneously. The keypad offers

dampener is instead applied to the point of maximum vibration, improving the airborne sound insulation in, says Icopal, a cost-effective way.

For more information visit: www.monarfloor.co.uk □

four marker keys for triggering an event recording or categorizing the type of noise during the measurements.

For more details go to <http://www.nti-audio.com/en/news.aspx> □



The XL2-TA sound level meter



Sound insulator: Monarfloor ARS

New version of Brüel & Kjær's Predictor-LimA software

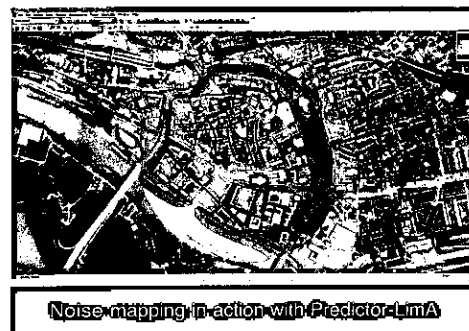
Brüel & Kjær has launched a new version of its Predictor-LimA software, version 10.0.

It utilises 64-bit processing, which, says the company, enables faster model set-up and helps the user to reduce time spent on mapping tasks.

It also provides a faster 3D view for mapping and viewing cross sections of large models. In addition, Web Map Services

(WMS) utilise on-line topographical maps to optimise the level of detail of background maps, in the software.

More information can be found at www.bksv.com. A trial software link is also available to download at <http://www.bksv.com/ServiceCalibration/Support/Downloads/7810Predictor/Firmware%20Installation%20Program> □



Noise mapping in action with Predictor-LimA

Svantek launches Android app for its SLMs

Svantek has launched an Android app, SvanMobile, to enable the remote operation of its SVAN 977B and SVAN 979 sound level meters.

The app enables the user to link measurement files from the sound level meter to media from smartphones such as images, videos and audio notes, as well as location and meteorological data. It is also possible to

use SvanMobile to connect to the sound level meter over the internet if it has a GPRS modem or WiFi.

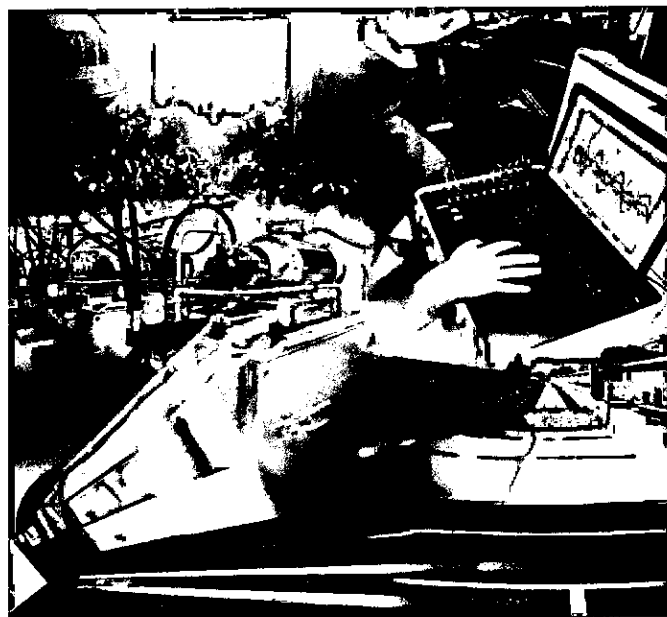
John Shelton, Managing Director at Svantek, said: "This is a significant development for us. For devices running on Android platform, SvanMobile helps extend the functionalities of the SVAN 977B and SVAN 979 sound level meters. Plus anyone who

monitors noise in the environment will appreciate being able to build a project around their sound level measurements by adding weather data and GPS positions."

For more information contact Paul Rubens on 01296 682040/ 07815 087905 or paulrubens@svantek.co.uk or visit www.svantek.co.uk. □

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Committee meetings 2015

DAY	DATE	TIME	MEETING
Thursday	22 January	10.30	Membership
Thursday	5 February	11.00	Publications
Tuesday	10 February	10.30	Medals & Awards
Tuesday	10 February	10.30	Executive
Tuesday	3 March	10.30	Diploma Tutors and Examiners
Tuesday	3 March	1.30	Education
Tuesday	5 March	10.30	Diploma Examiners
Tuesday	10 March	10.30	Council
Wednesday	8 April	11.00	Research Co-ordination
Thursday	9 April	11.30	Meetings
Tuesday	14 April	10.30	CCWPNA Examiners
Tuesday	14 April	1.30	CCWPNA Committee
Thursday	30 April	10.30	Membership
Thursday	14 May	11.00	Publications
Tuesday	19 May	10.30	CCHAV Examiners
Tuesday	19 May	1.30	CCHAV Committee
Tuesday	26 May	10.30	Executive
Monday	8 June	10.30	ASBA Examiners
Monday	8 June	1.30	ASBA Committee
Tuesday	16 June	10.30	Council
Wednesday	24 June	10.30	CCENM Examiners
Wednesday	24 June	1.30	CCENM Committee
Wednesday	24 June	10.30	CCBAM
Thursday	25 June	10.30	Distance Learning Tutors WG
Thursday	25 June	1.30	Education
Thursday	16 July	11.30	Meetings
Tuesday	4 August	10.30	Diploma Moderators Meeting
Thursday	13 August	10.30	Membership
Tuesday	8 September	10.30	Executive
Tuesday	15 September	10.30	Council
Thursday	24 September	10.30	Engineering Division
Monday	28 September	11.00	Research Co-ordination
Thursday	22 October	11.00	Publications
Thursday	29 October	10.30	Membership

Refreshments will be served after or before all meetings. In order to facilitate the catering arrangements it would be appreciated if those members unable to attend meetings would send apologies at least 24 hours before the meeting.

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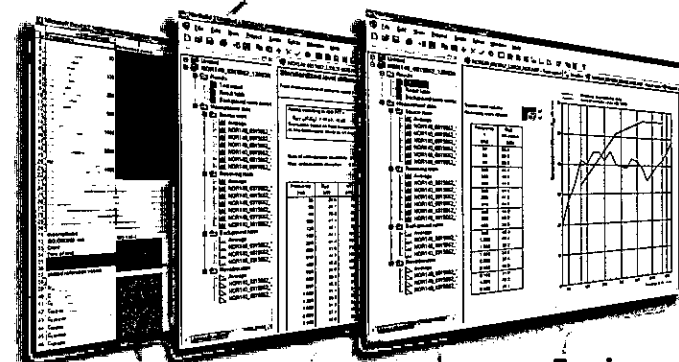
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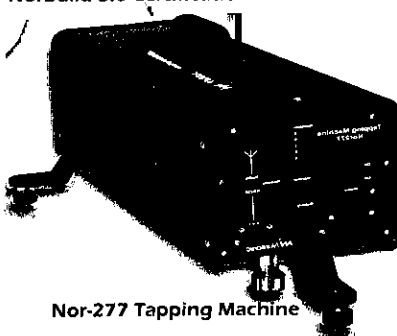
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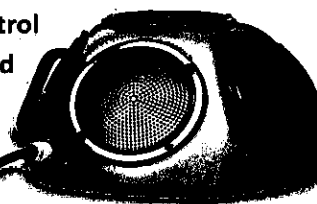
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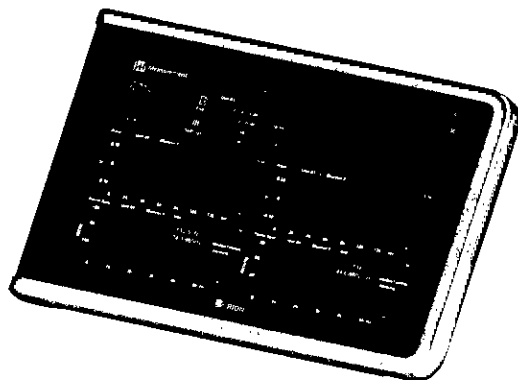
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