Vol 39 No 1 January/February 2014

ACOUSTICS BULLETIN

in this issue... **Uncertainty and diversity in construction noise assessment**

Institute of Acoustics

40

1974 - 2014

plus... Students throng to Reproduced Sound 2013 in Manchester

Problems in residential design for ventilation and noise part 2: mechanical ventilation

Why speech perception declines across the adult lifespan: effects of age on audition and cognition

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Front cover photograph:
Construction noise assessments are fraught with difficulty

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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.

Institute of Acoustics

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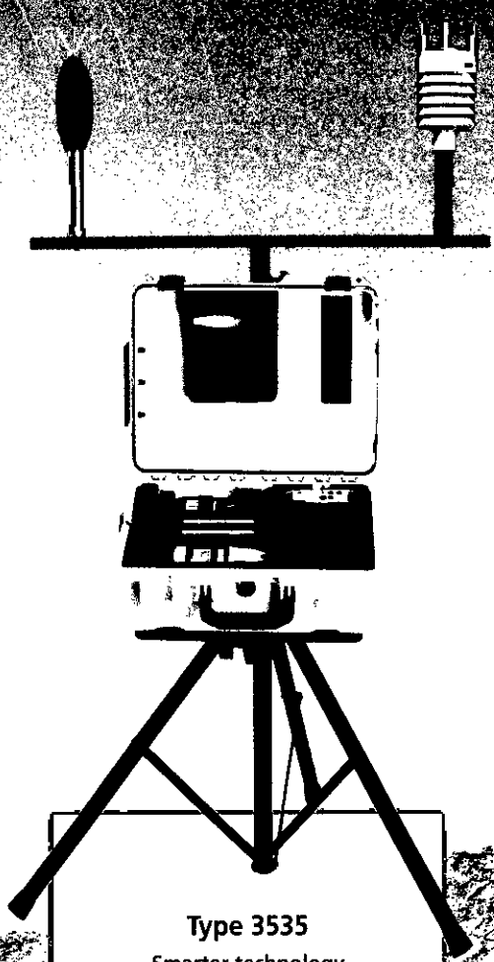

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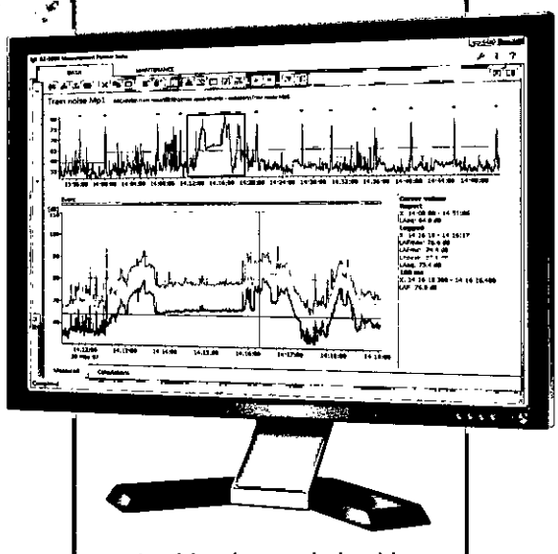

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creating sustainable value

Conference and branch programme 2014

28 February
Organised by the Southern Branch and the Musical Acoustics Group
Creative soundscapes 2104
Brighton

12 March
Organised by the Measurement & Instrumentation Group
Railway noise – is HS2 on the right track?
Birmingham

26 March
Organised by the Electro-Acoustics and Musical Acoustics Groups
Sound recording techniques and their influence on musical composition, interpretation, performance and appreciation
Salford

17-19 September
Organised by the Underwater Acoustics Group
Third international conference on synthetic aperture sonar and synthetic aperture radar
Lerici, Italy

14-15 October
Organised by the Electro-Acoustics Group
Reproduced Sound 2014
Birmingham

15-16 October
Institute 40th Anniversary Conference
Birmingham

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

Dear Members

A Happy New Year to everyone! 2014 promises to be another successful and exciting year.

First, we will of course be celebrating our 40th anniversary. A call for papers will shortly be going out for the anniversary conference which will be held at the NEC in Birmingham in October. As some of you already know, all specialist groups will be involved in the conference which will take place in parallel sessions over two days. Each group will have two half-day sessions, one on each day. This is to encourage all members to participate and to mix with other groups, and to celebrate all our different areas of activity. There will be several plenary sessions and the programme will be planned so that, hopefully, at all times there will be something of interest to all delegates.

As well as the conference, Council is encouraging and enabling local branches to put on their own special event to mark the anniversary. There will also be a commemorative issue of the Bulletin later in the year, which will contain articles on all our specialist topics, looking at the past to inform the future. This is in addition to the 'History of the IOA' book being put together by Geoff Kerry and the history working group. As well as all their efforts collating material specifically for the book, the group is doing sterling work in collecting together all the documentary records, such as Council minutes and past Bulletins, to ensure that we have a comprehensive archive of all our activities and achievements over the past 40 years.

Another working group recently established is the Sustainability Design Task Force, led by Peter Rogers and Richard Cowell, whom I would like to thank for their efforts in taking this forward. Sustainability is something that we should be considering in all our activities – from the way the office is run to our professional involvement in acoustics. The SDTF will become more active over the coming year in spreading the word around the Institute.

The other excellent news for the start the year is of course the launch of our new website. Many thanks to Allan Chesney and all the office staff, especially Chantel Sankey, for all their hard work, especially over the last few months, towards its development. It certainly looks good and I hope you will all find it works for you. As usual, feedback would be welcome – both

complimentary and critical!

If you go into the members' area of the website you will find an electronic version of the Bulletin. In the 2012 membership survey a significant number of members expressed a preference for an electronic version so, during this year, the Bulletin will be delivered to you in the traditional manner and will also be available electronically. This will enable you to decide which version you prefer and how you would like to receive it in future. Obviously distributing it electronically will represent a significant saving in printing and postage costs, as well as reducing the amount of paper used. So after this year, members who opt for an electronic version will receive a reduction in their membership fees, while overseas members who wish to continue receiving a paper version will pay a surcharge to cover the extra postage costs. Again, your views are welcome.

I am going to end with a quote from Nelson Mandela. A few days after his death I heard an extract from his autobiography on the radio, in which he mentioned acoustics! He was talking about his trial in 1969, which was held in the Old Synagogue in Pretoria. He said that he and his fellow accused used to joke that "between the poor acoustics of the hall and the confused and inaccurate reports of special branch detectives we could be fined for what we did not say, imprisoned for what we did not hear, and hanged for what we did not do". How sad that we cannot invite him to the 40th anniversary conference to talk about the importance of good acoustics in courtrooms. ◘

Bridget

Bridget Shield, President

Students throng to Reproduced Sound 2013 in Manchester

Full conference round-up

Report by Bob Walker

The 2013 Reproduced Sound Conference was held on 13-14 November, with informal events on the 12th to allow delegates to get together and a visit on the 15th. This year it was held in a new venue at the **Renaissance Hotel** in Manchester.

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

The meeting room had been equipped with an advanced audio-visual system that tracked the speakers and controlled the loudspeakers to match their position. This had been organised and managed by **John Taylor** of d&b audiotechnik, assisted by professional operators. The organising committee gratefully acknowledges the effort put in by many people in setting up the technical support.

The contributions of the exhibitors to the success of the conference are also gratefully acknowledged – they were valuable and much appreciated.

The technical presentations took place in part of the Medici ballroom suite, with the adjoining part being used by the exhibitors, for the refreshment breaks and for the conference dinner.

The conference theme continued from previous years, with its focus on developments in spatial acoustics, electro-acoustics, room acoustics and intelligibility. In addition to one keynote paper, the Peter Barnett Memorial Student Award paper and the IOA/IAC Young Person's Award for Innovation in Acoustical Engineering 2013 paper, 23 other technical papers were presented in eight sessions. There were also four posters. This made for a very busy and intensive programme, fully occupying both days.

The conference was well attended, with101 registered delegates, of whom 38 were registered as students, plus two exhibitors. The committee was again pleased to see a number of new faces, as well as the much larger-than-usual complement of students.

The delegates certainly appeared to have had an enjoyable and worthwhile conference. Overall, the Electro-Acoustics Group committee was very satisfied with the response to the programme and the smooth running and friendly atmosphere. The 2014 event will be held on 14-15 October at the NEC, Birmingham, in conjunction with the Institute's annual conference on 15-16 October and will celebrate the 40th anniversary of the Institute and the 30th of Reproduced Sound.

The conference programme

The programme began on the 12th with a visit to the BBC at MediaCityUK. About 30 delegates enjoyed a thorough and informative visit to see the main TV studios, Radio 5 Live studios, the Breakfast TV studio and the sports news area. Afterwards, members of BBC R&D gave several talks and demonstrations of their current work on virtual audio and audio processing. It included a demonstration of a recent experimental programme made using sound objects and capable of being rendered in any suitable output format rather than being limited to a fixed format with downmixing for other formats. Overall, the visit was very informative and all delegates found it worthwhile. Many thanks are due to the BBC for all of the great effort they put into hosting this event.

In the evening the University of Salford hosted a second talk and demonstration session also at Salford Quays, beginning with a reception. About 50 delegates were present. After brief technical presentations, the delegates were shown demonstrations of room mode control by sub-woofer positioning, interactive auralisation with gesture control to match a video scene and ambisonic reproduction and wavefield synthesis of the acoustics of Stonehenge. The group was also taken on a tour of some of the technical facilities in the faculty. These were all fitted with modern video, sound and lighting equipment, housed in immaculate studios and control rooms. Many thanks go to Professor Trevor Cox and his colleagues for the great effort they had put into making the arrangements, setting up the demonstrations and giving up their evening time to look after the visitors so well.

The conference was formally opened the next day by **Paul Malpas**. In welcoming delegates, he said 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 welcome to attend throughout the conference. He thanked the committee, the delegates, the Institute, the students and all others who had helped to make sure the conference happened.

On the 16th there was a visit to the Royal Exchange Theatre, Manchester, organised by **John Taylor**. About 30 delegates stayed over to take part in this very interesting and informative visit.

Technical Sessions 13 November

Session 1: Spatial audio, Chairman – Mark Bailey

The conference began with the keynote paper *The sound of entertainment* by **Dennis Baxter** (Baxter Sound). The presentation consisted of a very entertaining revue of mostly non-technical issues and management problems associated with high-profile events such as the World Cup and Olympics. Dennis described how the basic principles had not changed much but the technology, and especially the audience expectations, had. Driven partly by the computer games industry, audiences now expect more than just realism. The sound designer now has to obtain (or synthesise) super-realistic sounds. Producers sometimes don't understand and can raise objections to the inclusion of artificially-generated sounds. The presentation was well received, with an extended discussion period.

The session continued with *A study of the broadcasting sound chain* by **Andrew Horsburgh** (Southampton Solent University), **Derek Turner** and **Jamie Size** (University of West Scotland). The presentation was by Derek and began with a review of current training opportunities, with the BBC apparently at last beginning to realise the shortage of younger qualified operation staff. A pilot study had been carried out in collaboration with the BBC. A survey of expectations and benefits had been carried out, with the result that managers appeared less certain of requirements than some workers.

The final paper of the session was *An investigation into the impact of 3D surround systems on spatial quality* by **Paul Power**, **W J Davies**, **J Hurst** (University of Salford) and **C Dunn** (BBC). It was presented by Paul and described the progression of multi-channel systems over the years from mono through stereo, 5.1 to various 3D audio systems such as ITU 10.2, NHK 22.2, Auro3D and Dolby Atmos. He said that there was not much evidence yet to support the use of these channels.

Session 2: Perception, Chairman – Adam Hill

The programme continued with *An investigation into the perception of reproduced urban sound fields* by **Tobias Ackroyd** and **Y W Lam** (University of Salford). The paper was presented by Tobias. He described a comparison of perception tests between real and ▶

virtual environments either using predefined lists of descriptors or allowing the subjects to use their own descriptors. Overall, differences in evaluation had been found between real and synthesised environments, with subjects scoring better in the real venues.

The second paper was *On the subjective nature of binaural externalisation* by **Alistair Plail** and **Bruno Fazenda** (University of Salford). The presentation was by Bruno and described an investigation into factors affecting externalisation, mainly in stereo. One of the difficult problems was getting the results from the test subjects. Subterfuge, using the "cocktail party" effect, had been used to obtain unbiased judgements of the effects. It had also been found that subjects externalise more plausible sounds better, especially if they had been pre-armed with audio cues.

The final paper in the session was *Subjective evaluation of audio egocentric distance in real and virtual environments using wavefield synthesis* by **Samuel Moulin**, **Rozenn Nicol**, **Laetitia Gros** and **P Mamassian** (Orange Labs, France). The paper was presented by Samuel. It described comparisons of distance perception in real and artificial rooms and the cues that might be significant. It was found that subjects were able to discriminate distance in a virtual environment rather well, though they consistently under-estimated longer distances.

A poster session followed lunch. The posters were:

a) *Improving the low-frequency directivity of line-array microphones* by **Udo Wagner** (Microtech Gefell, Germany) and **John Willett** (Sound-Link ProAudio) in which improvements in low frequency directivity and lower noise characteristics of a new microphone were presented.

b) *Audio flipboard: a spatial audio display exploiting simultaneity in the presentation of a collection of organised media articles* by **Joe Sinker** and **Ben Shirley** (University of Salford) – a proof of concept for a display utilising binaural audio. It took advantage of the "cocktail party" effect to provide a dynamic, multi-source environment for browsing collections of audio streams.

c) *Awareness system for headphone users* by **Jonathan Kay** and **Bruno Fazenda** (University of Salford) – an application for portable devices to increase the auditory awareness of headphone users to their environment. That had been realised by exploiting the external microphone on such devices which, unlike the ears of the user, is not occluded by the headphones.

d) *In-situ measurement of the sound absorption characteristics of existing building fabrics* by **John Grimes**, **Oliver Kinnane**, **R Walker** and **S. Pavia** (Trinity College, Ireland). A portable system for measuring the sound absorption co-efficient of existing surfaces in-situ using a two-microphone impedance tube method.

Session 3: Modelling, Chairman – Paul Malpas

Wolfgang Anhert (AFMG Technologies, Germany) presented *Improving speech intelligibility using numerical sound system optimisation* by himself and **Stefan Feistal** (also AFMG Technologies). He described how loudspeaker arrays could improve intelligibility. Using a computer model, long FIR filters could be optimised to meet coverage requirements – to allow focussing on audience areas and reducing unwanted reflections. Several examples were described and a live demonstration given of the optimising process. The process had a potentially very large number of degrees of freedom (several thousand) and could take a while.

The next paper was *Validation of the binaural room scanning method for cinema audio research* by **Linda A Gedemer** (University of Salford) and **Todd Weilti** (Harmon International, USA), presented by Linda. It discussed some aspects of listener perception as a function of room size and that full-size tests in real rooms are too expensive. Binaural impulse response measurements had been carried out in a room at 5° intervals over the range +/- 40°. Using carefully equalised headphones and room reproduction system, subjective comparisons were made between the real and synthesised rooms to validate the method.

In the final paper, **John Braiden** (Braiden Acoustics) presented *Ear canal modelling with in-situ in-ear devices* in which he described the derivation of an electrical equivalent of the ear canal transmission characteristics. He also described some historic attempts using scaled-up models and showed a number of casts of real ear canals and how most differed from the current straight standard model. The intention was to allow in-ear devices to be modelled more accurately to aid their development.

John Willet tests the BBC's stereoscopic and binaural head-tracking

Stuart Gillan auditions the University of Salford's subwoofer mode-control demo

Session 4: Intelligibility. Chairman – Helen Goddard

After the tea break, in *Self-monitoring and self-optimising PA systems* by **Sander van Wijngaarden** and **Jan Verhave** (Embedded Acoustics, The Netherlands) Sander described the challenges faced by system designers and installers in difficult environments such as traffic tunnels. Not only are the systems difficult to set up but they also deteriorate with time and conditions change. Authorities require the performance to be maintained over years. A system for automated adjustment and continuing optimisation was described that used the normal audio test messages rather than test signals.

The second paper was *On the importance of the speech spectrum on the STI calculations* by **Lorenzo Morales** (London South Bank University) and **Glenn Leembruggen** (ICE Designs, Australia). The paper was presented by Lorenzo. He described how STI measurements depended heavily on the test spectrum and how the existing standard spectrum, IEC 60268-16, differed from real speech. Measurements had been made to derive a new (better) standard spectrum for male English speech. The results suggested that the current standard spectrum for STI measurement should be reviewed.

The next paper was *The problems with minimum STI* by **Anthony Stacy** (AMS Acoustics). Anthony described how requirements for system installations are almost always expressed in terms of pass or failure to meet a minimum value of STI throughout an area. Such absolute assessments are very P8

P7 poor criteria on which to judge system performance because they are neither practical nor robust and can be unduly influenced by localised effects. They also depend on the sampling scheme, which is not specified. Accurate prediction of minimum values is also made impossible by the same factors. A requirement based on average values would be an improvement, but that still left sampling issues.

That was followed by the Peter Barnett Memorial Student Award presentation to **Luis Gomez-Agustina** of London South Bank University (see page 15). The citation was read by the Institute President **Bridget Shield**. Following the award, Luis presented his paper *Improvement of voice alarm systems in underground stations* in which he gave an overview of intelligibility problems, especially in deep tube stations. Previous incidents had demonstrated how the voice alarm system can be a life-critical component. Even so, the authorities appear reluctant to spend very much on it. Luis described a number of potential methods for introducing acoustic absorption and some of the improvements that could be obtained. One questioner from the audience commented that few materials satisfy the fire regulations. Another commented that treating underground stations was more expensive than had been suggested.

Afterwards there was a short break until a reception which was followed by the conference dinner.

Technical Sessions, 14 November

Session 5: Perception, Chairman – Glenn Leembruggen

The day started with *Quality, timbre and distortion: perceived quality of clipped music* by **Trevor Cox, Bruno Fazenda, Stephen Groves-Kirby, Iain Jackson, Paul Kendrick** and **F Li** (University of Salford). The paper was presented by Iain. He described the selection of representative musical samples on the basis of MEL measurements. Subjective tests were carried out to determine the degree of impairment with different degrees of clipping. Rather unsurprisingly, highly compressed music such as rock/pop, with its frequent peak excursions, was more susceptible to impairment than music with a wider dynamic range.

The second presentation was *Perception and evaluation of audio quality in commercial music production* by **Alex Wilson** and **Bruno Fazenda** (University of Salford). The paper was presented by Alex. A set of audio clips had been prepared and assessed subjectively. Features had been extracted and correlations with the subjective assessments calculated. It showed that subjective responses might be correlated to some objective metrics. In particular, spectral and dynamic measures, distortion and tempo were found to be significantly correlated. Quality estimators had been derived, showing some promise.

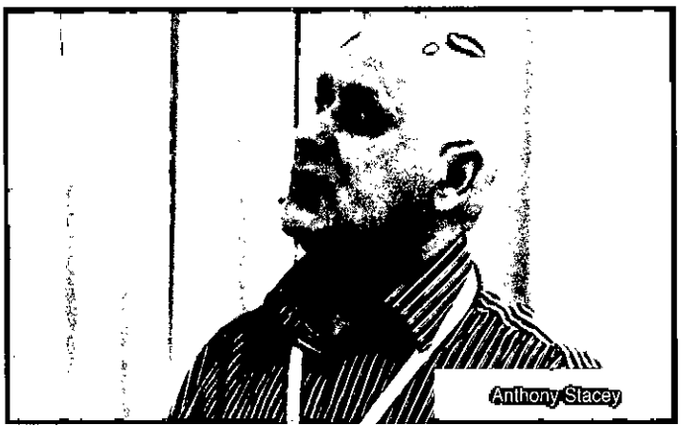
The third paper was *Low frequency sound source localisation as a function of closed acoustic spaces* by **Adam Hill** (University of Derby) and **Malcolm Hawksford** (University of Essex). The paper was presented by Adam. In it, Adam described the calculation of room impulse responses and the derivation of IACCs to derive a potential criterion that 1.4 uncontaminated wavelengths are required for localisation. It was also concluded that the main influence was the difference between the direct sound and the first reflection. The results remain to be confirmed by listening tests.

The final paper was *What happens when we move off-centre?* by **Darius Satonger, Chris Pike** and **Yiu W Lam** (University of Salford). The paper was presented by Darius and described the subjective modelling of listening tests via binaural systems. This paper discussed some of the problems for a listener away from the central position, such as the influence of loudspeaker directivity, time-of-arrival differences and the asymmetry of the loudspeaker layout geometry. The challenges presented by subjective testing at off-centre listening positions were also analysed and possible solutions proposed.

Session 6: Measurement, Chairman – Tony Stacey

The first paper was *Determination and display of 3-D room impulse response* by **Daniel Protheroe, Keith Ballagh, Daryl Prasad** and **Robert Conetta** (Marshall Day). The paper was presented by Daryl and presented an investigation into the determination and display of 3D room impulse responses using a relatively inexpensive, commercially available A-format microphone array. The system provided impressive interactive 3-D plots of image arrival times, direction and strength.


Lorenzo Morales


Anthony Stacey

The next paper was *A simplified, automated system for measuring room acoustic responses* by **Bob Walker**. The paper included a brief outline of room impulse response measurement using correlation and a proposal for automating the process of extracting the direct sound component. The intention was to place the development software in the public domain so that further work on standardisation could be carried out by others.

The final paper was *Using maximum entropy to achieve better acoustic responses* by **Jamie Angus** (University of Salford). Jamie began by discussing the relationship between thermodynamical entropy and measurement results. After entertaining the audience with the Flanders and Swan track on thermodynamics and including yet another excuse for a gin and tonic, Jamie described how the (common) use of time-domain windows in acoustic measurement adds unwanted data. An improved method based on "whitening" the error signal to maximise the entropy estimation was described. Examples of application of the method to real data were examined and the limitations, and possible errors, of the method discussed. Jamie showed that it may be possible to achieve a higher resolution from a measurement than by blindly windowing the data. The audience was left wondering as to how the calculations were actually carried out.

The session was followed by a break for lunch and another opportunity for the delegates to discuss the posters. After lunch the EAG AGM was held in the meeting room.

Session 7: Physical acoustics and loudspeakers, Chairman – Bob Walker

The first paper was *An investigation into the acoustic effect of cinema screens on loudspeaker performance* by **Philip Newell** (Consultant, Spain), **Jana Guijarro Garcia** and **Keith Holland** (ISVR). Philip described how the cinema industry had developed "acoustically transparent" screens and how these could still alter the transmitted sound and affect the dynamic behaviour of the P10

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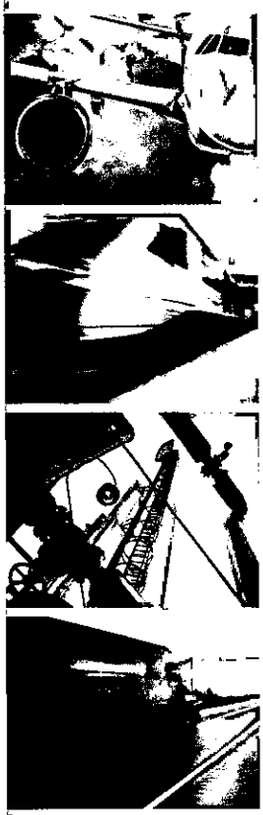

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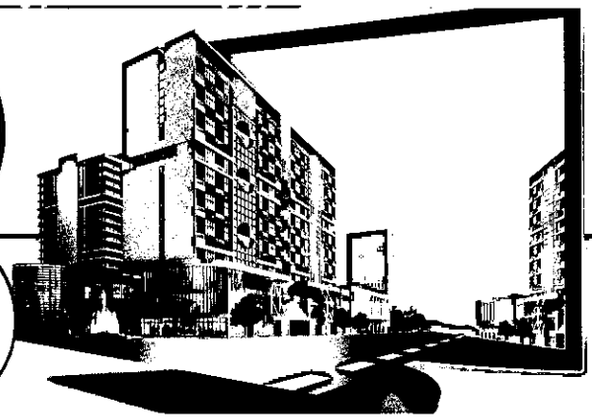

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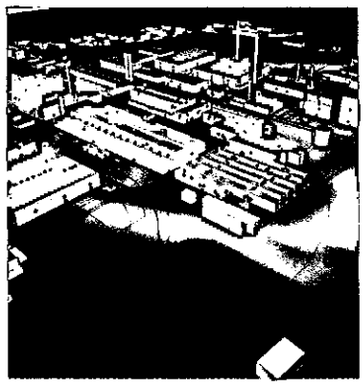
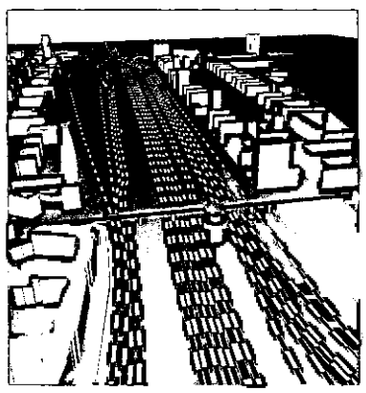
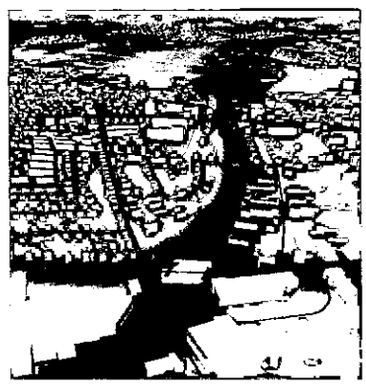


Prediction and detailed analysis of noise at industrial facilities



Optimization of building layout near roads and railway lines



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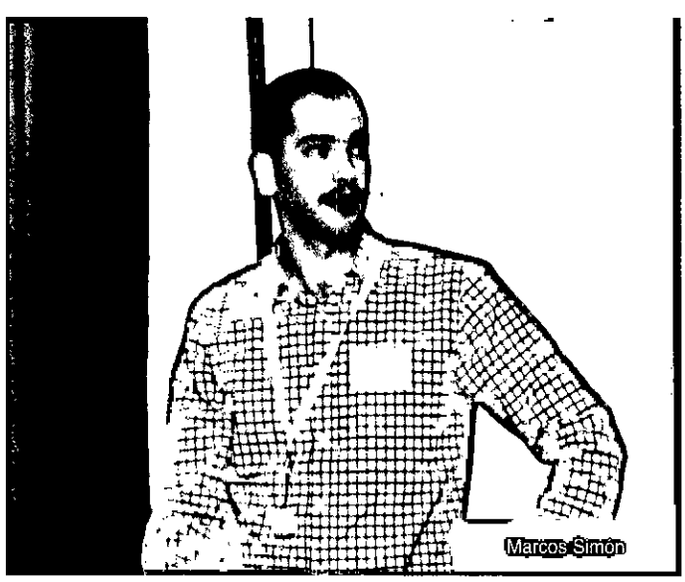
CadnaA Training - Spring 2014 - Dates to be announced


Bob Walker


Delegates enjoy the conference dinner


IOA President Bridget Shield (right nearest camera) with top table guests


Marcos Simón

P8 loudspeakers and their directivity. Many graphs were used to show the reflection amplitudes as functions of the many variables. Overall, the industry appears still to be grappling with these problems.

The second presentation was the presentation of the IOA/IAC Young Person's Award for Innovation in Acoustical Engineering 2013 to **Marcos F Simón**. The citation was read by Geoff Crowhurst, of IAC, who also presented the award. Afterwards, Marcos presented the paper *Array-based TV listening aid for the hearing impaired* by **Marcos F Simón**, **Stephen J Elliott**, **Arthur Marker**, **Jordan Cheer** (University of Southampton). Marcos described a system using a line array of eight tiny loudspeakers to create a steerable array. The objective was to create an enhanced sound field in the vicinity of an impaired listener without affecting other members of the audience. The loudspeaker rear response had been minimised by phase shift sources. To enhance the sound sufficiently in reverberant spaces it had been found necessary to increase the array to 8 x 2 by paralleling pairs horizontally, but retaining a common set of filters.

The final paper was *Drive granularity for straight and curved loudspeaker arrays* by **Ambrose Thompson** and **Josebaitor Luzarranga** (Martin Audio) The paper was presented by Ambrose. It described how the problems of uniform audience coverage was being met with loudspeaker arrays where some or all of the elements were driven independently. To control costs and complexity, the number of independent channels had to be minimised. The paper presented simulations of arrangements of loudspeakers and processing channels and presented results demonstrating how performance degraded with reductions in channel numbers.

Session 8: Sound reinforcement, Chairman – John Taylor

After the break, *A scientific approach to microphone placement* by **Joshua Harrison** and **Adam Hill** (University of Derby) was presented by Joshua. He described how current practice in placing microphones on drum kits was governed by personal experience and industry standard practice. He presented the results of a large number of measurements of cymbal directivity in order to find favourable and unfavourable microphone locations. Ideal overhead microphone placement diagrams had been created, giving sound engineers a quick reference guide for best practice at live events.

In *The propagation of low frequency sound through an audience*, **Elena Shabalina** (d&d audiotechnik, The Netherlands) Elena described how the problem had been studied using analytical models, live concert measurements, measurements of absorption of people in a reverberation chamber, laboratory scale measurements and BEM simulations. However, audiences were often packed tightly and affected the propagation. It had been found that the audience forms a medium with an impedance significantly different from that of air. That mismatch causes a reflection and uneven low frequency level distribution in the audience area.

The final paper was *Use of Ambisonics reproduction techniques for popular music – a jazz concert application* by **Serafino Di Rosario** (Buro Happlold). He described the application of ambisonics to augment a live jazz performance. The author had been invited to create bespoke software that was controllable in real time, allowing the "engineer" to be part of the band on stage as an additional musician. At the end of the presentation, the question of timing problems with the sound processing in a live performance was discussed extensively.

That concluded the formal conference proceedings. An informal meeting of the Young Members' Group was held in the Renaissance bar, organised by Mike Lotinga. Students were also welcomed to join in. ◘

Wind turbine noise working party prepares to finalise guidance notes

By Richard Perkins, GPG working group Chairman

The Institute wind turbine noise Good Practice Guide (GPG) working group is preparing to analyse the consultation responses to its Supplementary Guidance Notes (SGNs) with a view to publishing the final versions before Easter.

Six notes have been prepared covering the following areas: data collection (SGN number 1); data processing and derivation of ETSU-R-97 background curves (2); sound power level data (3); wind shear (4); post completion measurements (5) and noise propagation over water for onshore wind turbines (6). The consultation is due to finish about the time you receive this copy of the Bulletin.

The consultation versions of the SGNs can be downloaded from the News section of the IOA website. It should be stressed that these are consultation drafts, and should not be cited until the final versions are published.

As with the GPG, the consultation responses to the SGN consultation will be published on the IOA website, and a peer review of the SGNs will be undertaken before the final versions are published. The President (Bridget Shield) will then write to the respective Governments to invite their endorsement.

The last few months of 2013 were spent spreading the word on the GPG and the SGN consultation. In October I visited Basingstoke to talk to the Southern Branch. In November I went to Edinburgh to launch the SGN consultation and then I visited Colchester to talk to the Eastern Branch. All three events were well attended, and I would like to thank the attendees for some interesting and constructive feedback on both the GPG and the SGNs.

On the whole, it would appear that the GPG has been well received, and the vast majority agree that it has provided a large step forward towards solving the issues with the methodology that were identified in the Hayes McKenzie report of 2011.

However, some criticisms of ETSU-R-97 remain, not least the issue of noise limits and amplitude modulation. To take these issues forward, a one day meeting is being planned to inform the debate. More details on this meeting will be published shortly.

The working group is also pleased to welcome the publication of the long-awaited report on amplitude modulation (AM) work funded by Renewables UK, and the latest evolution of a proposed planning condition to deal with it.

This work is the latest in a number of papers on the subject that have appeared over the last six months or so (Mike Stigwood in the November-December 2013 Bulletin, and various articles to the Denver Wind Turbine Noise Conference in August 2013 which are cited in the article).

It is important that all those dealing with wind farm noise issues are encouraged to review those papers, to critique the proposed condition, and to work towards an agreed solution. The working group will keep the AM condition under review, and will consider whether it is "good practice" in due course once it has been tested and a consensus reached on its suitability. ◘

Institute signs Equality and Diversity Concordat

The Institute has signed up to the Royal Academy of Engineering Equality and Diversity Concordat, a voluntary commitment by Professional Engineering Institutions (PEIs) to take action to attract, recruit and retain people from increasingly diverse backgrounds into professional membership and registration.

The signing ceremony was attended by presidents of many PEIs large and small engineering institutions. The Concordat has now been signed by 26 (out of a possible 36) PEIs. By signing it the IOA is committed to implementing the Concordat to address the gender, disability and ethnicity gaps in our profession.

The Concordat is led by Dame Wendy Hall of Southampton University. She said: "The ultimate goal of the Concordat is to ensure our profession and its institutions continue to thrive both now and in the future. To do this, each and every one of us must play a part in attracting and retaining engineers from increasingly diverse backgrounds."

The figures for the UK are startling. For example, while people from ethnic minorities make up 24% of suitably qualified graduates, they make up only 6% of people working in engineering professions. The representation of women in the UK professional engineering workforce is the lowest in Europe: while 51% of the UK workforce is female, only 8% of those working in engineering are women.

By signing the Concordat the IOA has agreed to work towards the following objectives:

- Communicate commitment to equality and inclusion principles and practice
- Take action to increase diversity amongst those in professional engineering membership and registration
- Monitor and measure progress.

By setting up the IOA Women and Families Working Group we have already started to work towards achieving some of the objectives.

IOA members will have noticed that, for the first time, personal information has been requested on the membership renewal form. A reason for this is to enable us to comply with the Concordat by collecting diversity data which will enable us to establish our current diversity profile, and to monitor changes over a period of years. ◘

Bridget Shield (left) with Dame Wendy Hall

Honorary Fellowship for former IOA Chief Executive Roy Bratby

Former IOA Chief Executive Roy Bratby has been made an Honorary Fellow of the Institute in recognition of his contribution to its development over many years. He received his award at the Reproduced Sound conference in Manchester from President Bridget Shield. Below is her citation.

Roy Bratby served the Institute as its Chief Executive from 1997 to 2006. Roy was appointed at a critical time for the Institute – the administration of the Institute had, for several years after its formation in 1973, been serviced by a staff member of the Institute of Physics, at whose premises Council meetings were held. In the late 1980s, Dr Roy Lawrence and Cathy McKenzie established a small office for the Institute in St Albans, and provided the secretariat services. Offices were leased in a central location, at Agriculture House in Holywell Hill, where Council meetings were held, supported by a nucleus of staff. It was clear to members of Council at that time that further development of the administrative services was needed and the formal post of Chief Executive was established, to which Roy was appointed in 1997.

An early task for Roy was the re-location of the office to a longer-lease central location and the offices at St Peter's Street were chosen. Further support staff members were recruited to meet the growing work of the Institute, which now included the secretariat of the European Acoustics Association. With a burgeoning membership and further international activities, the demands of the management of the office became ever more complex.

As Chief Executive, Roy met these diverse challenges with dedication and enthusiasm, while maintaining the due diligence needed, leading from his position the deliberations of Council, under the auspices of the several Presidents who were fortunate to have his support for their term of office. In his private life, Roy has always been willing to serve and support charitable work, and to this day he acts as Chairman of the British Tinnitus Association, in addition to providing a considerable level of support to local health care voluntary services in St Albans. In his earlier career, Roy has held a diverse range of posts, from CEO of an electronics company, MD of a baby clothing company, land agent for the Stair Estate in Stranraer, to CEO of the Country Houses Association.

In recognition of the unique contribution that Roy has made to the Institute's professional development and its financial viability over a vital period of the Institute's life, the Institute is delighted to award him an Honorary Fellowship. ◘

Roy Bratby receives his award from Bridget Shield

Investigation into the effect of historic noise policy interventions

By Stuart Dryden

Defra has published the results of this research project that examined the effects of a range of noise policies implemented over the past 50 years or so (since 1960 when the Noise Abatement Act was passed).

The initial policy areas considered were: aircraft noise, road traffic noise, Planning Policy Guidance, the Noise Insulation Regulations, Codes of Practice, Building Regulations, the Environmental Impact Assessment Regulations, and noise control legislation.

The first stage of the project investigated the availability of data from which the effects of policy could be investigated for those topics and after that review the topics selected for analysis in the study were: aircraft noise, road traffic noise, Building Regulations, noise control legislation, and the control of construction noise.

The project was led by Rupert Taylor's practice, with support in particular policy areas from Philip Dunbavin, Lisa Livia (Noise Abatement Society), Howard Price and Kim Willis (Chartered Institute of Environmental Health), Mary Stevens (formerly of Environmental Protection UK), and Gary Timmins (BRE).

This study forms the first stage of an approach to policy formulation known as Policy Futures which seeks to inform policy development over the next 50 years.

Two papers drawing on the findings of this study were presented at the IOA conference *The Wilson Report – 50 years on* in London in October and will form the basis of technical articles to be published in a future issue of *Acoustics Bulletin*.

If you wish to view the study's findings in the meantime, the summary report and its six annexes can be downloaded from Defra's website at **http://bit.ly/1fd7K8H** or for more information contact Stuart Dryden (**smd@ruperttaylor.com**). ◘

Jon Lee and David Sproston receive Distinguished Service Awards

Jon Lee and David Sproston have received Distinguished Service Awards to the Institute in recognition of their contributions to the website redevelopment. They were presented with the awards by President Bridget Shield at the RS 2013 conference in Manchester. Below is her citation.

David Sproston has been a corporate member of the Institute since September 2011, having joined as an associate in 2007. He is a consultant with Hepworth Acoustics. He joined the Publications Committee in 2008 and has made many valuable contributions in the five years since then. David has a website design background which has been very useful to the committee in recent years. During 2008 and 2009 he carried out a review of the progress of the development of a new Institute website.

Jon Lee joined the Institute as an associate in 2008 and was elected to corporate grade in September 2011. He works for Waterman Energy Environment and Design. He also has a background in website design and hosting. In 2010 David and Jon both joined the website sub-committee chaired by Allen Mornington-West. They took a very active role in the requirements capture and development of a possible new website. For the next three years they worked many long hours, day and night, on the website project, including spending several days in the Institute office in St Albans working with the staff there. This was in addition to their full time consultancy jobs, and the Institute is grateful not only to David and Jon but also to their employers for allowing them to spend so much time working on the website. This period of hard work also coincided with the arrival of David's daughter Imogen in 2011.

For their hard work and dedication the Institute is pleased to present Distinguished Service Awards to David Sproston and Jon Lee. ◘

Jon Lee with his award

David Sproston receives his award

Luis receives Peter Barnett Student Memorial Award


Luis receives his award from Bridget Shield

Research fellow Luis Gomez-Agustina has been awarded the Peter Barnett Student Memorial Award for his contributions to electro-acoustics and speech for his PhD research on the design and optimisation of voice alarm systems for underground stations.

Following completion of his MSc in environmental and architectural acoustics at London South Bank University, he was appointed as an associate to work on a Knowledge Transfer Partnership (KTP) project awarded to LSBU and Telent, aimed at improving speech intelligibility of voice alarm (VA) systems on the London Underground. Luis was the key member of the acoustics team, working with system designers and management to develop and test electro acoustic design processes for PA/VA systems on deep platforms. During the project Luis studied the validity and efficiency of different acoustic measurement techniques for deep underground spaces, and was central in developing in-house test methodologies which reduced test time and increased test reliability and efficiency.

While working as a KTP associate Luis also studied for a PhD, using his work with Telent as the basis for his research project. His research examined real world issues faced during the design process of VA systems in underground spaces, and has provided a specific knowledge base not generally available on practical aspects of speech intelligibility and the performance of VA systems in such spaces. He has proposed a new performance design parameter as well as a novel acoustic treatment design concept for platform tunnels. He also developed an empirical computer model tool for the prediction of STI on deep platforms, and his thesis provided design guidelines for underground VA systems.

Luis is now employed as a research fellow at LSBU, where, in addition to teaching on the MSc and running the IOA Diploma, he is continuing his research, investigating the effects of platform occupancy on VA performance in emergency situations. He is also actively promoting the need for the creation of a new British Standard dedicated to the design, testing and installation of VA systems on underground stations.

In presenting him with the award, IOA President Bridget Shield said: "Luis has shown a creative and innovating ability to analyse acoustical problems. In addition, he aims to raise awareness of acoustics and electro-acoustics among other professional disciplines. His insights, advice and initiatives combine technical expertise with a realistic approach to implementation in which all aspects of engineering and project management are considered."

Allen Mornington-West receives Distinguished Service Award

Allen Mornington-West has received an Award for Distinguished Services to the Institute in recognition of his work for the Electro-Acoustics Group and the development of the Institute website. He was presented with the honour by President Bridget Shield at RS 2013 in Manchester. Below is her citation.

Allen has been a member since 1984 and has been a valued member of both the Publications Committee and the Electro-Acoustics Group.

Throughout his membership he has been a supporter and contributor to the Reproduced Sound conferences, and indeed we believe that he is one of those very few remaining people who were present at the first meeting in Windermere in 1984. He has continued to attend the conferences nearly every year since then and has made many contributions during that time. Amongst these were his musical contributions to the memorable late night/all night jam sessions in the bar at the Hydro hotel.

Allen has also been a member of the Electro-Acoustics Group committee for many years and has contributed much to the organisation of their very successful Reproduced Sound conferences.

Allen has also been very active on the Publications Committee, which he joined in 2010.

At that time there were a number of concerns about the Institute's website and Allen took the role of chairing the newly established website sub-committee.

The sub-committee met for the first time in April 2010. Allen reviewed the existing website and made proposals for the management and running of the new website considering a number of options. It was agreed that a complete re-design of the website was required and Allen undertook a requirements capture throughout 2010 for the Institute to establish the detail of the project, and implemented project management and change management controls. By June 2010 the sub-committee comprised nine members.

Until the development of this website was put on hold at the end of 2012 Allen and the committee had achieved a great deal in moving the website forwards identifying solutions to a number of important issues including the unification of data between the website database and the office databases at St Albans, the removal of many duplicated data entry systems, and the move to many Institute functions being online rather than paper-based. Over almost three years Allen put in many long days and long nights leading the website project, for which the Institute is very grateful.


Allen Mornington-West receives his award from Bridget Shield

Another of Allen's very valuable contributions to the Institute was his creation and management of a business model that has helped to maintain the financial viability of the Reproduced Sound conferences. Without this, we probably wouldn't be here!

So for his long standing contributions to the Electro-Acoustics Group over many years, and for his tireless efforts on the website development in recent years, the Institute is pleased to present Allen with a Distinguished Service Award.

The Wilson Report – 50 Years On

By Stephen Turner

About 50 delegates gathered at the Royal Society in London in October to mark the 50th anniversary of the publication of the final report of the "Committee on the Problem of Noise" chaired by Sir Alan Wilson, known throughout the profession as the Wilson report.

Some delegates had brought along their own copies of Wilson, with the characteristic blue cover, and all showing how they had been well-thumbed over the years. Comparisons were made about which edition they had and the fold out noise contours of Heathrow were carefully unwrapped and displayed and could be seen to be generally still intact. (The Wilson report contained actual noise contours for 1961 and forecast noise contours for 1970).

The first paper came from Adam Lawrence and built on his Bulletin article (July/August 2013). He provided an overview of the document and made some general comparisons about the key issues then and now.

Bernard Berry looked back at Wilson's views on managing noise from industry. He noted the language of the time "...noise from industrial premises, as it affects people living within earshot" and some of the sources of noise then "rattling of milk churns". He also highlighted that Annex 15 contained what was effectively the first draft of what became BS 4142. He looked at how BS 4142 has evolved since then and brought us right up-to-date with some information about the emerging thinking around the current revision to BS 4142, including the possible change of title to "Method for Rating and Assessing Industrial and Commercial Sound".

The next paper on aircraft noise should have been given by Rupert Taylor, but unfortunately he was required to give expert evidence in Singapore. Consequently, his colleague Stuart Dryden stepped in. Rupert was with us for a while, though, due to the wonders of Skype. Their subject was aircraft noise and the paper recorded that the Wilson committee commissioned a jury study of the acceptability of aircraft noise; a noise and social survey around Heathrow and introduced the Noise and Number Index, the indicator used in the noise contours mentioned above. The paper went on to note that since then, the noise generated by individual aircraft types had reduced but that the number of movements had increased. The paper covered how the description of aircraft noise impact had evolved and finished by mentioning the Government's Aviation Policy Framework that was published in March 2013.

Howard Price from the Chartered Institute of Environmental

Health provided a commentary on noise in the law, noting how Wilson discussed the advent of the Noise Abatement Act in 1960 which made noise a potential statutory nuisance. Howard described the interaction between statutory, common and public nuisances and how the number of topics that can be a statutory nuisance has increased over the years. He concluded his presentation with some forthright comments on the Anti-Social Behaviour, Crime and Policing Bill that is currently going through Parliament.

The final two papers of the morning provided information on how the noise environment had changed since Wilson. The first, given by Stuart Dryden, described results of a Defra-sponsored study investigating the effectiveness of policy interventions. Six different areas were examined, including road vehicle noise emission limits; aircraft noise emission limits and changes to Building Regulations. Data were available in some areas to enable a detailed analysis to be carried out, including an estimate of what the noise environment might have been like without the intervention. For others, detailed data were not available so more qualitative conclusions could only be drawn. For both the emission standards, the benefits obtained have outstripped the increase in the number of vehicles/ aircraft in use. The inclusion of converted dwellings in the Building Regulations in 1992 resulted in an estimated 83,000 dwellings benefiting with better sound insulation than would otherwise have been the case. The requirement for pre-completion testing in the 2003 regulations has resulted in some 300,000 units benefiting from better sound insulation.

During the discussion about construction noise it was observed that there was a clear reduction in the number of Section 60 notices (under the Control of Pollution Act) served after about 1991. The meeting recognised that it was about that time that there had been a move to require contractors, especially on large infrastructure projects, to seek prior consent under Section 61. With such a consent in place, Section 60 powers are no longer available. There was a degree of satisfaction that a plausible cause had been identified.

Paul Shields finished the morning session with a few slides showing some early results of another Defra-sponsored project, this time involving noise monitoring. In particular, he showed the results of recent monitoring at five locations in central London which had previously featured in the London Noise Survey of 1961/62 and which had been mentioned in Wilson. It was not possible to place the microphone in exactly the same location as 50 years ago, but taking the results at face value, the results show that it is quieter in London now. However, at one location, it was possible also to look at results over the last 10 years as well, and that showed that the noise levels seem to have plateaued over the last 10 years.

The afternoon session commenced with Stephen Turner describing current noise policy and comparing its content with previous policy documents. He touched on the emerging National Planning Practice Guidance and noted how, in the context of the current debate about the setting of national numerical guidelines, Wilson had offered some guideline values that did vary with location. He also discussed the meaning of the words "acceptable" and "unacceptable" which can be found in various policy documents over the years.

Richard Greer gave a very thoughtful presentation on the current techniques available for assessing large infrastructure projects. He not only focused on the assessment of the construction phase but also discussed whether "significant" as found in the Environmental Impact Assessment regulations had the same meaning as "significant" in the Noise Policy Statement in England.

The final paper was arguably a "first" for the Institute. It was introduced by Tania Plahay, head of environmental noise policy at Defra, and she described a workshop that Defra had organised earlier this year looking at how the noise environment might change in the future. Hayley Shaw from Cranfield University, who was one of the main facilitators of the workshop, then presented a paper that explained that futures research is not about predicting the future, but instead involves looking at plausible future scenarios. She described how the workshop drew on six scenarios that had been developed for the 2011 National Ecosystem Assessment and then considered what the noise environment might be like in those scenarios. Drivers were identified including transport technology, public perceptions and tolerance of noise, the approach to planning policy and development, the level of social cohesion and the links between noise and health. The scenarios included "A Green and Pleasant Land" where a preservationist attitude arises because the UK can afford to look after its own backyard without diminishing the ever increasing standards of living, and "National Security" where climate change results in increased global energy prices forcing many countries to attempt greater self-sufficiency (and efficiency) in many of their core industries. Hayley described how, for each of the scenarios, the workshop considered what might happen to the drivers. Tania confirmed that a report on the workshop will be published by Defra in due course.

For such a seminal document as the Wilson report, it seemed very appropriate that the Institute should mark the 50th anniversary at the Royal Society, and there seemed to be a general mood that the meeting had done it justice.

The conference speakers

Ninety-one students awarded Institute Diploma in 2013

By Keith Attenborough, Education Manager

In 2012/2013 the IOA Diploma in Acoustics and Noise Control was centre-based at four institutions (Derby University, Leeds Metropolitan University, the University of Salford and the University of the West of England, Bristol), and offered through a further five tutored distance learning centres (St Albans, Ulster, Bristol, Southampton Solent University and Edinburgh Napier University). The 2012/13 Diploma presentation was the fifth year since major revisions made in 2008.

The GPA Part A questions concerned acoustic intensity, A-weighting, enclosure modes, definitions of noise indices and calculation of sound level from pressure, beats, reverberation time, the hearing mechanism and vibration-induced physiological effects. Surprisingly the RT question was answered least well, but, on the whole, these Part A questions were answered well. This year, no candidate failed the GPA only as a result of not meeting the 50% threshold for Part A. Part B questions were about outdoor sound, building acoustics, airport noise, vibration isolation and room acoustics. The question on vibration isolation was least popular but answered well by those who attempted it. The question on room acoustics was most popular but answered least well. All part B questions resulted in mean marks above 60%. The coursework assignments concerned assessment of aircraft noise and school building acoustics. The mean conflated 2013 GPA mark is not as high as in 2012 or 2009 but comparable with other years.

It was found necessary again to moderate some centre marks for the laboratory module to bring them into line with those for DL candidates. Feedback from DL candidates about the laboratory sessions at Liverpool has been uniformly positive. The laboratory module continues to have a high percentage of merits (54% this year).

A criterion based on the means and standard deviations was used to decide whether or not to moderate marks for the

Centre Name	GRADE	GPA	PROJECT	LAB	BA	NVCE	RA	EN
	Merit	4	1	1	1	2	0	1
DL (Bristol)	Pass	1	4	4	3	1	0	1
	Fail	0	1	0	1	0	0	0
	Merit	0	0	0	0	0	0	0
DL (Cornwall)	Pass	0	0	0	0	0	0	1
	Fail	0	0	0	0	0	0	0
	Merit	6	2	5	1	3	0	2
DL (Edinburgh)	Pass	3	6	3	3	0	3	5
	Fail	1	2	0	0	0	1	1
	Merit	16	5	8	5	9	3	5
DL (St Albans)	Pass	12	14	17	11	4	1	6
	Fail	5	11	1	6	6	4	5
	Merit	6	1	5	0	0	0	5
DL (Ulster)	Pass	4	9	5	3	3	6	3
	Fail	0	0	0	0	0	0	0
	Merit	6	3	3	4	4	0	4
DL (South-ampton Solent University)	Pass	3	7	6	1	3	2	0
	Fail	0	0	0	1	0	0	1
	Merit	5	2	3	1	3	0	0
Leeds Met University	Pass	4	6	3	4	1	2	2
	Fail	1	3	2	3	2	0	0
	Merit	6	1	4	2	5	0	0
University of Salford	Pass	2	3	4	3	0	0	0
	Fail	0	4	0	4	3	0	0
	Merit	7	3	8	0	2	0	10
University of Derby	Pass	16	21	17	12	5	12	11
	Fail	4	3	0	3	0	1	0
	Merit	0	1	0	1	0	0	2
University of the West of England	Pass	1	2	0	2	0	1	1
	Fail	0	1	0	0	0	0	0
	Merit	**56**	**19**	**37**	**15**	**28**	**3**	**29**
Totals	**Pass**	**46**	**72**	**59**	**42**	**17**	**27**	**30**
	Fail	**11**	**25**	**3**	**18**	**11**	**6**	**7**

IOA Diploma results chart for 2013

specialist modules. This year the marks for the Building Acoustics assignment, concerning the acoustical implications of closing the roof at the Centre Court at Wimbledon, were anomalously low and a blanket increase was applied at moderation. Subsequent discussion has indicated that the layout of the assignment may have been partly to blame. The first page preamble included details of how the questions (on the second page) were to be approached and it appears that many candidates did not bother to read the first page with sufficient care.

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 following table of results. 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 113 candidates (including four from overseas) entered for the General Principles of Acoustics (GPA) written paper in 2013. This is more than in the last two years but well below the peak of 216 in 2006. There were 36 candidates for Regulation and Assessment of Noise (RAN), 56 for Noise and Vibration Control Engineering (NVCE), 75 for Building Acoustics (BA) and 66 for Environmental Noise Measurement, Prediction and Control (EN). Out of the 116 registered for the Project Module, 25 candidates listed as having failed the project in the table 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 Samuel Daintree (Leeds Metropolitan University). Special commendation letters offering congratulations on also achieving five merits have been sent to Muhammad Gul and Chloe Long (DL St Albans) and Mark Underhill (DL Bristol). Suzanne McCreesh (DL Ulster), who obtained four merits, is recommended for the IOA Irish Branch award for the best-performing Irish Diploma student this year.

David McArthur, one of the students awarded a project merit in (2011-12), has received the ANC best project award for his project, *Amplitude modulation in large wind turbines and the application of the Den Brook Condition.*

Last but not least, I would like to express thanks to all tutors and examiners and to Hansa Parmar in the IOA office for their contributions during the 2012/2013 presentation year of the Diploma.

List of successful Diploma candidates in 2012/13

(R) indicates a resit candidate completing in 2013

Distance learning (Bristol)

Burns O
Lillis-James J
Underhill M A
Wigfield W J

Distance learning (Cornwall)

Gillilan I (R)

Distance learning (Edinburgh)

Barbour A
Cartwright M (R)
Coulon M
Dobinson N A
Kontesidou E
Lauder G M
Quayle E L
Robertson M A
Wilson I S

Distance learning (St Albans)

Byrne J N
Gul M S
Harlow C
Kourtis G
Lees A J
Long C
Marsters H E
Micallef C
Minns G
Myles H S
NG T S
Robinson A W
Singh J (R)
Talbot M P (R)
Thomason R S
Thomson P E
Trup A T
Walshe M A (R)
Williams M N R
von Borzyszkowska A

Distance learning (Ulster)

Alonso Garcia J C
Daly C M
Kinnear S G
Lilley M
McCambley D G
McCreesh S M
Mills S A
O'Donovan M W
Roche C
Starbuck A

Leeds Metropolitan University

Ashby R J
Daintree S P
Dennon N
Dowker G I (R)
Lathan D
Martin A T
Rees J

University of Salford

Davies G D
Fletcher P A (R)
Hughes G A
Sanderson T I
Smout C D

Southampton Solent University

Bamford A S
Bradding D R
Ingram C E J
Loft M
Niemann J
Richardson P
Whitmarsh D P J
Williams J P
Wilson G L

University of Derby

Bell F N
Bush N
Buttery D
Crimp M
Davis G R
Fountain D A (R)
Gaten B L
Girvan C L
Green J S
Jeffcoat P
Long R
Maple K D
Mart J
Patel K
Pears J P
Price R J
Rawson T L (R)
Rogers P W
Sherlock-Brown T
Skopinski N
Strutt P H
Taylor R G

University of the West of England

Bartlett S M (R)
Taylor D M
Waring M T
Wiltshire M

Please note: the titles of the student projects will appear in the next issue.

Institute Council approves nearly 70 more membership applications

Sixty-nine applications for Institute membership were approved by Council in December following the recommendations of the Membership Committee.

Of the total, 47 applications were for new or reinstated membership and the remainder were for upgrades. ◘

Fellow
Kahn S W

Member
Barrett S M
Best A
Blacklock J D
Brandon J
Bullmore A J
Cardoso C F
Chan H B
Chan H
Cheong M A
Clark C
Clarke A S
Drever J L
Farrer E J
Fryer A D
Grimes J R
Harbon D
Haynes S L
Hills T D
Laws S R
Mackay J
Matheson C
Pink R S
Popoola A O
Queenan A E
Ruiz Caro M D
Smith N
Sutton D P
Todd A S
Wheeler S

Associate Member
Arnold J J
Baldwin J M
Bartlett S M
Berry S D
Blanco Galindo M
Bonnet F
Bradley C D
Cumming S F C
Degos D
Di Carlantonio G
Di Stefano P
Eldret E
Fletcher P A
Fletcher R
Flood D
Fuzellier M F P
Gabor T
Goldsmith E M
Huntington P D
Langrish D G
Morgan M
O'Donnell J
Plail A
Price A S
Singh J
Talbot M P
Taylor A
Thomson M J
Walshe M A
Wilkin J A
Wong G K

Affiliate
Hall M
James R L

Technician
Latta P
Nikolova L S
Taylor D R

Student
Holmes C
Southgate B

Sponsor
Xi Engineering Consultants

BB93 update and practical acoustics and noise control

Central Branch reports

By Richard Collman

In October Andrew Parkin presented an update on BB93 based on his lengthy experience with the evolution of this document.

Andrew managed the difficult balance of covering a wide range of the changes in this guidance but explaining in sufficient detail that made sense to listeners not familiar with this relatively comprehensive and technical guidance document. Other factors that affect school acoustics were also reviewed, including the challenges of the Priority Schools Building Programme setting generally tighter standards (except in acoustics?) but with a much smaller budget for achieving them. It was interesting to hear that while steel is generally less suitable than concrete for thermal inertia, rusty steel provides more comparable performance but is not likely to be used as an alternative material. Andrew discussed some of the challenges posed by sports halls, open plan teaching areas and "long rooms" together with how these are to be addressed in the new guidance. Other challenges, such as those posed by the inevitably contradictory requirements of sustainable building, were also considered. Andrew also had an important message for acousticians working in many areas of construction in that we must understand other disciplines if we are to function effectively as part of the design team and ensure that acoustics is treated as seriously as it should be at the design stage.

For the November meeting Paul Absolon of CMS Danskin talked about his extensive experience of noise control mainly in the relatively heavy engineering sector over the past few decades. One of his earliest projects was reducing noise from BT's mobile generators to a level suitable for residential areas at night. As is often the case with this type of work, the most difficult part was not in reducing the noise level but with other client requirements, surviving a three day "weather ingress" test which included soaking the enclosure and then driving it over "rough terrain" (logs on a road). Another memorable job was restoring the stealth to nuclear submarines after the installation of new fans increased the hulls' radiated acoustic energy, making them easily detectable when on patrol.

More recently Paul has been working with screens, partitions, lagging and flooring systems covering a wide range of applications, including some requiring very high levels of sound insulation to be achieved. Several of these projects for major developments have shown how important it is that acoustics be properly addressed at the design stage and, equally importantly, that the construction work then properly implements the designed acoustic solution. Where this good practice has not been followed it has added several hundred thousand pounds to the cost of acoustic treatment for some projects, particularly when it has necessitated stripping out fittings etc before being able to rectify the faults in the acoustic work.

As usual after both meetings, the discussion continued and broadened to other (generally acoustically related) topics at a local Indian restaurant. Our thanks go to Andrew and Paul for interesting and entertaining talks and to NHBC for hosting both meetings. ◘

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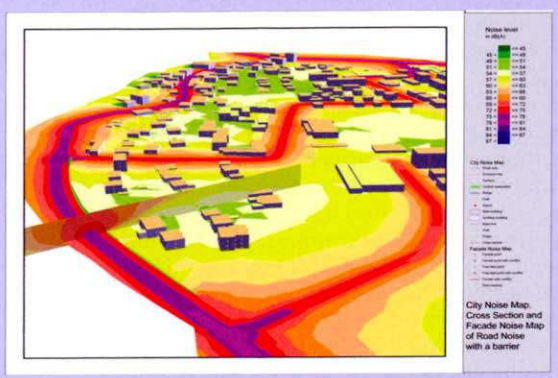
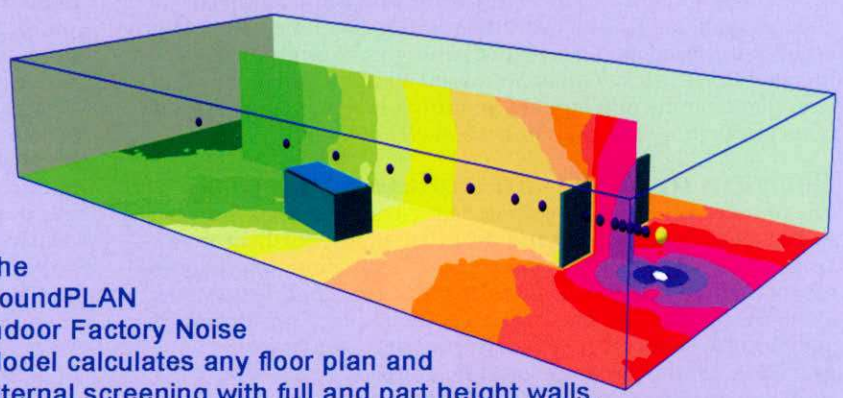


City Noise Map, Cross Section and Facade Noise Map of Road Noise with a barrier

Stunning, easy to use Graphics.



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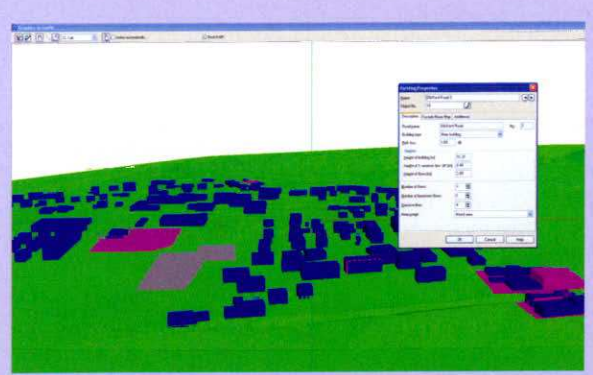

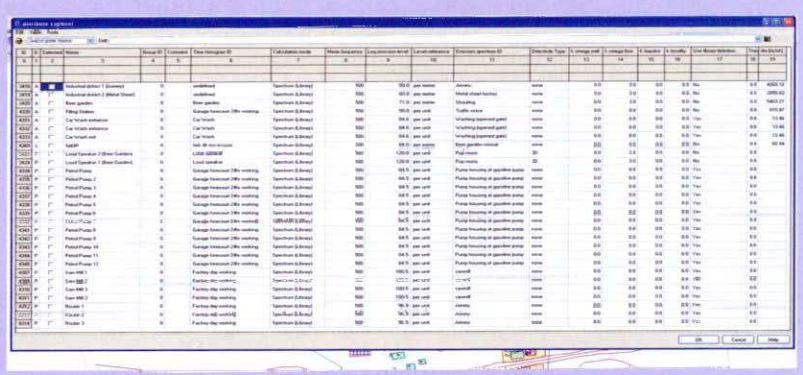

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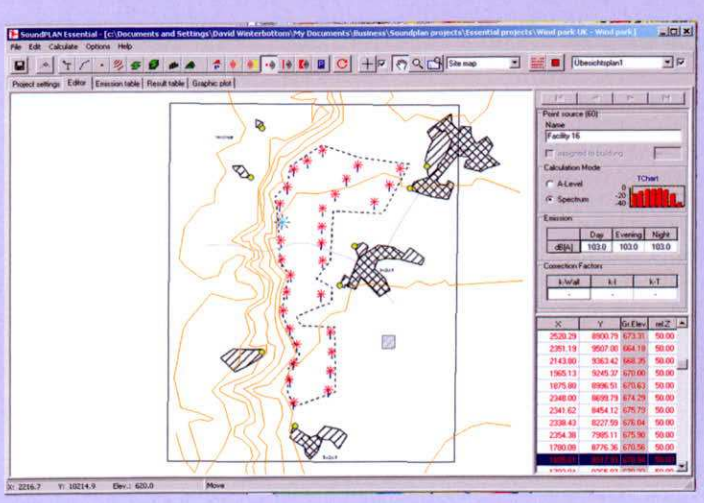
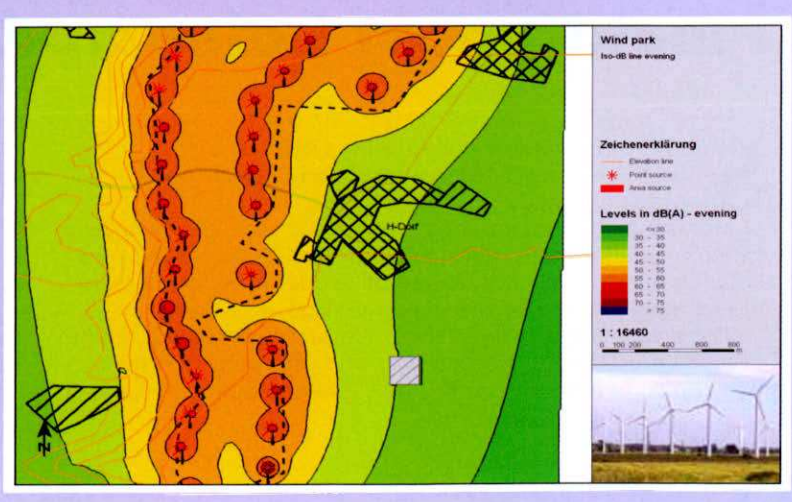




North West Branch meetings

Reports by Mike Hewett, Michael Lotinga and Carl Hopkins

Revision to BS 8233: what's it all about?

Phil Dunbavin presented an update on the proposed changes to BS8233 to a large enthralled audience at the Arup offices in Manchester. The presentation generated a stunned silence from most of the audience as the magnitude and implications of the changes sank in. Later a lively discussion developed particularly around proposed changes to and omissions from the recommended noise levels. Phil encouraged all present to log any comments on the official BSI consultation website that was open at the time. The outcome is eagerly awaited.

Revision to BB93 – an update on its progress

The branch met again at Arup in Manchester, to hear Andy Parkin give a helpful and candid update on the forthcoming revised version of BB93. In the discussion session that followed, one of the main points of concern raised was that the new standards could, in effect, lead to lower acoustic performance standards in school music accommodation, when some attendees felt the previous standards already resulted in problems for some schools. In response, it was pointed out that schools acoustics are not immune from the economic constraints affecting policy with regards to publicly funded buildings, and the new document perhaps represented the best compromise that could be realistically expected in the current climate.

Interactive performance for musicians with a hearing impairment

At a meeting held at the University of Liverpool, Carl Hopkins and Saúl Maté-Cid presented findings from recent AHRC-funded research involving collaboration between the Acoustics Research Unit at Liverpool and the Royal Northern College of Music. The research was inspired by Dame Evelyn Glennie who describes feeling and using vibration when playing percussion instruments. The aim was to investigate the potential for vibrotactile feedback to facilitate interactive group performance with deaf musicians to compensate for the lack of auditory cues, and to avoid reliance on visual cues. The intention was to open up new opportunities for people with a hearing impairment to become musicians and perform with other musicians. After the presentations, Gary Seiffert gave demonstrations of vibrotactile feedback on the hands and feet for attendees to try out.

The first component of the research established the limits for perceiving vibration (vibrotactile thresholds) on the glabrous skin of the fingertips and feet over a range of musical notes (C1 to C6). It was found that that there is no statistically significant difference between vibrotactile thresholds for people with a severe/profound hearing impairment and normal hearing. These thresholds helped define the usable dynamic range that would avoid vascular symptoms from exposure to vibration because musicians typically practise/perform for several hours each day. Practical implementation of vibrotactile technology poses no issues for pop/rock although classical music might require compression to increase the level of quiet music (e.g. pianissimo) and decrease the level of loud music (e.g. fortissimo). Another finding was that it is not possible to perceive pitch information reliably above the note A5 (almost two octaves above middle C).

The second component concerned the perception and learning of basic relative pitch through the skin. Both normal and hearing impaired participants undertook a pitch discrimination experiment with a full test before and after a 16-session training period, which indicated a high success rate for basic relative pitch with and without training. This has important implications as it was postulated that hearing impaired participants might be better at the task due to neural plasticity (where the brain reorganises the sensory processing) such that some somatosensory processing takes place in the auditory cortex. This implies that everyone has a basic ability to perceive relative pitch. Tests also identified an important limitation of vibrotactile feedback as it was shown to be difficult to distinguish intervals smaller than three semitones.

The third component provided "proof of principle" through audio and video recording of a group musical performance using vibrotactile feedback. For this performance, the acoustic labs at Liverpool were used to ensure that all auditory cues from other musicians were removed and there was no visual contact between the musicians. The song *Day Tripper* by The Beatles was chosen because it contains ample opportunities to demonstrate timing, pitch awareness and ensemble playing. The subtitled video was aimed at a lay audience to increase public understanding and appreciation of how music can be performed without auditory feedback as well as disseminating the headline research findings. The video had more than 1,000 views in its first week online (see **https://stream.liv.ac.uk/kgfymdz4**).

The branch extends its grateful thanks to Phil Dunbavin, Andy Parkin, Carl Hopkins, Saúl Maté-Cid and Gary Seiffert for their contributions, as well as to Arup and the University of Liverpool for providing hospitality.

Southern Branch revs ups for motorsport noise update

Southern Branch was delighted to welcome Mike Stigwood of MAS Environmental to talk on motorsport noise.

Mike's detailed presentation provided a review of his investigation techniques into nuisance claims, assessment and presentation of evidence. It included a flavour of the recent techniques adopted to inform decision makers.

The presentation covered the main principles which tend to be given most weight by the courts and the forms of evidence that appear to have most influence. Mike also provided a review of the major cases in which he is involved and his interpretation of the decision of the Court of Appeal in the Mildenhall case.

He also provided his assessment on how this conflicts with other decisions of the courts leading to legal conflict which it is hoped the Supreme Court will resolve in the coming months.

We are also pleased to report that around 20 people registered to view the live webstream of the presentation via the Go To Webinar software, with excellent feedback received. The presentation is available at: **http://bit.ly/IP73Xn**

Acoustics with lasers

Midlands Branch report

By Kevin Howell

For our October meeting we were welcomed to a new venue – Jacobs Engineering, Coventry, where Ben Piper of NPL presented *Acoustics with lasers: Work towards a new free-field primary standard and seeing sound fields.*

Ben began with a brief description of the NPL (founded in 1900), its state-of-the-art laboratory facilities and 450 plus measurements specialists. He then looked in detail at two current research projects at NPL which uses lasers to measure the properties of airborne sound.

Ben described the primary measurement standards in acoustics and the principle of using the reciprocity method in both pressure fields and free field. However, the presence of the microphone causes diffraction of the sound wave and requires that corrections are made to the measured results which depend on the particular test specimen. He mentioned a number of optical methods available for measuring sound and then concentrated on Photon Correlation Spectroscopy, which is a method for measuring the absolute free-field acoustic particle velocity due to a propagating sound field. This technique could provide a new standard for the free-field calibration of microphones by allowing the direct measurement of the pressure at a precise point within an anechoic chamber at which a microphone can then be placed and its sensitivity determined. With the use of some fascinating videos, he demonstrated the method and then summarised the results to date, the current limitations of the method and the future plans to overcome these.

The second method he described makes use of a scanning laser vibrometer to exploit the acousto-optic effect. This technique can give spatially detailed information about the sound radiating from a sound source or the interaction between a surface and an incident sound wave. Ben described the experimental set up and compared results from the acousto-optic method and a conventional microphone set up. The method is a useful tool for exploring and visualising sound fields, for example how sound diffracts around a loudspeaker cabinet, or how it is reflected from a diffusing or absorbing surface or interacts with obstacles and boundaries.

Ben concluded that lasers can be used to measure sound and that these methods can lead to a new free-field primary standard that is absolute, direct and independent of the physical characteristics of the particular item being tested. They can also offer an alternative to microphone arrays for measuring sound fields.

Thank you to Ben for his very detailed presentation and to Adam Baker and Jacobs for providing the venue. ◘

Note from the editor

A bigger number of contributions than usual has inevitably meant that several items have had to be held over until the next issue. Apologies to authors and readers who had been expecting to see them in this issue. Please note that the deadline for the March-April issue is 12 February but it always assists the editor if items can be sent a few days before, if not even earlier. ◘

Lively debate on schools acoustics at the ANC's annual conference

Green Book launch

The first edition of the ANC Green Book, Environmental Noise Measurement Guide, was launched at its annual conference in Birmingham. It can be purchased from the ANC website (**http://www.association-of-noise-consultants.co.uk/Publications_Guidelines**)

Graham Parry (ACCON), Ed Clarke and Daniel Saunders (both of Clarke Saunders Associates) provided an overview of its contents and its intended use. It was explained that it had been written to provide guidance aimed at junior acoustics professionals that would also be useful to more experienced practitioners. In addition, it aims to provide advice relevant to the measurement of noise, evidence of good practice in the measurement of noise and information useful when reviewing measurements and assessments carried out by others.

Dan ran through the main sections which included advice covering: noise policy and sector guidelines; scoping; survey methodology and preparation; site work; data handling and storage; analysis and assessment; and reporting. Graham, Dan and Ed went on to discuss each section in more detail.

The importance of understanding the aim of a noise assessment before planning and undertaking any measurements was identified and it was suggested that where possible, consultants should "start where they want to finish" when planning noise measurements.

We were told that with modern equipment the collection and post processing of large quantities of data was now possible and that it is very rare to have "too much data". However, it was stressed that additional accompanying information such as photos and detailed site notes were just as important as measured noise data. Dan Saunders went on to say that a consultant's eyes and ears were just as important as a sound level meter (and personal protective equipment) when carrying out noise measurements.

Attendees were also reminded that it is important to fully understand the requirements of the client before beginning a noise assessment and undertaking any measurements. It was pointed out that the client's understanding of the scope of a noise measurement and assessment exercise may be very different to that of the consultant and ensuring all parties fully understand the works at an early stage could avoid difficulties later on.

The presentation led to a lively discussion session. One key area of discussion was around measurement uncertainty and it was suggested that a "round robin" study to investigate uncertainty associated with environmental noise measurement may be a very useful exercise.

Schools acoustics

Andy Parkin, ANC Vice Chairman, opened the schools section with a request to delegates to "get Tweeting" to reflect the technology which the ANC was embracing. He had hoped that the day would have seen a replacement for Building Bulletin 93, *Acoustic Design of Schools: A Design Guide (BB93)*, but, due to ministerial "faffing", the draft had not yet been published.

Andy gave an overview with the proposed changes to BB93 introduced in 2003 which was not equipped to deal with refurbishments due to the fact that pre-recession there was more money "sloshing around", which meant that new build developments were preferred with typically fewer design constraints.

Issues raised by Andy included: were proposed standards for refurbishments OK? Were sound insulation target too low or too generic? The change from $D_{nT,mf,max}$ to $D_{nT,w}$ – was it a good one? Peak summer to mid season ventilation openings roughly translated meant that an external level of 56dB $L_{Aeq,30mins}$ was now within target for a secondary school classroom, previously this was closer to 54dB $L_{Aeq,30mins}$ under Building Bulletin 101 Ventilation and indoor air quality in schools (BB101). The L_{A1} parameter was dropped too as statistically impossible to exceed in a space if ambient target met. Internal noise targets during heavy rain were 25dB above internal noise targets – 5dB higher than currently required under Building Research Establishment Environmental Assessment Method (BREEAM). The sound insulation matrix has been simplified with no more "very low". Other changes include composite sound insulation performance for corridors; a broader Reverberation Time (RT) target for Special Educational Needs (SEN) children; a longer RT for sports halls and; more onus on computer modelling for open-plan spaces.

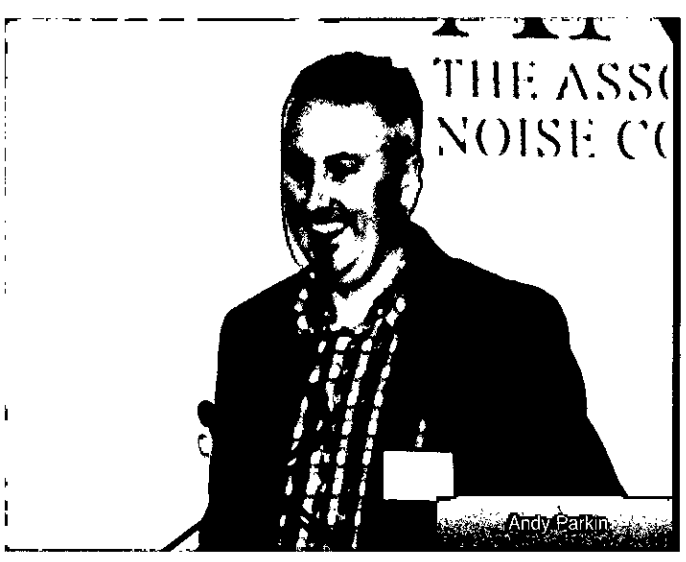
Before handing over to Jack Harvie-Clark, Andy raised the query about accreditation for testers following an email prompt from United Kingdom Accreditation Service (UKAS) and a reminder that the IOA/ANC response was needed end of November in real terms.

As the managing director of a UKAS-accredited acoustic consultancy, Jack was well positioned to discuss commissioning with a reminder that we could "regulate" but not "accredit" as per UKAS. It was a contractual requirement to test under the Priority Schools Building Programme (PSPB) but ANC members could test using guidance under the ANC Good Practice Guide. However, this was done at own risk and no reports or procedures were checked by the ANC or other recognised body.

The ANC position was best summarised in that the existing pre-completion testing registration scheme for residential dwellings could be extended to schools. Jack also made the point that third party "accreditation" for schools testing were important to protect testers from the contractor's brown envelope. In summary, we cannot afford not to have some form of school testing.

Questions to a panel comprising Andy, Jack, Adrian James and Richard Mackenzie then came thick and fast:

Green Book panel (left to right) Dan Saunders, Graham Parry and Ed Clarke



Andy Parkin

Dan Saunders made the point that there was a framework in place so it is not difficult to extend it.

Richard Mackenzie answered by saying that competency could be accredited. Anne Budd asked if schools' testing was required under the Building Regulations. Andy pointed out it wasn't but is under PSBP, academies and certain contracts.

Adrian James view was that UKAS concerns raised were nonsensical as they were recognised for residential testing only.

Pete Rogers then took the microphone to ask whether we were trying to raise or maintain standards in schools. Was the ANC to be regarded as schools testing policeman?

Andy Parkin responded that building control should be "police people". Adrian added that we are not the police but competency is a real issue particularly regarding some of the reports he has seen.

After further discussion Adrian also pointed out that ADE would be with us for at least another 10 years. The testing debate was rather succinctly put to bed by Adrian and Richard who, rather than reverting to technical argument, gave us an insight into their experiences when the whole requirement for sound insulation performance between residential dwellings was nearly dropped. Instead 2003 saw a relaxation to the guidance but testing became mandatory, the point being that a slight relaxation in standards but with compulsory testing was a good way to actually raise the standard.

There was discussion regarding CO_2 levels in classrooms, opening windows and the Napier Research document where up to 18dB reduction could be achieved depending on orientation of building to source, type and size of window opening.

Ed Clarke made the valid point about the important of acoustics being part of the contract as it was understandable that contractors have to be cost aware. Andy brought this back to funding with new schemes being around half of that under Building Schools for the Future (BSF) previously.

There was a discussion regarding uncertainty, not just in relation to measurement e.g. measurement locations chose but also modelling.

Bridget Shield, IOA President, was interested to discuss pupils with Special Educational Needs (SEN) as it was important to have conditions suitable to the needs of these children under the Equalities Act. For example, children for whom English was a foreign language would have their academic performance affected by poor acoustics. Paul Canning, who helped advise on the former BB93, said advice from audiologists was important. Adrian James explored this further, saying that American research had shown that children with cochlear implants were more sensitive to low frequency noise, hence the greater required control of low frequency reverberation under the new draft!

Environmental Noise Directive and National Planning Practice Guidance on Noise

This session, led by Stephen Turner and Jenny Keating of Defra, began with an introduction to current noise policy issues and moved on to a discussion of the requirements of the Environmental Noise Directive (END). Further information was provided relating to the identification of "Important Areas" under the END in addition to discussion about "Quiet Areas". Stephen and Jenny then provided information about the draft National Planning Practice Guidance (NPPG), which was followed by a question and discussion session.

Stephen began by reminding people of the three requirements of the END: to produce strategic noise maps, adopt noise action plans and make information available to the public. Further information was provided relating to noise action plans and the identification of Important Areas. It was then explained that for the Round 2 noise mapping exercise the criteria for the identification of important areas remained broadly similar, although there were slight tweaks to the criteria for road and aircraft noise.

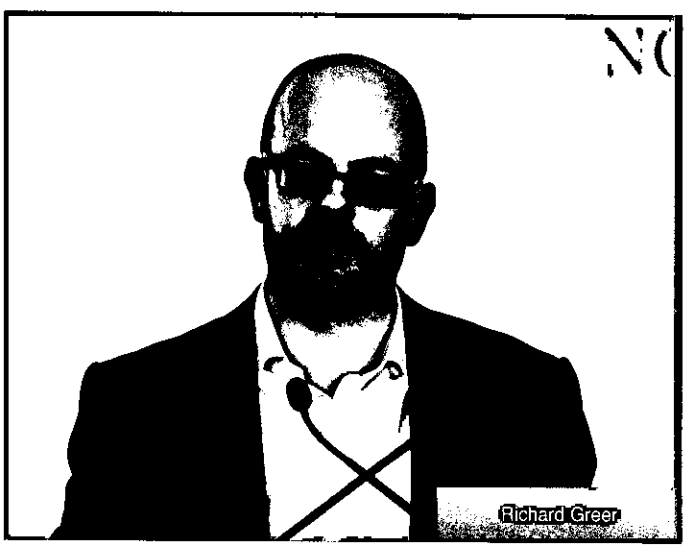
The topic of Quiet Areas was addressed next and the benefits that these areas can bring were identified, including improved human wellbeing in addition to social and economic benefits. It was explained that the END requires that Noise Action Plans include the actions that member states intend to take in the next five years, including any measures to preserve Quiet Areas in agglomerations. However, the END leaves it to member states to decide how to identify and preserve such spaces. The policy and legislative framework around Quiet Areas in the UK was then discussed in more detail and it was explained that at this point in time no local authorities have chosen to identify any Quiet Areas under the END (although a number have shown interest). Information from pilot studies and other feedback suggests that central guidance is needed to facilitate the identification of quiet areas. Further information was then provided covering how Quiet Areas will be addressed during the Round 2 Action Plans. Stephen Turner reminded attendees that the consultation on Draft Action Plans would run to the 29 October and welcomed responses. Publication of Action Plans following consultation and government response is planned for late January 2014.

The consultation draft of the NPPG, one of the hot topics of the day, was the next subject of the presentation. Stephen and Jenny initially discussed some of the key sections of the National Planning Policy Framework (NPPF) and went on to discuss the Taylor Review, which had identified additional planning guidance regarding noise was required, which in turn led to the production of the draft NPPG.

Stephen provided information on a number of key elements of the NPPG. He explained that it aims to make people think about issues but does not prescribe detailed methodology. It was also explained that noise can over-ride other planning considerations but that noise should not be considered in isolation. Listeners were then provided with information about the origins and content of the table in the NPPG that describes the increasing severity of noise effects, starting from "not noticeable" (no observed effect) up to "noticeable and very disruptive" (unacceptable adverse effects). Other key elements of the guidance included information on mitigation, which stated that care should be taken when considering mitigation to ensure that measures did not make for an unsatisfactory development. It was also noted that in relation to external amenity spaces the NPPG advises that where such spaces are an intrinsic part of a development, the acoustic environment of those spaces should be considered so that they can be enjoyed as intended.

The presentation then moved on to the issue of "numbers". Stephen explained that although there were no quantitative criteria included in the NPPG, local authorities working with local communities may decide to include specific noise standards in their local plans. However, it would be important to avoid implementing fixed thresholds as specific circumstances may justify some variation being allowed.

The session ended with a panel discussion chaired by Richard Greer (Arup). Fellow members were Stephen, Graham Parry (ACCON), Colin Cobbing (ARM Acoustics) and Colin Grimwood (CJG Environmental Management). Richard began by summarising the initial ANC response to the NPPG. He explaining that the ANC welcomed the guidance overall but also identified a few key points that had been raised by ANC members. These included the lack of signposting in the NPPG to key guidance documents and the information being web based only. This then led to a brief but lively period of discussion which finished with Graham suggesting that the planning guidance should include or "signpost" some form of quantitative noise criteria. He suggested that this would increase the efficiency of planning decisions without compromising sustainability objectives.



Steve solves the mystery of the moving Egyptian relic


The relic

The mystery of why an ancient Egyptian relic in Manchester Museum appeared to spin around by itself has been solved for an ITV programme, *Mystery Map*, by an IOA member.

The 4,000-year-old statuette of a man called Neb-Senu was caught on a time-lapse camera earlier this year rotating 180 degrees, despite being locked in a sturdy glass case. At the time the story generated headlines in national and international press.

Mystery Map, which investigates myths and mysterious stories, enlisted the help of Southampton-based consultants 24 Acoustics who demonstrated that vibration from traffic and footfall on the road outside the museum was causing the statuette to move.

Vibration expert Steve Gosling undertook a 24-hour test by placing a specialist three-axis sensor under the wall-mounted cabinet containing the relic, to record any vibrations present.


Steve Gosling explains the mystery to presenter Julia Bradbury

Beginning the test at 6pm, Steve found there was a peak in vibration level which correlated with movement at this time. Overnight the vibrations stopped and the statue stopped rotating. Movement began again at 7am the following day – at the same time the vibrations also started again.

Steve said: "The vibration is a combination of multiple sources so there are buses outside on the busy road, there's footfall activity. And it's all of those things combined."

Steve also explained to *Mystery Map* presenter Julia Bradbury why three other statues in the same glass case at the museum were not affected by the vibrations.

He said: "This statue has a convex base. There's a lump at the bottom which makes it more susceptible to vibrations than the others which have a flat base. We are 100 per cent satisfied this is the cause of the rotation."

Over last summer, there were a number of theories on why it was moving; one outlandish suggestion was it was the spirit of Michael Jackson moving it from beyond the grave. Others believed it was the spirit of Neb-Senu himself moving it.

For a fuller explanation on Steve's test see **www.24acoustics.co.uk**

Heathrow schools to get 'anti noise' Adobe buildings

Heathrow Airport is offering nearby schools the chance to build "noise repellent" Adobe buildings to protect pupils from aircraft noise.

The buildings use a construction system known as "Superadobe"; long tubes of woven polypropylene are filled with soil, laid into shape and then compacted. Barbed wire is used between the layers, acting a bit like Velcro, sticking the tubes together and at the same time providing reinforcement.

Seating up to 30 pupils, they are said to provide significant noise respite from overhead aircraft, whilst still retaining a feeling of being outside.

They are an invention of Californian architect Nader Khalili developed in 1984 in response to a NASA call for designs for human settlements on the Moon and Mars. They are often used to provide emergency shelters but the benefits have spread further afield.

The airport will offer 21 local schools £85,000 each to install an Adobe building in their grounds, as part of its drive to reduce the impact of noise on local communities. The move follows the pilot of an Adobe building at Hounslow Heath School.


An Adobe building

Study in excellence: a brief history of the Institute of Sound and Vibration Research

In his second report celebrating the 50th anniversary of the ISVR, Frank Fahy looks back at the origins of the Institute and at some of the key developments since 1963 which have seen it evolve into an internationally recognised centre of excellence for research, teaching and consultancy in acoustics, noise and vibration

1952-62 Aeronautical origins

The University of Southampton received its Royal Charter in 1952. The age of the turbojet-driven airliner began in 1949 with the introduction into service of the de Havilland Comet, followed in 1954 by the Boeing 707. During the 1950s, the head of the Aeronautics Department at Southampton was Professor Elfyn J Richards (EJR) who had previously been Chief Aerodynamicist and Assistant Chief Designer at Vickers Armstrong. He became most concerned about the impact on exposed communities and aircraft structures of the very high levels of noise generated by jet airliners. He set up a strong postgraduate research school to explore noise and vibration aspects of unsteady airflow, and of aircraft structures and materials, fields that he perceived to be deficient in research in the UK and beyond. In 1958, the department received a large grant from the US Air Force to research acoustically induced damage to aircraft and rocket launcher structures. In 1961, the department inaugurated a master's course in noise and vibration studies.

1963 The ISVR is born

In the early 1960s, EJR's concerns about many different aspects of noise in the environment and in work places grew and he served on the Government's Noise Advisory Council. He proposed to the university the foundation of a new institute that would specialise in noise and vibration. In spite of opposition from some academic quarters, his tenacity and negotiating skill won the day. In October 1963, the Institute of Sound and Vibration was formally established. The members of the academic staff initially comprised EJR, Newby Curle, Peter Davies, Philip Doak, Brian Clarkson and Graham Gladwell, subsequently joined by Theo Priede and Peter Tanner. Research Fellows were Max Bull, Mike Fisher, Tony Pretlove, John Willis and Frank Fahy, later joined by Chris Morfey, Maurice Petyt, Chris Rice, Mike Shelton and Emeritus Professor Eric Zepler. Grace Hyde was the ISVR secretary.

1963-5 Major acoustic test facilities constructed: MSc course in sound and vibration initiated

During 1963-64 a bid to the Department for Scientific Research for a block grant of £140,000, which included a substantial sum for the construction of acoustic test facilities, is successful, P28

◀P27▶ which ultimately leads to the construction of the Rayleigh Laboratories comprising two reverberation chambers, an anechoic chamber and associated offices. An MSc course in sound and vibration studies is initiated. Research projects predominantly address aerospace-oriented topics, particularly acoustic fatigue of aircraft structures, the physical and subjective effects of sonic boom, and boundary layer noise; but the scope rapidly expands to include machinery noise, pipe noise and vibration and general noise control. In 1964, Philip Doak founds the *Journal of Sound and Vibration* of which he continues as editor-in-chief for four decades.

Although very much concerned with the engineering aspects of noise and vibration control, EJR did not neglect the audiological and societal impacts of noise. During 1964-5, academic and research appointments are made in the fields of audiology and subjective acoustics. Surgeon Commander Ross Coles is appointed Senior Clinical Research Fellow. His initial research at the ISVR continued earlier studies in gunfire noise induced hearing loss, but he was to become increasingly involved, in collaboration with Chris Rice, with the hazard to hearing of industrial noise and with clinical diagnostics

1966-7 Research groups and consulting unit formed: Data Analysis Centre established

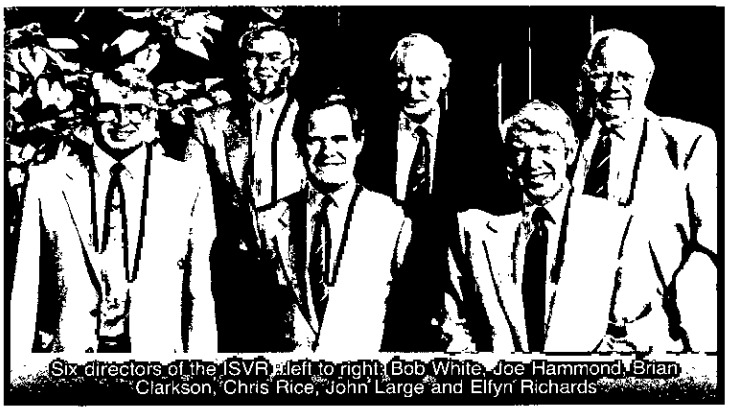
In a development that underpinned much of the subsequent success of the ISVR, Phil Doak sets up a system of four research groups that are managed and led by senior members of academic staff and have associated with them dedicated secretaries and technicians whom they supported largely through research grants. The groups are Structures and Vibrations, Audiology, Industrial Noise and Instrumentation, and Fundamental Acoustics and Aerodynamics. As a result of the increasing adverse impact of road traffic noise, an Automotive Research Group is later established under the leadership of Theo Priede. An Industrial Noise Unit is formed with three consultants. Subsequently, the unit becomes the Wolfson Unit for Noise and Vibration Control. The Structures and Vibration group is awarded an Science Research Council grant of £55,000 for a Random Data Analysis unit, as a result of which a Marconi Myriad computer is purchased: subsequently, the RDAU becomes the Data Analysis Centre, managed by Colin Mercer. In October 1967, EJR is appointed Vice Chancellor of Loughborough University, and Professor Brian Clarkson becomes the Director of the ISVR. The Audiology and Human Factors group is formed under the leadership of Ross Coles and Chris Rice. The Rayleigh building and laboratories are completed and fitted with three I.C. engine test cells.

1968-73 Automotive Advisory Unit established: Undergraduate engineering acoustics course initiated

In 1970, the Fluid Dynamics and Acoustics group receives a major grant for research into means for developing in-duct systems for reducing jet engine compressor noise. The Automotive Research group receives a grant for collaborative research with the Motor Industry Research Association aimed at developing low noise designs of turbocharged diesel engine, as a result of which an outdoor engine test facility is constructed. A major grant is awarded by the Medical Research Council which supported four scientists and six support staff for six-and-a-half years. The Automotive Design and Advisory Unit (ADAU) is formed in 1971. The unit operated both in research and consultancy modes. The installation of three engine test cells allowed the ADAU to collaborate with every major automotive engine manufacturer in the world. In 1973, the Wolfson Unit launches a hearing conservation service for industry. The undergraduate course in engineering acoustics is initiated. Research into methods of measuring sound intensity begin.

1974-82 Auditory research groups formed: Research into wind turbine noise begins

Professor Richards returns to the ISVR in 1974 and sets up an Industrial Noise Research and Development group. In 1978, Brian



Six directors of the ISVR, left to right, Bob White, Joe Hammond, Brian Clarkson, Chris Rice, John Large and Elfyn Richards

The Queen presents her anniversary prize to Steve Elliott and Phil Nelson

Clarkson is appointed as Dean of the Faculty of Engineering and Applied Science and is succeeded by John Large as ISVR Director. In 1981, the Auditory Communication and Hearing Conservation Unit is formed, with Peter Wheeler as Manager. In 1982, Bob White succeeds John Large as ISVR Director in which position he remains for seven years. An auditory vestibular research facility is established. Philip Evans is appointed head of the Wessex Audiology Clinic within which a new Hearing Aid Rehabilitation Service is established. Douglas Robinson (ex NPL) is appointed visiting research professor. Research begins on wind energy turbine noise.

1984-7 Underwater acoustics tank installed: Signal Processing Group formed

During 1984-7, Neil Halliwell and Chris Pickering coin the term "Particle Image Velocimetry" (PIV) for their technique which is now a standard for flow mapping. A Signal Processing Group, chaired by Joe Hammond, evolves out of the Data Analysis Centre, subsequently renamed the Design and Analysis Centre; this implements new software to enable file transfer, email and campus-wide terminal access, plus gateways to JANET. An image processing facility is funded by SERC. The construction of the A B Wood underwater acoustic tank marks the beginning of what was to become, and still is, a very important programme of underwater acoustics research. From 1970 to 1990, Bob White is sponsored by RAE, EPSRC and BAC Airbus to improve the damping of lightweight composite structures that are now basic to modern Airbus products. In the 1980s and 1990s he helps the MOD to develop improved ship machinery mounting systems that reduce noise and vibration.

1987-89 Audiology activity enhanced: Successful flight trial of ISVR active noise control system

The period 1987-89, during which Chris Rice succeeds ◀P30▶

P28 Bob White as Director in 1989, is rich in terms of the number of substantial grants awarded and research projects initiated. A large grant is received from Wessex Regional Health Authority to enhance the role of the Wessex Regional Audiology Centres on campus and at Southampton University Hospital. Major motor manufacturers sponsor a research programme into subjective response to vehicle interior noise. Studies of motion sickness at sea lead to the evolution of a motion sickness dose value. A prototype system for the active control of aircraft interior noise is developed in a laboratory rig and is successfully flight-trialled in collaboration with British Aerospace. A blast wave simulator is constructed. The HVLab system for evaluating the health risks of human exposure to vibrational inputs developed by the Human Factors Research Unit (HFRU) is widely adopted.

1990-91 Cochlear implantation begins: Acoustic sizing of small air bubbles in spume achieved

The period 1990-91 is especially marked by the first cochlear implantation involving the ISVR Hearing and Balance Centre, leading to the formation of the South of England Cochlear Implant Centre (SOECIC). A brief history of the centre (recently renamed The University of Southampton Auditory Implant Service) can be found in the article on ISVR 50 in Vol. 38, No. 5 of *Acoustics Bulletin*. A new listening room is constructed for audio system research. The ISVR establishes the EC COMETT network SAVOIR (Sound and Vibration: Organisation, Information and Resources) which included TNO (Netherlands), Metravib (France), Brüel and Kjær (Denmark), KUL (Belgium). The first stage in what was to become a major research programme led by Tim Leighton into bubble sizing in sea spume is funded by the NERC. Collaboration with Ford produces an automotive engine noise simulator.

1992-4 Human vibration models refined: Underwater hearing thresholds measured

In 1992, Joe Hammond succeeds Chris Rice as ISVR Director. A large number of research programmes are begun during this period, of which there is space to mention only a few. They include the evaluation of vibration transmissibility through a seat in the absence of a human subject; dynamic interaction between the head and helmet with visual display; development of smart structures to reduce sound radiation; higher order spectral analysis for the identification of sources of machinery noise. Major Research Council grants are awarded in the following year for research into ocean sound propagation, biomechanics of the impact-excited brain, and the mechanics of gas bubble behaviour in the ocean. New test facilities are commissioned for the motoring of IC engines, for testing fuel injection systems and the evaluation of underwater hearing thresholds.

1994-6 Detection of buried objects: Survey of noise of railway freight traffic

In 1994-6, major new EC-funded research projects include hybrid laminar flow demonstration on aircraft, and a study of noise generated by railway freight traffic. Other projects include a study of sound propagation in suspended sediments, detection of buried objects and the development of dynamic models of postural stability of the human body in moving environments.

1997-9 Founding of the Rolls-Royce University Technology Centre: Early detection of noise-induced hearing loss

EU-funded research projects initiated during 1997 include multi-national collaboration with the aim of improving signal-to-noise ratios in hearing aids and telephones adapted for disabled persons, "Silent Track", aimed at reducing the noise of freight trains, and a programme funded by the HSE to integrate methods for early detection of noise-induced hearing loss on the basis of otoacoustic emissions. In the following two years, the EC grants £430,000 for research into means of reducing aircraft noise. A new link with DERA provides £148,000, and EPSRC grants £359,000, for the enhancement of sonar detection in bubbly environments. The standardised procedure proposed by the HFRU to quantify signs of vascular and neurological disorders associated with hand-transmitted vibration is accepted by the Health and Safety Executive. The undergraduate course acoustics with music begins in 1998. The major event of 1999 is the opening of the Rolls-Royce University Technology Centre (UTC) in Gas Turbine Noise. Research by this group has been instrumental in assisting RR to maintain its position as a world leader in gas turbine P32


Students attempting to conduct a sonar experiment in the sea


The 6 axis motion simulator in action

P30 manufacture and a major contributor to the GDP of the UK.

2000-2 ISVR coordinates EU Doctorate in Sound and Vibration: Rail damper patented

In 2000, the EU appoints the ISVR as coordinator of the EU Doctorate in Sound and Vibration Studies by which PhD students in EU member states are funded to pursue their research studies for a year in another state. In the following year Phil Nelson succeeds Joe Hammond as ISVR Director. During 2001-2, new EPSRC projects include control of underwater autonomous vehicles, walking orthosis development, development of a 3D chirp sub-bottom profiling system and a study of ground vibration in railway tunnels. The DTI awards a large research contract to a multidisciplinary team to reassess attitudes to aircraft noise in England; Ian Flindell of the ISVR is appointed the team's Technical Advisor on noise. In a major development, an historic sea trial of a system for measuring air bubble populations in sea spume is successfully implemented. A study is made of the perception of music by cochlear implantees. The HFRU wins EU funding for studies of the risk of human exposure to vibration. A new form of rail damper developed by David Thompson is patented and subsequently installed by a number of European railway companies. ISVR research funded by the RNID underpins the NHS programme to provide digital hearing aids. The ISVR Interior Noise Contribution Analysis software is adopted by Ford and is also employed by Jaguar Land Rover and Volvo to this day.

2003-6 Award of the Queen's Prize: Undergraduate programme in audiology initiated

In 2006, the ISVR is awarded the Queen's Anniversary Prize for higher and further education for sustained excellence and outstanding achievements in research in sound and vibration. The prize is part of the national honours system and is awarded every two years to only about 20 university and FE departments across all disciplines. Steve Elliott succeeds Phil Nelson who becomes Pro-Vice Chancellor of Southampton University. The UK government awards a major grant for research into broadband aerofoil noise (in collaboration with Cambridge University). Projects begin on the assessment of the likelihood of auditory system damage by mobile phone use and on a study of sensor clustering in active control systems. A "Skills" laboratory for audiology teaching is opened. A "Joint Lab" is opened for development of virtual 3-D audio systems in conjunction with Samsung Electronics. A programme begins aimed at advancing the state-of-the-art in early seizure onset via electroencephalography. Large grants are received for knowledge networking and concept studies and by the UTC for the reduction of aircraft noise disturbance by novel technology. ISVR initiates Rail Research UK, an EPSRC grant which funds collaborative research in nine universities from 2003 to 2009. Four major research programmes in aircraft engine noise reduction are awarded by the EU. ISVR participates in an EU research network aimed at understanding archaeological and fossil evidence for the evolution of human speech and manual dexterity.

2007-2009 Building 19 for SOECIC and HFRU completed: the HFRU six-axis motion simulator is commissioned

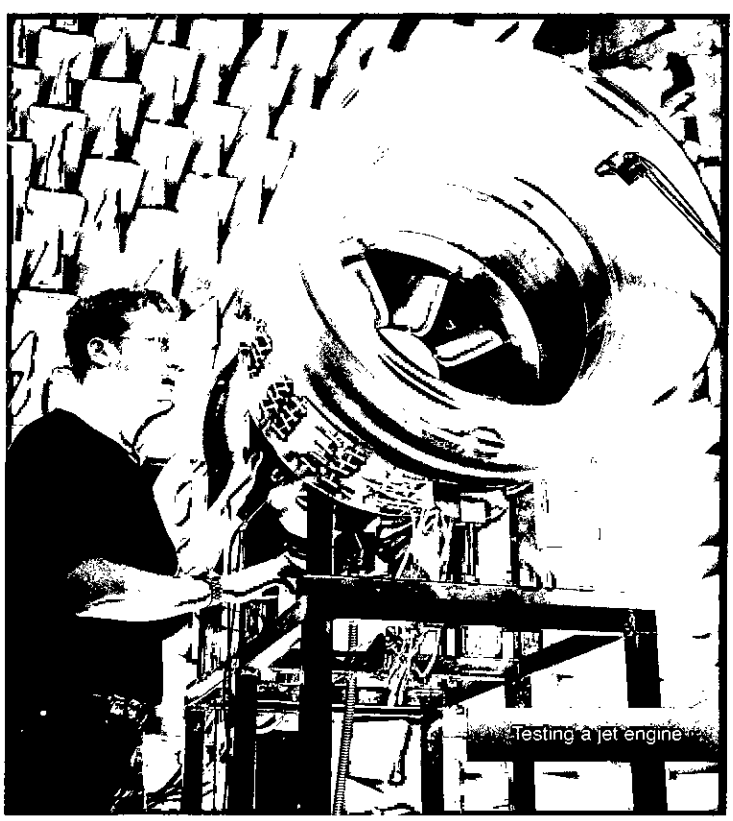
The Earl of Wessex opens Building 19 that contains a unique high fidelity six-axis motion simulator for the study of human responses to vibration.. The Ultrasonics and Underwater Acoustics group receives a grant of US$1.4million to study high energy neutron generation. A Qinetiq award is received for a study of the hazard posed to beaked whales by sonar. ISVR IT support staff are subsumed by the central computing administration. A collaborative programme with Southampton General Hospital and the Universities of Leicester and East Anglia begins to investigate new experimental procedures for detecting patients at risk from inadequate blood flow to the brain. Major EU funding is won for digital signal processing in audiology. Collaboration is undertaken with the University of Nottingham on wave chaos approach to high frequency structural dynamics and Bayesian approach to the estimation of structural dynamic parameters is developed.

2010-13 The ISVR loses much autonomy: Scientific Advisory Board dissolved: Last annual report

In 2010, Jeremy Astley succeeds Steve Elliott as Director. SOECIC conducts the first UK single cochlear implant that serves both ears. Tim Leighton invents the 'Smart Stethoscope'. An inverse microphone array technique for locating and quantifying jet engine sources in a reverberant test cell is successfully implemented. Active control of ship vibration is developed. In 2011, the ISVR is demoted from a department to an academic unit and loses much autonomy and many support staff. ISVR Consulting and SOECIC become enterprise units within the Faculty of Engineering and the Environment. SOECIC becomes University of Southampton Auditory Implant Service. The ISVR Scientific Advisory Board, which was established in 1963 to provide external guidance as required by Senate, is dissolved. The associated ISVR annual report, which has provided a comprehensive archive and also valuable publicity for the ISVR among many acousticians and potential students around the world for 47 years, is subsumed into a faculty report and ceases to be compiled. In 2013, Paul White succeeds Jeremy Astley as ISVR Director. ◘

Some key facts

- The ISVR currently has 33 academic staff, 127 registered research students, 26 research and teaching fellows, 37 Master's students and 1.5 administrative and nine technical support staff assigned by the faculty.
- 789 first degrees, 1,316 Master's degrees and 495 PhDs have been awarded to ISVR students since 1966
- 31 technical books have been authored or edited by ISVR personnel
- Professors Nelson and Rice have served as IOA Presidents
- Professor Chris Rice served as IOA President while ISVR Director



Testing a jet engine

Problems in residential design for ventilation and noise part 2: mechanical ventilation

By Jack Harvie-Clark of Apex Acoustics and Mark Siddall of LEAP (Low Energy Architectural Practice) and Northumbria University

Introduction

Part 1 of this article described the design drivers and regulatory regime for noise and ventilation in dwellings through the Planning system and Building Regulations. This part discusses noise aspects of mechanical ventilation systems in dwellings. Mechanical ventilation is increasingly adopted to meet more onerous energy performance requirements, or to limit the potential for external noise ingress. General limits for internal ambient noise levels described in the World Health Organisations Guidelines for Community Noise (GCN)[1] are generally unsuitable for noise from mechanical services, as they are frequently too high to tolerate. Noise from mechanical ventilation systems is not currently regulated in the UK.

In the UK the industry for the design, supply, installation, commissioning and maintenance of domestic mechanical ventilation systems is currently in its infancy. Although the skills and expertise required to address all issues in every part of the supply chain are present and utilised for commercial buildings, they are rarely applied to dwellings. Failures in parts of the supply chain can result in excessive noise levels. Domestic mechanical ventilation systems have at times attracted bad press as if they are the cause of problems in buildings, when it has often been failures in the design, installation and commissioning that makes them unsuitable to use.

With an industry currently unwilling to acknowledge the challenges of providing appropriate mechanical ventilation systems in dwellings and in the absence of regulation of noise levels, it is unsurprising that excessive noise frequently results. As the systems are usually under the control of the occupants, systems are generally operated at the level at which noise is tolerable – or turned off completely. As noted in part one of this article, the adverse impact of inadequate ventilation upon health and well-being is extensively documented as a public health problem and is not repeated here.

The ventilation requirements and conditions under Part F are described first. This article is based on the paper presented at the 2013 IOA Spring conference [2], with additional material that has subsequently become available.

Mechanical ventilation systems

Since 2002 one of the driving forces to improve standards of energy efficiency in national regulations has been European legislation [3]. The changes in standards have in turn led to the more extensive use of mechanical ventilation with heat recovery. As mechanical ventilation is inherently more controllable than natural ventilation, heat loss P34

◀P33▶ from uncontrolled ventilation through façade vents can be reduced. Mechanical ventilation with heat recovery brings increasing thermal performance benefits as the airtightness of the building envelope is increased [4]. Approved Document F (AD-F) describes two general Systems for compliance with the ventilation requirements using mechanical ventilation, System 3 and System 4, which are outlined below.

System 3 – Continuous mechanical extract (MEV)
This type of ventilation system extracts air from wet rooms (kitchens, bathrooms, utility rooms). The replacement air is either provided by means of background ventilators, or infiltration (air passing through the building envelope) may be relied upon where the design air permeability is greater than 5 $m^3/(h.m^2)$. The system can be either a centralised system, comprising a single fan ducted to extract from multiple rooms, or a decentralised system where individual fans extract air from each room. The systems have two ventilation rates, often referred to as "trickle" and "boost". The minimum low rate or trickle rate must meet the minimum ventilation rates in Table 5.1b in AD-F, and the boost setting must meet those in Table 5.1a for continuous extract - minimum high rate. Systems may also have other settings for user comfort purposes. Purge ventilation may be provided by opening windows.

System 4 – Continuous mechanical supply and extract with heat recovery (MVHR)
Air is extracted through ducts from wet rooms. The extracted air passes through a heat exchanger before being exhausted to outside. Incoming fresh air is pre-heated as it passes through the heat exchanger before being supplied to habitable rooms such as living rooms and bedrooms. The systems in AD-F have two ventilation rates - trickle and boost, and must meet the same minimum ventilation rates for each state as MEV, although again other systems settings may be provided for user comfort and control. Purge ventilation may be provided by opening windows. Background ventilators are not required.

Noise aspects of ventilation conditions

For Systems 3 and 4, AD-F provides for two controlled ventilation conditions as well as purge ventilation in order to address the various demands imposed by occupation. The noise aspects of the two controlled ventilation conditions are discussed below.

Whole dwelling ventilation
Whole dwelling ventilation is the minimum ventilation required continuously while the dwelling is occupied; it would seem entirely appropriate to achieve appropriate indoor ambient noise level limits under this ventilation condition. Appropriate noise level limits are discussed below. It is proposed that this should be the minimum ventilation requirement associated with limits for noise from mechanical services. In practice, mechanical systems may have more operational set points that are controllable by the users than those conditions required for compliance with AD-F. While it is desirable for the occupants that noise levels are satisfactory for all continuous whole-dwelling ventilation rates they may select, this may be the consideration of the designers rather than of regulation.

Control of humidity in bathrooms and kitchens
For the control of humidity from bathrooms, kitchens and utility rooms, extract ventilation rates are lower for Systems 3 and 4 that provide whole dwelling ventilation continuously, compared with intermittent extract rates required for ventilation provided with System 1. Minimum wet room intermittent extract rates for System 3 and 4 are described as the "minimum high rate" in AD-F, and often referred to as "boost" ventilation. Depending on the whole dwelling ventilation rate and dwelling requirements, the boost ventilation rate may be no higher or only marginally higher than the whole dwelling ventilation rates in any case; they are generally of the same order of magnitude. Some informative research is discussed in later sections concerning the boost rate for mechanical extract, but more research is needed to inform acceptable noise limits for this ventilating condition.

Purge ventilation
Even where whole dwelling ventilation is provided by mechanical means, the most common means of providing purge ventilation is via opening windows. Noise considerations of purge ventilation provided in this manner are discussed in Part 1 of this article. As provision of purge ventilation by mechanical means is rare, no discussion of the noise aspects of this subject has been identified in the literature. It would seem that higher noise levels than those required for continuous operation are likely to be acceptable to occupants, but identification of particular levels is not currently possible.

Purge ventilation and overheating
It should be noted that a common use of purge ventilation is to assist in the provision of thermal comfort by reducing the potential for overheating. Whilst this may be convenient and practical, in terms of compliance with the Building Regulations it is a benefit but not the primary purpose of purge ventilation. Overheating is not currently controlled under the Building Regulations. The ventilation rates required to control overheating may be determined for a particular design; there is no reason why the ventilation rates identified for purge ventilation in AD-F should also be the same ventilation rate to control overheating.

Overheating is currently the subject of much analysis, research, definition, and attempted mitigation in some circumstances; enhancing thermal comfort may be achieved in a variety of ways, and relying on purge ventilation provided by opening windows is not always suitable. High external noise levels have been cited [23] as a reason that occupants are reluctant to open windows to provide higher natural ventilation rates during hot weather, when various degrees of elevated temperatures may result. However, the balance between occupants' preferences between various degrees of elevated temperature compared with elevated noise levels has not been documented in the literature, and can only be subject to speculation. Further research is urgently needed to better inform this area of indoor environmental quality where the balance between environmental factors is under the control of the occupants.

Requirement to limit noise levels in dwellings

Requirements to control noise levels in new dwellings may be described in planning conditions, generally where environmental health officers identify external noise as being a concern, but not typically to identify mechanical services noise specifically. Employers or developers occasionally include a performance requirement for noise levels from mechanical services; although this would be normal practice in a commercial development, it is not yet so for new dwellings.

AD-F refers to BS 8233 and recommends, but does not require, that noise levels do not exceed 30 dB(A) in bedrooms and living rooms when a mechanical system is running on its minimum low rate. AD-F also suggests that noise levels should be lower; this consideration is discussed in more detail later. As a recommendation the noise criteria in AD-F are not regulated. Part E of the Building Regulations governing the Resistance to the Passage of Sound, described in Approved Document E (AD-E) does not address the penetration of mechanical services noise into habitable spaces. Until the appropriate place for legislation to control these aspects is determined, LPAs could regulate noise from mechanical services with a planning condition exactly as for external noise ingress.

Awareness of the issues associated with the provision of mechanical ventilation and noise pre-date the larger scale adoption of the technology over the last decade, although it would appear that the pitfalls that have been identified historically may not have been widely considered. For instance, in the Netherlands, the more recent, widespread and increasing use of mechanical ventilation has lead to much controversy [6, 10] which could no doubt have been avoided had the lessons been heeded. To date the implications of mechanical ventilation have been more thoroughly reviewed in other countries, and that research is discussed below.

Problems with System 3, MEV

With MEV, as noted previously, building leakage may be relied upon for make up air, but this relies upon assumptions about both the design and as-built air permeability. It may be considered prudent and appropriate at the design stage to include trickle vents providing an effective area of 2,500 mm2 in each habitable room, such that the design may be suitable for buildings of all air permeabilities.

Inclusion of a typical trickle vent of 2,500 mm^2 effective area into the bedrooms in the examples in Appendix C of AD-F is calculated to result in a sound level difference of 28 dB for the ground floor flat (example C1), and 26 dB for the smaller bedroom in example C3. These values are still less than the calculated level difference due to standard glazing; ◘

however, when only one vent is required, it is usually practical and feasible to use "acoustic" trickle vents, and hence achieve greater attenuation as required to control external noise ingress. It is therefore relatively straightforward to carry out the façade sound insulation design if System 3 is adopted.

This ventilation strategy may also present the lowest level of acoustic risk for designers as extract is typically made from rooms that are not noise sensitive i.e. bathrooms and kitchens; however, MEV still requires coordinated consideration by the design team. Balvers et al [6] reported in 2012 that in 67 % of cases ventilation units were located in positions that increased the chances of ventilation noise; positions cited include a built-in cupboard in a bedroom, or on a lightweight wall without proper vibration control. The location of the ventilation unit, or ventilation units in the case of decentralised systems, is therefore an issue that needs to be addressed in order to mitigate noise related concerns. At a time when noise levels were not regulated in the Netherlands, noise levels exceeded 30 dB(A) in 54 % of living rooms and 21 % of bedrooms when MEV was employed.

Stevenson et al [18] note excessive noise arising from poor ductwork in MEV systems on a small development that they studied. In order to control noise levels occupants were reported to have the habit of keeping the MEV ventilation rate low. The non-acoustic drawbacks of MEV relate to energy use and comfort; the fans used to establish air flow require energy, hence the appeal of MVHR.

Problems with System 4, MVHR

In a 1997 Swiss study, Dorer et al [7] suggested that noise levels should be evaluated in comparison to the background noise, as historically ventilation systems had been based on natural systems without mechanical noise. Although this may not generally be practical, those researchers also concluded that sound levels according to the Swiss standards of the time for system noise, 30 to 35 dB(A), were too high, and that acceptable ventilation system noise should be limited to 20 - 25 dB(A).

In another 1997 study, Veld et al [8] considered that the acceptance and appreciation of ventilation systems is mainly determined by the perceived indoor air quality, thermal comfort and noise. System generated noise, and cross-talk through ventilation ducts between rooms were both noted. In particular, it was remarked that noise relating to the ventilation system and components can result in users turning off the ventilation system or closing vents; actions that have a correspondingly negative influence on ventilation and indoor air quality.

Alexander et al [16] reported at the turn of the millennium on a UK study of 50 low-energy rental dwellings; they encountered criticisms relating to noise and established that noise was one of the main reasons for switching back to "normal" ventilation (presumed to mean natural ventilation). Macintosh and Steemers [17] reported in 2005 on a study of 58 urban UK homes with MVHR systems. Complaints by occupants about noise from the inlets were observed. A limited number of sound level measurements were undertaken with windows both open and closed. It was remarked that in one case, the ventilation system was almost as noisy as having a window open. In these studies systematic measurements of noise levels were not made, so that the comments can only be interpreted qualitatively. In 2002 Concannon [20] noted that noise levels from mechanical systems of 30 to 45 dB(A) are typical in single-family dwellings if no sound reduction measures are present.

In 2007 Kurnitski [9] reported on a Finnish study of 102 newly built houses. He concluded that only 57 % of the dwellings were capable of complying with the ventilation regulations of 0.5 ach with a noise level in living rooms and bedrooms not exceeding 28 dB(A). Complaints about ventilation noise were found to correlate best with the maximum noise level in bedrooms when the ventilation system was operated at its maximum fan speed, the boost setting. The as-used average sound pressure level, including background noise, was recorded to be 22 dB(A); cases of noise levels as low as 17 and 18 dB(A) were recorded. Measurement periods with a background noise level below 20 dB(A) were available in all houses. Systems were generally operated at the level at which noise was tolerable, despite the ventilation rate potentially being inadequate at those settings. Noise levels up to 30 dB(A) were described as "too noisy" by more than 40 % of respondents.

In 2008, Hasselaar [10] inspected 500 homes with measurements and occupant interviews. He noted that noise of fans limits the occupiers' use of higher set points for the required ventilation volumes, and the rooms became polluted as a result. Similarly, Hady et al [11] note from a survey of 100 homes that the noise level at the set point was so high that users operated systems at lower levels, and significant adverse health effects were the result of insufficient ventilation.

Many of these findings were identified again by Balvers et al [6] in 2012, following surveys of 299 homes in the Netherlands. At the time of the study noise levels were unregulated. With the mechanical systems set to provide the required flow rates (or highest possible where they did not comply), noise levels exceeded 30 dB(A) in one or more bedrooms in 86 % of homes with MVHR. The ventilation unit was considered to be in an inappropriate place, such as in a bedroom cupboard, in 53 % of homes; and silencers were not properly installed on either the supply or exhaust ducts in 66 % of cases. Not surprisingly, most users do not operate ventilation systems as recommended for air flow rates because of high noise levels. In 2012, the Dutch introduced a regulation to limit noise at 30 dB(A) from mechanical ventilation systems in living rooms and bedrooms.

A recent report on MVHR systems in Code for Sustainable Homes level 6 dwellings in the UK has been published [24]. Initially, noise resulted in the MVHR system being listed in the occupant surveys as one of the 'worst things about the house'. The MVHR fan units installed in the homes were running at close to maximum fan speed; this resulted in the systems being very noisy, which was noticed and annoying to nearly all the occupants. It was considered necessary to intervene in the monitoring after 12 months to recommission all 10 systems and replace some of the components, including the fan unit in one case. Changes were also made to air valves, and noise levels were significantly reduced as part of the recommissioning. A focus group revealed that the reduction in noise from the MVHR system was listed as one of the best things about the homes since the previous survey. The recommissioning by the Building Research Establishment allowed the MVHR system to be slowed and the noise levels reduced for most homes to within the CIBSE guidelines of NR 30 for living rooms, and NR 25 for bedrooms. The improvement was noted as being very significant and resulted in the occupants commenting that they could hardly hear the fan units running. The report concludes P36

P35 that the CIBSE guideline figures provide a good basis for acoustic design of these products in energy efficient homes, although appropriate levels are discussed further below.

Causes of excessive noise

The following list of issues are all taken from actual findings on investigations that have been reported. Issues that can lead to excessive noise for occupants are noted under the following headings of design, installation, commissioning and maintenance.

Design issues

- Centralised MEV or MVHR unit located in inappropriate place for break out or structure borne noise, e.g. bedroom cupboard or on rafters in loft above a bedroom.
- Poor ductwork layout – too many bends can lead to additional fan pressure requirement and regenerated noise
- Specification of flexible ductwork
- Inadequate attenuation of duct borne noise
- Installation issues
- Ductwork kinked or damaged inhibiting flow
- Ducts not connected up to supply or extract valves (which will inhibit flow and require higher fan setting)
- Wrong type of outlet fitted (using extract outlets for supply air can lead to regenerated noise)
- No anti-vibration mounts used
- Failure to ensure ductwork is clean when installed prior to commissioning
- Use of flexible ductwork where not specified

Commissioning issues

- The standard practice of commissioning with non-compensating flow measurement devices means that flows are not generally well balanced or indeed correctly set.

Maintenance issues

- Failure to replace filters at appropriate intervals (the market for replacement filters clearly indicates that very few users replace filters at appropriate intervals)

Appropriate noise limits

Detailed Finnish study

Kurnitski et al [9] undertook a survey examining the dependency between the maximum noise level in bedrooms and ventilation noise complaints. An upper limit threshold of 22 dB(A) resulted in < 10 % complaints and an upper limit threshold of 25 dB(A) resulted in < 20 % complaints. Based upon this same research a significant dependency was found between the maximum fan speed of the ventilation unit (boost mode) and complaints, rather than the whole dwelling ventilation rate. Under this scenario complaints of < 20 % could be associated with the boost condition with the consequence that, at the continuous extract minimum low rate (as AD-F), the number of complaints for the majority of time would fall nearer to, or within, the < 10 % threshold. UK research is required to determine if attitudes are similar.

Suitable noise metric

Building services noise levels well below 30 dB(A) are clearly necessary for user acceptance in many instances. The A-weighted scale may not be the most appropriate metric for such noise levels, as the loudness of the lower frequency components at these lower levels is under-represented. Researchers have correlated annoyance of building services noise with other metrics in an office scenario [22], but no similar association in a domestic situation where noise levels are lower is known.

European guidance and standards

Some Europeans countries have standards and guidance for noise from building services. For example, Finnish guidance [19] published in 2008 requires that noise from HVAC systems in residential rooms does not exceed 28 dB(A), with a limit of 24 dB(A) for a better quality indoor environment. For all standards of internal environment, noise levels in kitchens must not exceed 33 dB(A).The standard for certified PassivHaus dwellings [13] is a limit of 25 dB(A) in both living rooms and bedrooms. For all residential building services, not just that using MVHR, BS EN 15251 [12] recommends a living room design range of 25 to 40 dB(A) with a default design value 32 dB(A) and a bedroom design range of 20 to 35 dB(A) with a default design value 26 dB(A). This guidance is perhaps superseded by the recent Cost Action described below.

COST Action TU0901

The recently concluded programme for European harmonisation of acoustic descriptors [25] has included the determination of Classes for noise from building services. The proposed classes are shown in Table 1.

This does not distinguish between different room types, and has much lower limits for the highest performance, Class A than may be anticipated by designers in the UK. The information about classes suggests occupant dissatisfaction levels as shown in Table 1 with around 20 % dissatisfaction for noise levels not exceeding 28 dB(A). On this basis it may be suggested that Class C should be the lowest class to which it is appropriate to build new dwellings, equivalent to a limit of 28 dB(A) in all rooms, if 20 % occupant dissatisfaction is acceptable.

Type of space and source	Class / Leq, dB(A), and dissatisfaction, %				
	A	B	C	D	E
Rooms in dwellings; ventilation / heating installation	≤ 20	≤ 24	≤ 28	≤ 32	≤ 36
Occupant dissatisfaction	≤ 5 %	≤ 10 %	≈ 20 %	≈ 40 %	≥ 60 %

Table 1: Class limits for service equipment noise proposed in COST Action 0901

Commissioning

Although the noise issues relating to mechanical ventilation have not been extensively researched in the UK, deficiencies in air flow rates are already widespread [5, 21], despite the requirement in the 2010 Part F for commissioning to be undertaken by a "competent person". The experience of the acoustic consulting industry clearly demonstrates that if a particular level of acoustic performance is sought, there needs to be a robust commissioning regime to ensure its implementation. The message from the above literature review of more than 1,000 homes is clear, and has been found on numerous occasions in multiple countries: if noise levels from mechanical systems are not regulated, they are generally excessive and consequently many people opt to live with inadequate ventilation and risk the associated health effects, rather than tolerate excessive noise levels.

No doubt acousticians would agree that commissioning checks on performance are only effective if there is also a requirement for the person carrying out the measurements to be independently accredited by a third party, to ensure consistency and to mitigate potential pressure brought to bear on the tester by the contractor. Testing on completion is risky for contractors; they need to be able to effectively manage the risk, which would mean that systems would need to be appropriately designed and constructed. In our experience, commissioning measurements are very seldom required by clients in dwellings, no doubt at least in part because the risk of excessive noise levels is not widely understood.

The authors' recent experience includes measurements of MVHR installations for which the units have not even been tested for noise emissions as described in BS EN 13141[15]; suppliers of MVHR systems can lack the knowledge and expertise to design appropriate noise control measures even where data is available.

Unless domestic mechanical noise levels are included within the regulatory framework, and are backed up with commissioning requirements, it is likely that no regard will be given to them. It is suggested that there could be a requirement in AD-F to control noise to suitable levels along with adequate flow rates. Until regulation of noise from mechanical services becomes a statutory duty, LPAs could also regularly stipulate the need for commissioning noise measurements for MEV and MVHR to demonstrate that adequate conditions have been achieved, whether or not external noise is an issue for those sites.

Conclusion

A common reason of occupant mis-operation of mechanical

ventilation systems is noise. If these systems are to be acceptable and used appropriately, it is imperative the noise emissions are regulated, and that the commissioning requires both airflow and noise levels measured by organisations with third party accreditation. It has been noted that AD-F, referring to BS 8233, recommends that noise levels from mechanical systems, when providing ventilation at the whole dwelling ventilation rate, do not exceed 30 dB(A) in bedrooms. The literature review above however suggests that this may be intolerable to a significant proportion of people. More UK specific research is needed to confirm appropriate upper limits; it is suggested that the BS EN 15251 default value of 26 dB(A) for bedrooms may be used in the absence of more informed levels, although this bedroom level may result in complaints from more than 20 % of occupants. Similarly, a limit of 28 dB(A) for living rooms is indicated in the COST Action as the likely limit for 20 % dissatisfaction.

Evidence suggests that it may be more appropriate for the upper limit threshold to relate to the continuous extract, minimum high rate (boost) rather than the minimum whole dwelling ventilation rate, as currently proposed by AD-F. Further UK specific research is required to determine suitable noise limit levels for boost ventilation rates from MEV and MVHR. Further UK specific research is also required into acceptable noise levels for the provision of purge ventilation from mechanical services, or higher ventilation rates as required to control overheating; owing to the complete lack of data it is suggested that this may be temporarily excluded from consideration within the design.

It is considered that Part F of the Building Regulations may be the appropriate place to provide statutory noise limits, and a requirement for commissioning noise measurements from mechanical services. In the meantime, LPAs could stipulate noise limits from mechanical systems within dwellings when there are no external noise issues identified. Greater coordination between the Approved Documents and technical guidance to accompany the NPPF is considered essential. It is suggested that the gap between LPAs and Building Control may be bridged if planning conditions refer to a "scheme of acoustic design to enable appropriate internal ambient noise levels to be achieved whilst ventilation is provided at the minimum whole building ventilation rate as described in Approved Document F". This type of condition would cover both natural and mechanical systems, depending on what is employed on a particular development, and enable separate limits for each. A requirement for commissioning measurements is considered appropriate in all cases.

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Why speech perception declines across the adult lifespan: effects of age on audition and cognition

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Abstract

The increasing life expectancy in most Western countries raises the question of the impact of aging on the individual's quality of life in the future as well as society's cost in providing adequate health care to respond to the specific needs associated with this demographic change. One consequence of aging is reduced comprehension of speech in the presence of background noise. This not only constitutes a social handicap for the affected person but may also accelerate cognitive decline, thereby representing a serious public-health issue. This article discusses the effects of aging on audibility (associated with processes in the cochlea), on central (*i.e.*, retro-cochlear) auditory processing and on cognitive functions involved in speech comprehension.

Background

Most of us are familiar with the notion of older persons struggling to identify and understand speech, especially in a noisy environment such as a cocktail party, a fact frequently played upon in film and literature for humoristic purposes (*e.g.* David Lodge's book *Deaf Sentence*). Such communication difficulties can adversely affect the efficiency of an aging workforce and constitute a socio-psychological handicap for the affected person, who might react by avoiding social situations because of their acoustically challenging nature. Such avoidance behaviour can lead to social isolation and depression which recently have been shown to be associated with faster cognitive decline than that due to "normal" aging (*e.g.* Lin *et al.*, 2011). Given the remarkable increase in life expectancy (Christensen *et al.*, 2009), improved understanding of exactly how aging affects our ability to comprehend speech is important for the future of our society, especially as it might lead to more efficient remediation and prevention strategies.

It has been known for a long time that the majority of older people suffering from speech-perception difficulties also show physiological changes in the most peripheral part of their auditory nervous system, the cochlea. In some cases, these changes can be directly linked to environmental factors such as the exposure to loud noises or ototoxic agents. However, biological aging *per se* also seems to affect peripheral hearing sensitivity in most of us, a phenomenon termed *presbyacusis*. Figure 1 shows age-typical audiograms for 20-, 40-, 60- and 90-year olds without any known history of (noticeable) noise exposure. Each curve indicates the hearing thresholds (*i.e.*, the quietest detectable level) for sounds of frequencies varying from 125 to 8000 Hz; the grey-shaded area represents schematically the so-called "speech banana" or amplitude-frequency space occupied by speech sounds. Clearly, the ability to hear faint sounds, especially in the high-frequency range, declines with age. The consequence of such a progressive reduction in sensitivity is the inaudibility of more and more speech sounds resulting in compromised speech intelligibility.

Modern digital hearing aids allow the selective amplification of those sounds whose frequency content falls into the region of hearing loss, thereby at least partially restoring their audibility (for an overview, see Dillon, 2001). However, many hearing-impaired listeners fitted with hearing aids do not achieve the level of speech intelligibility that would be predicted based on the audibility of the speech signal (Moore, 2007). Since the age of the average first-time hearing aid users is above 65 years (Kochkin, 2009), these listeners may not only suffer from peripheral hearing loss, but also experience age-dependent changes in "retro-cochlear" auditory processes (located in the more central portions of the auditory system than the cochlea) and cognitive abilities involved in speech comprehension.

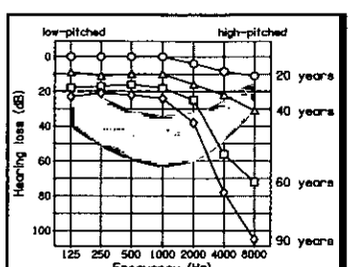

Figure 1: Age-typical audiograms for four age groups (see different symbols) and schematic representation of speech sounds in the amplitude-frequency space. The broken line represents the criterion that is often used to indicate clinically normal hearing.

Effect of age on central auditory processing

A prerequisite for speech perception is audibility of the acoustic signal. However, to ensure ▶

comprehension, the speech sounds also need to be identified (e.g. the distinction between "t" and "f" is crucial for the correct understanding of the sentence "The bathers were alarmed by the sight of a tin/fin in the water.") and organised into discreet auditory objects or streams, such as the analysis of babble produced by the guests in a busy restaurant into individual voices in order to focus attention on the person across the table. These processes rely on the auditory system's capacity to discriminate sounds based on their spectro-temporal properties.

One acoustic cue is the fast fluctuation in instantaneous pressure in different frequency bands, called temporal fine structure (TFS). It seems that good sensitivity to TFS is particularly important for the identification of speech in noise (for an overview, see Moore, 2012). Indeed, it has been shown that listeners with a hearing loss, as indicated by the audiogram, have reduced ability to process TFS information (Hopkins and Moore, 2007) and to identify speech that was processed to contain mainly TFS cues (Lorenzi et al., 2006). In this population, the cochlear damage underlying the hearing loss may cause the pathological changes in TFS coding (Henry and Heinz, 2013). However, other factors may affect the sensitivity to TFS cues, consistent with the clinical observation that some people suffer from speech-perception difficulties despite having normal audiograms (Middelweerd *et al.*, 1990).

To establish whether aging of the central auditory system could cause "hidden hearing loss" for people with normal audiograms (Shamma, 2011), I recently assessed sensitivity to monaural and binaural TFS cues for young (< 30 years) and older (≥ 40 years) listeners with no clinically significant hearing loss, defined as hearing thresholds better than 20 dB HL between 125 and 4000 Hz (Füllgrabe, 2013). Two psychoacoustical tests of sensitivity to TFS were used. In a monaural task (Moore and Sek, 2009), listeners had to distinguish harmonic and inharmonic complex tones. The latter tones were obtained by shifting each frequency component of the harmonic complex by the same amount in Hertz; this resulted in changes in the TFS without affecting the repetition rate of the temporal envelope (i.e., the slow fluctuation in global amplitude). All stimuli were bandpass filtered to reduce the spectral cues associated with the frequency shift, thereby forcing the listener to rely only on TFS information to perform the task. In a binaural task (Hopkins and Moore, 2010), listeners distinguished diotic (*i.e.*, identical at the two ears) pure tones from the same tones with a phase difference between the two ears. Figure 2 shows individual and mean sensitivities in the two TFS tasks for the different age groups.

Despite considerable inter-subject variability even within a narrow age group, the results show a progressive decline with age in the ability to process monaural and binaural TFS cues. A statistically significant change in sensitivity from young adulthood was found for listeners as young as 40-49 years. Since other recent studies, using different procedures to study TFS sensitivity (Ross *et al.*, 2006; Grose and Mamo, 2010), report similar observations, it seems that TFS processing is compromised from mid-life onwards. Given this, it is surprising that people in that age range do not generally complain about difficulties in speech-in-noise perception. This could be explained by the fact that speech is a highly redundant signal; linguistic information is carried by multiple acoustic cues, such as the spectral energy, the temporal envelope and the TFS (for an overview, see Pickett, 1999). Consequently, good intelligibility can be maintained in the face of degraded TFS sensitivity if the processing of other acoustic cues and/or non-acoustic information (such as that gleaned from "lip reading") is unaffected. Also, with increasing age, people seem to engage their cognitive abilities more heavily during speech comprehension, for example by using contextual cues (Pichora-Fuller, 2008), presumably to compensate for poorer central auditory processing.

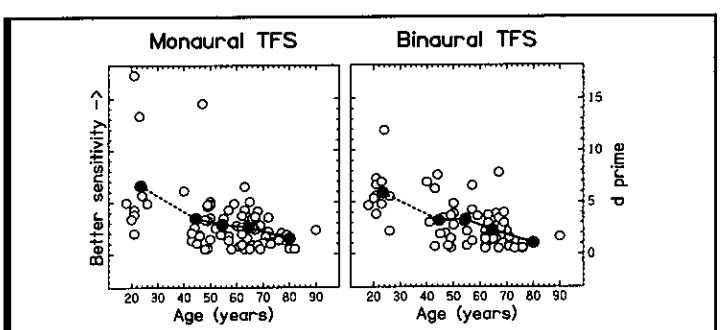

Figure 2: Sensitivity to monaural (left panel) and binaural (right panel) temporal-fine-structure (TFS) cues for normal-hearing listeners of different ages. The centre frequency of the monaurally presented tone complexes was 2 kHz; the frequency of the binaural stimuli was 0.85 kHz. The open symbols denote individual data and the filled symbols denote the average sensitivity for each of the five age groups (18-29 years, 40-49 years, 50-59 years, 60-69 years and 70+ years). Adapted from Füllgrabe (2013).

Effect of age on cognitive processing

In most real-life situations, such as listening to an ongoing conversation in the presence of interfering voices, a variety of cognitive processes (*e.g.* attention and memory) come into play to allow the listener to select and focus on a given auditory stream (e.g. a particular voice amongst many), and to store and update in memory information that contributes to the general comprehension of the conversation.

Given such cognitive involvement, could the age-related decline in speech comprehension be explained at least partially by a reduction in cognitive abilities with age? If so, which cognitive function(s) decline and from which age onwards? To assess performance in different cognitive domains (e.g. memory, attention, processing speed) across adulthood, we (Füllgrabe and Moore, 2013) are currently testing a large cohort of participants, aged 18 to 91 years, on a battery of cognitive tests. The mean results obtained so far for the seven roughly decade-wide age groups (18-29 years, 30-39 years, 40-49 years, ..., ≥ 80 years) are presented in Figure 3.

Consistent with earlier findings by Park and Reuter-Lorenz (2009), performance on most of the cognitive tests tended to decline progressively with age, with statistically significant changes apparent from early middle age onwards. However, performance based on "knowledge" (such as that contributing to verbal fluency) showed little or no change with age. It is interesting to highlight the dissociation in performance in our cohort of normal-hearing participants for the two tests of memory: while the capacity to temporarily store new information (i.e., short-term memory) hardly changed over the 60-year range, working memory (which involves the transformation and updating of stored information) showed a strong decrease with increasing age. Interestingly, it is this latter type of memory that is assumed to be heavily involved in speech comprehension (for a discussion of the link between cognition and speech perception, see Akeroyd, 2008).

Effect of age on speech intelligibility

After having reviewed some experimental evidence showing deleterious effects of normal aging on TFS processing and many cognitive abilities, it remains to establish that such changes are indeed linked to the difficulties in speech comprehension experienced by older listeners. For example, does speech intelligibility still decline with age when all speech sounds are clearly audible? To address this question, we (Füllgrabe *et al.*, 2012) compared speech identification performance for audiometrically matched young (< 30 years) and older listeners (≥ 60 years) using a target talker presented either in quiet or in the presence of two interfering talkers. All participants had normal audiograms (defined as audiometric thresholds ≤ 20 dB HL) up to 6000 Hz in both ears. The results are shown in Figure 4.

For both age groups, speech intelligibility in quiet was at ceiling. Intelligibility declined when the interfering voices were introduced. Consistent with previous publications (*e.g.* Freyman *et al.*, 1999), this masking effect was more pronounced when the interference came from the same spatial location as the target talker (the "co-located" condition) than when it was presented from a different spatial location (the "separate" condition). The reduction in intelligibility due to age is mainly apparent in the most challenging listening condition. Since peripheral hearing sensitivity was identical in the two age groups, the observed deficits most likely result from age-dependent changes in central P40

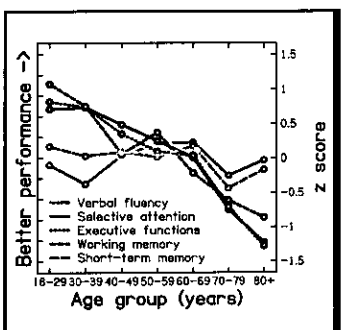

Figure 3: Normalized mean performance on different cognitive tests (see legend) for seven age groups spanning the adult age range.

P39 auditory processing and cognitive abilities. This hypothesis is supported by the observation that speech-in-noise perception in these listeners was positively correlated with TFS sensitivity and general cognitive ability, as shown in the left and right panels of Figure 5, respectively.

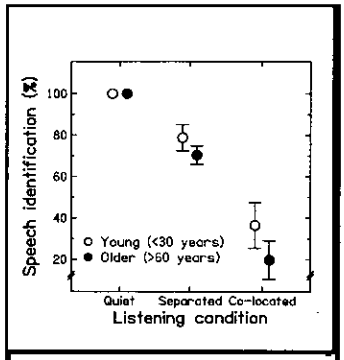

Figure 4. Identification scores for target sentences for normal-hearing young (< 30 years) and older (≥ 60 years) listeners. Mean audiograms were matched across the two age groups. The target speech was presented either in quiet or in two interfering talkers presented at a different spatial location ("Separated") or the same spatial location ("Co-located") as the target speech.

Summary and conclusions

The ease and precision with which we understand speech, especially in noisy environments, reduces across the adult lifespan. The progressive decline in peripheral hearing sensitivity with age (*presbyacusis*), resulting in a reduction of the audibility of speech sounds, is a well-documented fact. However, as illustrated in this article, there is increasing evidence that central auditory processing abilities and cognitive functions underlying speech identification and comprehension are also affected by biological aging, and this occurs as early as young adulthood.

Currently, the main clinical tool (and in some countries the only one!) used in the diagnosis of patients with reported "hearing problems" is the audiogram, which quantifies the audibility of pure tones in quiet across a wide frequency range. While this measure is relatively quick, it is insensitive to central auditory processing deficits which, as shown in Figure 5, are associated with speech-in-noise perception. In addition, a formal evaluation of basic cognitive and linguistic functions that undoubtedly underpin successful speech comprehension is currently not part of the standard audiological assessment. The efficiency of any intervention cannot be optimised until all processes involved in the act of understanding speech are taken into account in the rehabilitation process.

The results presented here might also act as a reminder for us and the people involved in policy making how very common speech-perception difficulties are and how they will, sooner or later, affect most people. Maybe such awareness will lead to a more compassionate attitude towards those already affected by speech-perception difficulties and result in better practice in accommodating the future needs of our aging society (for example, by creating quieter public spaces and reducing background sounds in TV and radio broadcasts).

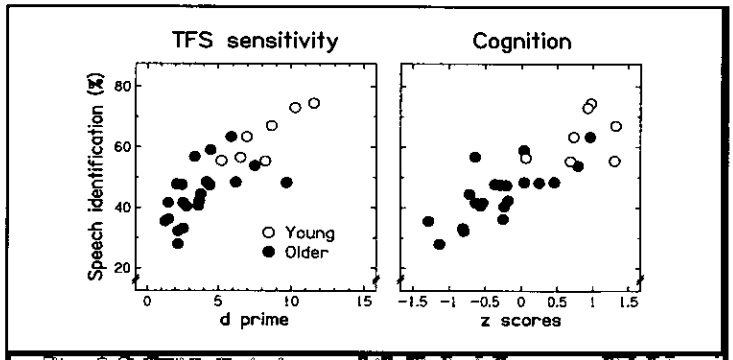

Figure 5. Scatterplots showing how speech identification in the presence of interfering talkers is related to (left) TFS sensitivity and composite cognition (obtained by averaging across performances on several cognitive tests) for young (< 30 years, open symbols) and older (≥ 60 years, filled symbols) normal-hearing listeners. Larger values on the x-axis denote better TFS sensitivity (left panel) and better cognitive performance (right panel).

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Moveable goalposts: a review of on-site performance of operable walls and folding partitions

By Joe Bear of Adrian James Acoustics

Background

As specialists in buildings for education and the arts, we frequently come across schemes that incorporate sliding, folding, moveable or otherwise operable partitions. The ability to change the size and shape of a room and the flexibility that this offers has obvious appeals to architects and clients alike. However, in our experience these elements generally fall short of the manufacturer's advertised performance figures when tested on site.

The problem of underperformance of operable walls on site has become more obvious in recent years with the increase in commissioning sound insulation measurements, as required to achieve BREEAM credits for internal acoustics. As project acousticians it is important that we are able to provide a realistic prediction of the expected performance to architects and client teams for them to make informed decisions.

This article presents the results of our investigation of the site performance of operable walls and comparison of this data against the manufacturers' published performance figures. This analysis does not seek to differentiate between individual systems or manufacturers' products and for that reason all references to specific products or manufacturers have been omitted.

The content in this article was originally presented at the IOA Measurement and Instrumentation Group conference *Trials and tribulations of overcoming acoustic challenges* in June 2013.

Sound insulation descriptors – lab versus site

The performance of sound insulating elements is assessed in a laboratory by measuring the Sound Reduction Index, R, in accordance with BS EN ISO 140-3 and weighting to a single figure index, Rw using the rating methodology set out in BS EN ISO 717-1. Laboratory measurements are conducted in a transmission suite, where all of the potential paths for flanking transmission are suppressed so it can be reliably assumed that all of the acoustic energy transferred between the rooms is transmitted through the test specimen alone.

On site, sound insulation is measured in terms of the Standardised Level Difference, D_{nT}, in accordance with BS EN ISO 140-4 and weighted to a single figure index, $D_{nT,w}$ using the rating methodology set out in BS EN ISO 717-1. The Standardised Level Difference is a measure of the acoustic energy transferred between the two spaces via all transmission paths, direct and indirect and standardised to a receiver room reverberation time of 0.5 seconds. In principle, if the all of the acoustic energy transmitted between two spaces passes directly though a single separating element, with no transmission via flanking paths, the Weighted Standardised Level Difference is related to the Weighted Sound Reduction Index as follows:

$$D_{nT,w} = R_w + 10 \log(V/S) - 5 \text{ dB} \qquad (1)$$

Of course, this is never the case in practice and it is common to include an allowance of around 7 dB for reductions in site performance due to detailing weaknesses, transmission via flanking paths and other non-ideal conditions. This gives rise to the following relationship which is used to estimate the required specification of a sound insulating element to achieve a required performance standard on site.

$$D_{nT,w} \approx R_w + 10 \log(V/S) - 12 \text{ dB} \qquad (2)$$

This is, of course, not an exact relationship but in our experience works adequately as an approximate rule of thumb to predict the performance of conventional fixed constructions on site. But in the case of operable walls we have found that this relationship does not accurately predict the performance that can be expected on site. This is demonstrated in the two recent examples, described in the following case studies.

Case study 1 – school

We worked on a project to relocate three existing schools into a single, purpose-built school campus building. The scheme made extensive use of operable walls including 12 sliding or folding partitions between classrooms and group rooms and five moveable walls sub-dividing "flexible" hall / dining hall / music and drama teaching spaces.

Despite lengthy discussions with the design team to explain the potential problems with the arrangements shown, it was determined they were essential to the teaching ethos of the new combined school campus and that they were to be retained within the scheme. We therefore recommended that the supplier of the partitions should be required to guarantee that the partitions installed would meet the required performance standards when tested on site.

Between classrooms and group rooms the supplier specified folding partitions rated at 48 dB R_w to meet the Building P42

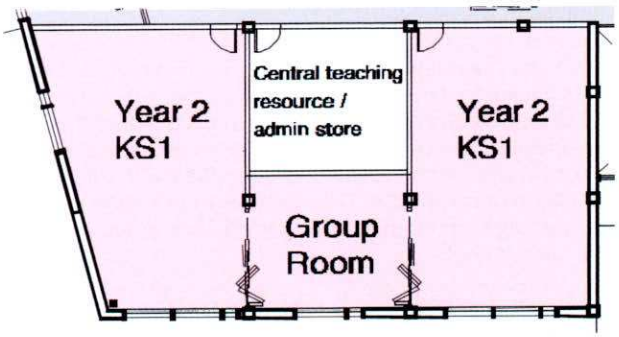

Figure 1 Operable walls between classrooms and a group room

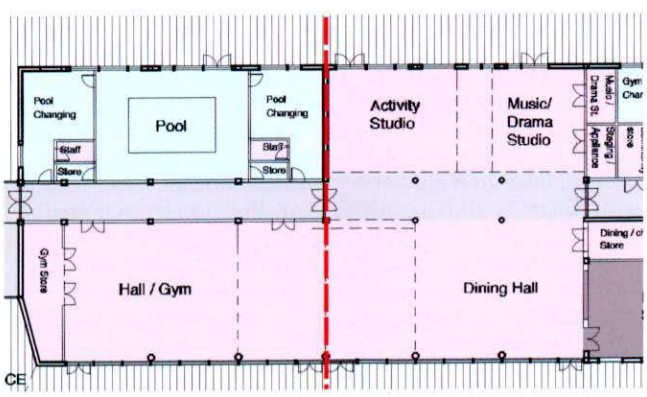

Figure 2 Operable walls in hall and music and drama teaching spaces (denoted by dashed grey lines)

◂P41 Bulletin 93 sound insulation requirement of 45 dB $D_{nT(Tmf,max),w}$. Between the various 'flexible' hall / dining hall / music and drama teaching spaces the supplier specified folding partitions rated at 57 dB R_w to meet our recommended Alternative Performance Requirement of 45 dB $D_{nT(Tmf,max),w}$.

Applying the rule of thumb set out in equation 2 suggests that the partitions should achieve around 44 dB $Dn_{T(Tmf,max),w}$ between classrooms and around 53 dB $D_{nT(Tmf,max),w}$ between the flexible hall spaces. In practice the partitions achieved between 26 and 35 dB $D_{nT(Tmf,max),w}$ between classrooms and 26 to 28 dB $D_{nT(Tmf,max),w}$ between flexible hall / studio spaces. In order to allow a direct comparison between site test data the lab data provided by the manufacturers, we converted the results to Apparent Sound Reduction Indices using the following formula.

$$R'_w = D_{nT,w} - 10\log(V/S) + 5 \qquad (3)$$

The graphs in Figures 3 and 4 show the published R_w lab data for two of the partitions types installed along with the R'_w site measurement results. The 48 dB R_w partitions consistently achieved between 22 and 25 dB below the published laboratory performance. This is well below the allowance for reduction in performance due to site conditions. Subjectively, the main path for noise transmission between the test rooms was through weaknesses at the joints between panels and around the perimeter of the partitions and through the partition panels themselves. There was no significant audible noise transmitted via the surrounding building elements.

The results for the partitions tested in the "flexible" hall / dining hall / music and drama teaching spaces were 33 and 35 dB below the stated performance of 57 dB R_w. In this case, the main path for noise transmission was via open gaps around the perimeter of the partitions and around pass doors contained within the partitions.

Some of the problems experienced at this school were due to poor installation but we consider that the wider consistency of the results suggests that the maximum achievable performance of partitions as installed is well below the performance stated in the manufacturer's published data.

The school was completed and handed over at the time of our tests and despite the client's insistence on the specific need for flexible spaces, the majority of the partitions were found with furniture installed in front of them which had to be moved before the partitions could be opened. The school staff also had to conduct a lengthy search to locate the hex tools which are supplied with the partitions and required to operate them. This suggests to us that in practice the movable partitions are opened infrequently, if ever, and are therefore probably not required.

Case study 2 – primary care centre

Another example of a project where we encountered problems with folding partitions is a new Primary Care Centre building designed to provide accommodation for GPs, health visitors and other community-based health professionals. The project included three pairs of group/meeting rooms, each sub-divided with operable partitions, two pairs of which are shown in Figure 5.

To comply with requirements on Health Technical Memorandum 08-01 and BREEAM Healthcare 2008 the required standard of sound insulation between each pair of sub-divided meeting rooms is 42 dB $D_{nT,w}$. The contractor specified partitions rated at 51 dB R_w. The relationship set out in equation 2 suggests that if these partitions perform as claimed these units should achieve at least 45 dB $D_{nT,w}$.

An initial measurement between one of the pairs of sub-divided rooms achieved 24 dB $D_{nT,w}$, which is 18 dB below the required standard. The main paths of transmission all appeared to be related to the seals between the hinged panels and the seal between the overall partition and the surrounding building elements. There were no prominent paths of flanking transmission via the surrounding building structure itself.

The installers were recalled to site to undertake remedial work on the partition to install seal sets that were left out at the time of the original installation. The result of the retest following the remedial work was 29 dB $D_{nT,w}$, which is 13 dB below the required standard.

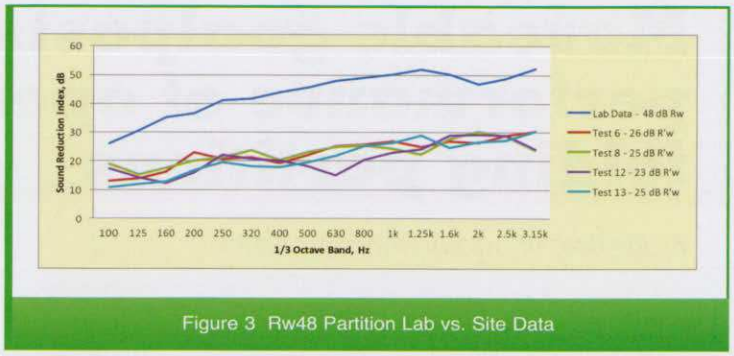

Figure 3 Rw48 Partition Lab vs. Site Data

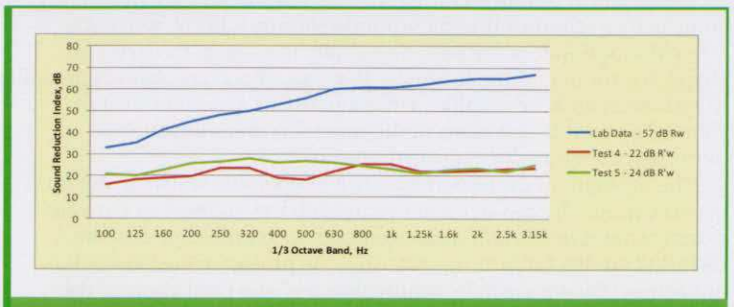

Figure 4 Rw57 Partition Lab vs. Site Data

A meeting with the supplier's representative then revealed that the wrong partition type had been installed. The suppliers agreed to remove all three partitions and install replacements partitions capable of achieving the 42 dB $D_{nT,w}$ performance criterion. Measurements across the replacement partitions achieved between 31 and 37 dB $D_{nT,w}$. This is a significant improvement but the results were still 5 to 11 dB below the standard required to comply with HTM 08-01 and BREEAM.

Some months later we were contacted by the client who asked us to check data from a further set of measurements conducted by the supplier following more remedial work. The test results supplied were quoted as 41.6, 41.8 and 43 dB $D_{nT,w}$. It is important to note that BS EN ISO 717-1 specifies single figure indices (R_w, R'_w $D_{nT,w}$) as whole numbers and provides clear guidance on the correct sequence of rounding calculation results. Where the above results are quoted to one decimal place they cannot simply be assumed to round up to 42 dB $D_{nT,w}$ and comply with the criterion.

We recalculated the weighted results using the supplied third octave band D_{nT} results and found the results of the suppliers tests were in fact 41, 41 and 43 dB $D_{nT,w}$. The partitions installed were not capable of achieving the required performance on site, even after three attempts to remedy the situation.

Wider data review

Our experience of folding partitions was limited to partitions from a small number of suppliers and manufacturers. We were curious to investigate whether the problems we have encountered were isolated instances or indicative of wider underperformance from these types of products. We contacted fellow member organisations of the Association of Noise Consultants and requested data from their site measurements across operable partitions.

Data was kindly supplied by Apex Acoustics, AECOM, Azymuth Acoustics, Miller Goodall, Paragon Acoustic Consultants, Red Twin Limited and Spectrum Acoustic Consultants.

In total we now have test data for measurements across 49 partitions and Figure 6 shows a distribution of all of the R'_w test results. This highest measurement result was 49 dB R'_w, although we understand that this was achieved by installing two partitions back to back to create a lobby zone between the two. The results for single partition installations show a spread of R'_w results from 22 dB up to 46 dB with a mean result of around 34 dB R'_w. We do not know the specification of all the partitions tested but these results appear to show that it is generally not possible to achieve an R'_w above P44▸

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Green Book – Environmental Noise
Red Book – Groundborne Noise and Vibration

Environmental Noise Measurement Guide

This invaluable book provides practical guidance to those involved in the measurement and analysis of environmental noise. A fundamental understanding of the acoustics theory involved is required too, however, which this book does not attempt to provide.

Areas which are covered include the preparation, execution and reporting of site survey work, and some road signs through the maze of guidance and policy applicable to this work. There is a great variety of situations in which environmental noise needs to be measured and assessed, some of which benefit from specific guidance, but many require 'case by case' consideration. This book seeks to assist the reader in adopting a considered and logical approach to fields as diverse as musical entertainment, wind turbines and motorsport.

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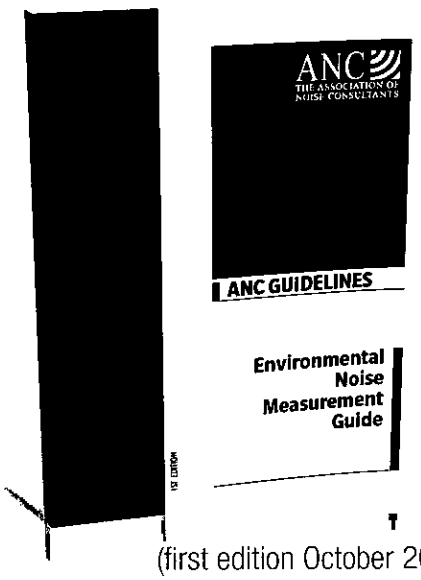

(first edition October 2013)

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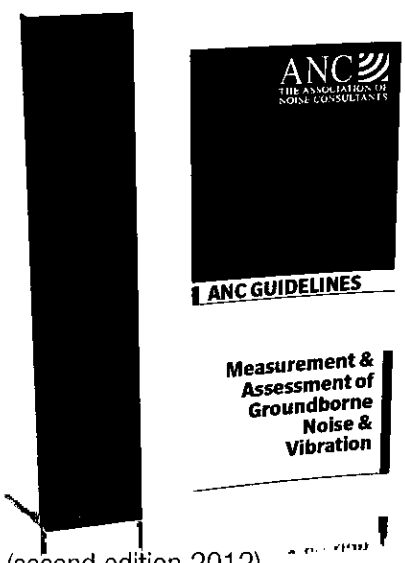

(second edition 2012)

This essential book provides practical guidelines on the measurement and assessment of groundborne noise and vibration. It has been prepared on behalf of the Association of Noise Consultants by specialists in this field. A wide range of vibration issues and sources is covered in this document with particular attention paid to railway vibration and groundborne noise.

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P42 46 dB R'_w with a single operable wall. To put this into context, only the very highest-performing partitions of those tested would meet the BB93 criterion of 45 dB $D_{nT,w}$ between two conventionally sized classrooms (7 x 7 x 3 m). However, we do not have sufficient data to determine any statistically significant variations in performance of products from different suppliers.

We do not know the specification of all of the partitions tested within this wider data set. Furthermore, some of the tests were identified as being limited by installation problems such as gaps around partitions. We revised the data set to only include measurements on known partitions and excluded any tests where the test specimen was known to have specific installation problems that would limit the performance below what could normally be expected.

Figure 7 shows the measured R'_w result plotted against the published R_w performance in each case. This appears to show a systematic problem of operable partitions failing to achieve the stated performance on site. The mean difference between R_w measured in a lab and R'_w measured on site is around 18 dB. It is possible that this mean result is being unduly biased by undiagnosed installation problems on the lowest performing partitions. However, if we omit results below 30 dB R'_w from the data set, the mean difference between the site and lab data is still 17 dB.

The complied data suggests that if an operable partition is installed and operated correctly the R'_w performance achieved is likely to be around 18 dB below the published R_w performance. This suggests that rule of thumb relationship set out in equation 2 should be amended as follows when specifying operable partitions.

$$D_{nT,w} \approx R_w + 10\log(V/S) - 23\ dB \qquad (4)$$

This is, of course, an over-simplification but it goes some way to highlighting the magnitude of the problem.

Reasons for underperformance

We have raised the subject of underperformance with a number of suppliers and manufacturers of operable walls. A typical response to this question is to blame flanking transmission via surrounding building elements. It is true that transmission via the surrounding structures must be considered in the specification of any sound insulating construction. This would typically include the specification of appropriate bulkhead constructions above the head track and detailing of interfaces with the surrounding structures. However, with the exception of partitions with insufficient sealing due to poor installation we have yet to witness an operable wall installation where the performance has been limited by flanking transmission via the surrounding building elements. Even if we exclude the tests where the operable partitions tested have been identified as having, or likely to have problems with the installation the data still appears to be suggest a systematic shortfall on site.

This leads us to question how well the lab test data represents the installations on site. Operable walls are generally bespoke constructions, custom made to fit the specific opening. It is therefore possible that the partitions constructed within transmission suites have fundamental differences to the specific installations on site which make the performance measured in the lab simply unattainable on site.

In our experience, there seems to be a problem of sales staff failing to properly interpret the test data and understand how the test installations compare to the site installations. For example, we have had two projects where suppliers have quoted performance figures for high-rated partitions without taking account of the inherent reduction in performance caused by the addition of a pass door in the partition on site. In another example, we found literature from a manufacturer where Rw performance figures had been quoted as R'_w figures.

Further work

This brief study has identified what appears to be a systematic difference between the claimed lab performance of operable walls and the sound insulation test results achieved on site. The simple answer for us as acousticians is to recommend that our clients do not use these types of products. Operable walls are no substitute for a proper design brief for the use of the different spaces within a building and a non specific desire for flexibility can place unintended limitations of use on to spaces separated by movable partitions. However, in the right circumstances operable walls can offer significant advantages to the clients and end users of buildings in terms of flexibility of use. We must be able to accurately predict the levels of performance that can be achieved in practice so we can allow our clients to make informed decisions on the appropriate specification of operable partitions. It is therefore important that we, as an industry, put pressure on the manufacturers and suppliers of operable partitions to provide reliable test data for the lab and site performance of their products. ■

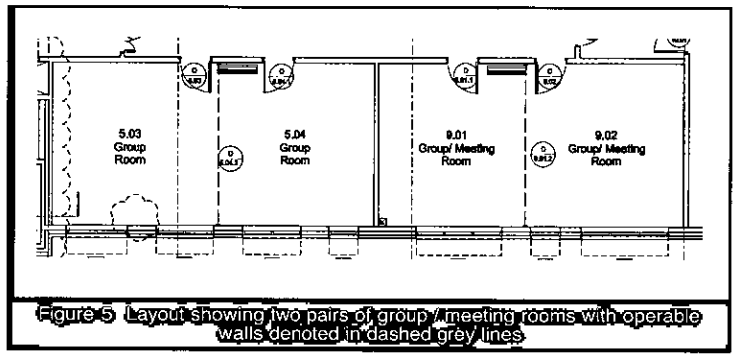


Figure 5 Layout showing two pairs of group / meeting rooms with operable walls denoted in dashed grey lines

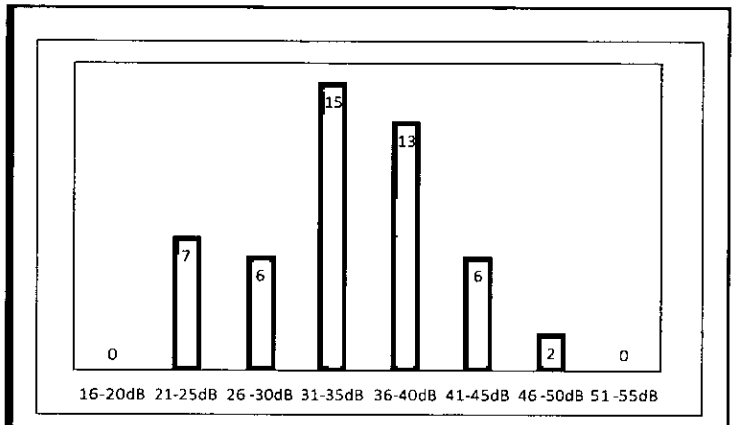


Figure 6 Distribution of all of the R'w results

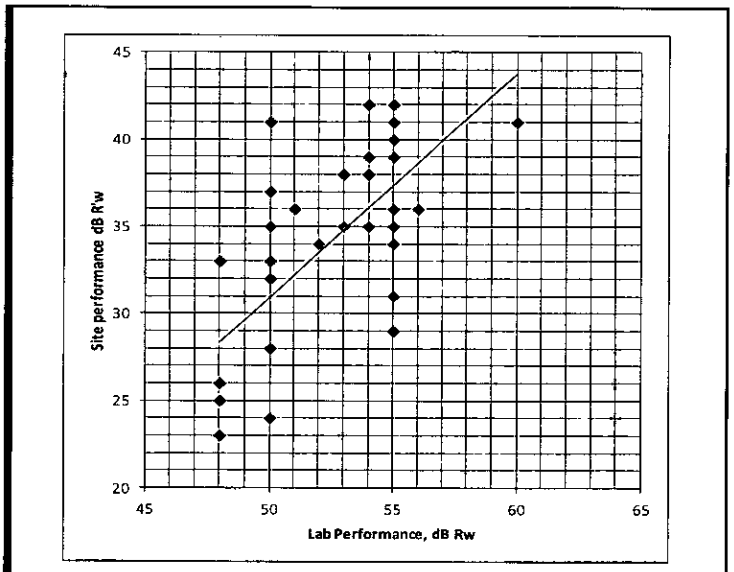


Figure 7 Lab performance (Rw) vs. Site performance (R'w) for individual partitions

Uncertainty and diversity in construction noise assessment

By Roger Tompsett of NoiseMap

Introduction

Construction noise assessments provide acousticians with a heavy workload: many are involved in the major infrastructure projects being undertaken in London and elsewhere. Such projects are fraught with uncertainty arising from unknown or unexpected circumstances on site, yet there is considerable pressure on acousticians to produce reliable and realistic predictions and to assure compliance through monitoring. Failure to meet the permitted levels can have serious consequences.

This article looks at some of the lessons learned from tackling this uncertainty in a current major project at Victoria Underground station in central London.

The project

Victoria Station is a major transport hub serving the administrative centre of London. It is adjacent to major roads with dense residential, hotel, commercial and government property, and two major theatres. It has a mainline station, bus station and Underground stations serving the District, Circle and Victoria lines, with more than 82 million passengers entering and exiting each year. The passenger-handling capacity of the Underground station is in urgent need of improvement by construction of new underground ticket halls, connecting tunnels and surface access facilities.

The work requires buildings to be demolished and deep shafts to be sunk, from which new passenger access tunnels will be driven. Large excavations are also needed to create or enlarge the station boxes. As is usual in railway work and on a live station, a considerable amount of the work needs to be done outside "traffic" hours – at night and at weekends.

Noise trigger levels

A complex set of noise limits has been agreed with the parties to the construction project and the local authority (Westminster City Council). There are also agreements with third parties having certain property rights in the area. Real-time noise reporting is provided by nine monitoring stations, with the results being displayed on a secure website. The system also reports with an SMS (text) message to site staff if trigger levels are exceeded.

Figure 1: Noise Monitoring Read-out

Most noise monitors are capable of triggering an alarm when a certain level is exceeded. The alarm will typically be issued when the 1-hour L_{Aeq} exceeds a given value. Possibly an "amber" prior warning will be triggered at a level slightly below the limiting level, as sending an alarm when the limit has been exceeded is simply closing the stable door after the horse has bolted. However, a lower "amber" warning level is hardly ideal as it will create alarms for perfectly permissible operations. This might avoid "red" alerts, but it could cause unnecessary curtailment of work. To be of genuine help to site staff, the noise monitoring system needs to have some predictive capability as to whether the present operation produces acceptable noise levels, whether it could potentially cause a problem, or whether it must stop soon.

Many of the trigger levels on this project were set as one-hour averages, so any prior-warning or predictive capability needs to report noise at shorter intervals. It was agreed that noise would be sampled at 15 minute intervals. A study of ambient readings showed frequent high levels from emergency services sirens, helicopters, refuse collections and the like. Even "crowd noise" could be high at times. This meant that a limit based on a 15-minute average could be regularly triggered by typical ambient events. It is highly undesirable for extraneous events to generate false alarms as the system would be regarded as unreliable and it would be ignored.

Alarm system

The alarm system, devised by the author at NoiseMap and implemented by Site Engineering Surveys, relies on the fact that a trigger level set in terms of L_{Aeq} is essentially a measure of the dose of noise that it is permissible to receive over a given period. This means that it is quite acceptable for a number of individual 15-minute L_{Aeq} samples to exceed the trigger level as long as the cumulative noise dose over the whole monitoring period does not exceed the trigger level.

This is most easily understood by looking at Figure 1. The black and yellow horizontal lines represent the trigger level (i.e. the maximum "noise dose") that is permitted within each period of a working weekday. The individual purple dots are the 15-minute L_{Aeq} samples. The green line represents the "Running Average", i.e. the average of the L_{Aeq} readings taken since the start of the current monitoring period.

The red line is the Period Average L_{Aeq}, which is the current value of the L_{Aeq} when averaged over the whole of the monitoring period. This monitoring period is one hour at night and in the shoulder periods, 10 hours in the day and various other periods in the evenings. (Weekends have different trigger levels and averaging times.)

The Period Average L_{Aeq} increases constantly throughout the period as the noise dose accumulates. By the end of the monitoring period, the Period L_{Aeq} is the same as the running P46

P45 average L_{Aeq}. It will be seen that in this example, the green Running Average remains fairly steady through each of the time periods. If it meets the yellow/black line, then an amber alert is issued, because the current rate of generating noise must be reduced otherwise the permissible noise dose (Period L_{Aeq}) will be exceeded.

If the Period Average L_{Aeq} reaches the permitted dose before the end of the period, then the red alert is issued because it is necessary to stop any further noise output, to prevent the noise limit from being breached.

This system gives site staff advanced warning of potential problems in time for them to deal with the matter.

If an exceedance does occur, it is necessary to establish its cause. Whilst an immediate inspection of the site can be made, this would not detect a short event that had already passed. Therefore, whenever a particular instantaneous level exceeded 75 dB(A) SPL, a 15-second audio recording was triggered. This enabled the event to be listened to and allowed the possibility of further acoustic analysis.

Effectiveness

A detailed examination of noise trigger events was made for the period October 2011 to July 2012. A total of 20 amber exceedances and one red exceedance were recorded at this monitor over this 10-month period. All but one of these occurred during the one-hour limit periods, and only nine exceedances could be attributed to the project work. The system has therefore caused a very small rate of 12 false alarms in more than 2,400 alarm periods, or 0.5 %. [It should be noted that the limits of the code of construction practice were not exceeded because the trigger levels are set below that limiting value.]

The system has been reliable, informative and successful in preventing any serious exceedances. It also enabled the automated production of the monthly monitoring reports for the local authority. It is therefore fair to conclude that the system has added value to the project, allowing work to continue in an extremely sensitive area, removing uncertainty and ensuring that noise limits were not breached. A similar rate of success has been achieved at the other monitoring locations.

Noise modelling and prediction

Before work could be started, it was necessary for the contractor and client to have confidence that the work could be carried out in compliance with legal agreements, and for prior consent to be obtained from the local authority. This needed detailed predictions of the construction noise that the works were anticipated to generate. The predictions were made in accordance with BS5228-1:2009 "Code of practice for noise and vibration control on construction and open sites" using NoiseMap's *SiteNoise* modelling software.

Data supplied

For the 10-month period discussed in this article, the site engineers provided detailed schedules of 31principal construction operations. The details included the working locations, the plant required, its expected sound level and its 'percentage of use'. In total, there were more than 150 generic types of plant, working at locations distributed across a wide area.

Input to the noise model

It had been agreed that the noise assessment should use a cautious approach, but "worst-case" noise predictions need to be realistic otherwise they simply create unnecessary costs and concerns. Just as for the noise monitoring, if they are unreliable, they will be ignored.

Several issues were identified with the schedules supplied, but BS5228 is not particularly helpful in what must be done to produce realistic scenarios for use in noise modelling. The following approach was used, based on established experience.

Selection of plant

Where it is clear that the plant list contains alternatives which will not all be used simultaneously, or maybe not used at all, put only the noisiest into the noise model.

Source noise levels

Check source levels against the BS5228 tables where possible, and where there are alternatives, use typical (rather than highest) values. Where specialist items cannot be readily verified from BS5228, check that the supplied sound levels are at least realistic (i.e. comparable to similar machines). Take care to ensure that noise levels relate to the plant when working (not simply the power pack running) and avoid confusion between L_{Aeq} and Sound Power Levels.

Percentage on-time

BS5228 calculations require the percentage on-time, i.e. the ▶

Figure 2: Noise Map resulting from piling activities spread over the work area

proportion of the assessment period that the equipment is creating the listed noise level, whereas construction schedules tend to show percentage availability. Allow for the fact that most construction operations are cyclic in nature, with different plant being used for different parts of the cycle. In the present project, it was concluded that for many items of plant the percentage on-times would be only half of the percentage availability (reducing the item's contribution to the period L_{Aeq} by 3 dB.)

Diversity factor

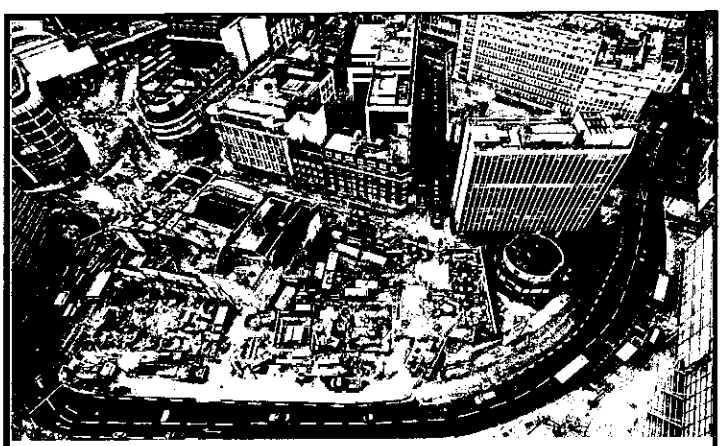
A noise monitor does not measure the noise from one activity alone, but the cumulative effect of all activities put together, to which local people are exposed.

It cannot be known exactly what activity will occur at any location on any day. Many of the operations will progress across the site during a time window of several weeks or months. When a particular operation takes place, it might only be for a few hours or days at a time, with an interruption before continuing in another location.

Owing to the large number of operations, their inherent randomness causes an averaging effect on noise levels: to provide a realistic noise assessment, this must be considered. This is a similar process to applying a diversity factor to electrical loads when designing an electrical distribution network. The assumption is that there is a negligible likelihood that all the noisiest operations would take place at the closest receiver at the same time.

Where operations progress across an area, it was decided to spread each operation across a number of working locations around the operational area and to divide the work between them, with a corresponding apportionment of the on-time. This has the effect of distributing the noise around the site, without the need to create a separate noise model for the closest approach of each operation to each monitoring location. Figure 2 shows a noise map of a piling operation where activities have been distributed in this way.

- Use typical plant levels in preference to noisiest
- Apply appropriate on-times to plant
- Distribute work around the site
- Apply a diversity factor to the operation
- Cumulative worst day may be sum of individual activities
- Typical day can be 6 dB lower than this



Overview of work sites in January 2012

The effectiveness of the approach

The sophisticated noise monitoring system allows the validity of these modelling assumptions to be assessed by comparing the predictions with the monitored noise levels.

This showed that over a 10-month period, the measured monthly *average* of the daily level (L_{Aeq}, 10h) was below the predicted cumulative level by an average of 6 dB. The measured monthly *highest* daily level (L_{Aeq}, 10h) was on average 2 dB below the predicted level, but two of the highest daily levels were an average of 2 dB above the predicted cumulative level (this is on two days only out of the 202 days assessed).

A study of one particularly noisy operation showed that if it had been assumed that all the work takes place at the closest location to the receiver point (rather than being distributed) the over-prediction of the cumulative noise level would have increased from 4 dB to 6 dB L_{Aeq} (10h).

These results indicate that without introducing the concept of diversity into the noise model, there would have been much greater likelihood of over-prediction of typical conditions. The fact that the noisiest individual days are close to the predicted cumulative values seems to show that the approach to plant noise levels and on-times described above is generally correct, and that it would have been incorrect to assume that all operations occurred simultaneously within the time window.

The effect of diversity is that although the worst day could equal the sum of all the events, the average level will be below this, with 6 dB as a typical value. This should be considered when distributing the operations, setting percentage on-times and considering noise trigger levels.

Conclusion

This paper has shown how an effective noise monitoring system can be designed with a predictive capability to warn of incipient noise problems without unduly impeding work or generating a significant number of false alarms, whilst also providing investigatory facilities.

It shows that when modelling noise, it is necessary to ensure that typical plant source noise levels are used, rather than worst-case, that some of the plant may not be used in practice and that appropriate on-times may be as little as half the time that the plant is "in use". Moreover, diversity factors should be applied and activities should be distributed around a working area with an appropriate correction to the on-time.

Once these factors have been taken into account, if there are many activities, it is possible that the cumulative worst-case level is equal to the sum of the individual activity sound levels, but the typical daily level can be 6 dB lower than this.

Acknowledgements

The author would like to thank London Underground Ltd and Taylor Woodrow BAM Nuttall JV for their kind permission to prepare and present this paper.

The author also gratefully acknowledges the generous help received from current and former staff of TWBN, especially Caroline O'Connor, Craig Prangley, Tom Whatling and Scott Tonkin. Also for assistance from Tom Wulfse of Site Engineering Surveys Ltd.

'Errors and inconsistencies' in floating room systems technical contribution

The science of vibration isolation is unfortunately a regularly misunderstood topic. Although the majority of readers of this publication will have a grasp of the basic principles, the finer points are often seen as a bit of an enigma. I was therefore very interested to read the technical contribution in the November-December 2013 issue of *Acoustics Bulletin* entitled "Floating room systems for noise reduction in mechanical spaces", in particular the section regarding the effect of air cavity stiffness on the overall natural frequency of the floated floor, one of these finer details that are often overlooked and not fully understood. Having read the report, I believe there were a number of errors and inconsistencies contained within it and so I felt compelled to pen this response.

In reading the contribution I felt that the narative seemed to switch between differing opionions, constantly contradicting itself, and this was no so more apparent than in the discussion regarding the stiffness of the trapped air within a cavity below a floating floor. I do not want this review to call in to question the author's knowledge or understanding, but I feel that air cavity stiffness is often overlooked and correcting this technically is really key.

Firstly I feel it is beneficial to define when the stiffness of the trapped air needs to be considered when calculating the overall natural frequency of a floated floor. Clearly a floated floor, where the perimeter is fully closed off (usually by a resilient material installed up against an adjacent wall) will have a volume of air that is "trapped" within the cavity. The use of a mineral wool type material within the void is often used to try and reduce the effect of the air cavity stiffness. This works on the principle of trying to avoid the presence of standing waves within the void and it does slightly reduces the air stiffness (as I will try and quantify later when I look at the equations that should be used) however by no means does this mean that the air cavity stiffness is suddenly insignificant. Often, as suppliers of floated floor systems, we at Total Vibration Solutions will see specifications stating that the floor should be fully vented to avoid the problems of air cavity stiffness. The idea behind this is usally to have open perimeters to the edge of the floor so that the volume of air under the floated floor is not constrained by it and as such the air adds nothing to the overall stiffness of the system. In reality however, even for a floor as small as 5m x 5m, the trapped air at the middle of the floor still has to travel more than 2.5m to get out and as such still is considered slightly "trapped". The effect this has will gradually increase as the area of the floated floor increases but unfortunately there is not a great deal of test data available on the subject. As such, unless you are looking at a floated floor with a very small area and an open perimeter, you should always consider the effect of the stiffness of the trapped air on the overall natural frequency of the floor.

This brings me to the equations in last months technical contribution and really the crux of the matter. I am in agreement with equations (1), (2) and (3) in the report as listed below.

$$f_n = \frac{1}{2\pi}\sqrt{\frac{k_a + k_{rm}}{M}} = \sqrt{f_a^2 + f_{rm}^2} \quad (1)$$

where
f_n = combined natural frequency (Hz)
k_a = air stiffness (N/m)
k_{rm} = resilient mount total stiffness (N/m)
M = total mass supported (kg)
f_a = natural frequency of airgap (Hz)
f_{rm} = natural frequency of resilient mount (Hz)

$$k_a = \frac{\rho.c^2}{t} \quad (2)$$

where
ρ = density of air (kg/m³)
c = speed of sound through air (m/s)
t = thickness of the airgap (m)

$$f_a = \frac{1}{2\pi}\sqrt{\frac{k_a}{M}} \quad (3)$$

Where the problems start is in substituting equation (2) into equation (3) the author comes up with an incorrect equation (4). This would have become apparent to anyone who tried to do an example situation and plug in the same values working of the initial equations and then off the incorrectly simplified equation (4). If you require a simplified equation of the form of equation (4), using a density of air at 20°C of 1.2kg/m³ and a speed of sound of 340m/s², then this would be much closer to equation (a) below.

$$f_a = \frac{59.3}{\sqrt{M.t}} \quad (a)$$

(note (4) had a constant of 19 as the numerator as opposed to the 59.3 shown in (a)).

However given that the density of air does vary with temperature, it is usually just as easy to stick with using equation (2) and (3).

Previously I had discussed the use of a mineral wool type product in the void. In this case, when we are looking at a room where the density of air is 1.2Kg/m³ a common practise is to substitute the $\rho.c^2$ term with a constant value of 110,000.

Getting back to to the contribution, the author then goes on to provide an example with a floating floor with 100kg/m² loading, supported by elastomeric mounts with a static deflection of 10mm and an airgap of 50mm.

The first thing to point out here is that the natural frequency of the isolator is being calculated using equation (5) and (6). These are equations that actually can only be applied if the isolator has a linear spring rate and is within its elastic limit. It is a common mistake to use these equations to calculate the natural frequency for all isolators as the effect of damping is ignored and the majority of isolators do not exhibit a linear spring rate. As such, best practise will always be to use the load vs natural frequency data from the manufacturer of the isolators.

If, however, we overlook this and asume that the isolator does indeed have a natural frequency of 5Hz (taken from inputting a static deflection of 10mm into equation (6), the natural frequency of the air (from equations (2) and (3)) would be 26.5Hz, giving a system natural frequency of 27Hz. This is a great deal higher than the 9.9Hz that the author states and truly shows the problems associated with lightweight floors and small airgaps. It also shows the massive problem that can be created from a misunderstanding of such an important subject.

The author later goes on to report that typically natural frequencies of the system of 15Hz can be achieved. This is entirely correct and, for instance, a 100mm thick concrete slab with a loading of 240kg/m² and a 100mm airgap, with mineral wool in the void on 10Hz mounts, would have an overall system natural frequency of approximately 14.7Hz. My concerns are that the statement clearly is at odds with the example calculation earlier in the contribution, where a 9.9Hz system is suggested possible in a situation where the parameters all point towards a worst case scenario; lightweight, small airgap. To me this suggests that the author is combining a number of different, contradicting sources, without a clear understanding of the topic at hand. This is certainly concerning and certainly something that I felt needed to be corrected in this issue. Air cavity stiffness is an often misunderstood or overlooked quantity and it is important that we are all aware and knowledgeable on its effects and how to calcualte them. ◘

Patrick Dent
Technical Director, Total Vibration Solutions

John Lloyd launches acoustic practice at Scotch Partners

After more than 25 years with AECOM, John Lloyd has moved from the global services provider to start a new acoustic practice within the design consultancy, Scotch Partners. John is no stranger to his new colleagues having worked with the partners for more than 20 years in his previous role.

John said: "It is refreshing to move away from the corporate culture into a more dynamic and agile environment.

"I was there at the start of Oscar Faber Acoustics (acquired by AECOM in 2001) and I am being reminded of the different challenges you face when starting a new acoustics practice from nothing. Scotch and many of my construction industry colleagues have been very encouraging and I'd like to thank them all for their support."

Steve Campbell, Partner, said: "It's fantastic that Scotch are now able to offer building acoustics to our clients. John is liked and well respected and is able to present acoustics in an understandable way to us non-acousticians. With the market starting to return, I am confident the addition of acoustics to our offering will help us secure more exciting projects."

As a former Director and Head of Building Acoustics at AECOM, John was responsible for the acoustic design of projects across all of the market sectors including hospitality, commercial, residential, healthcare and education.

'Egg whisk' wind turbine scoops design award

An innovative design for a six-bladed wind turbine said to be much quieter than conventional three-bladed versions has won an award from *NASA Tech Briefs* magazine in the US.

The Canadian-designed LUX turbine, which has been likened to a giant egg whisk, won first prize in the sustainable technologies category in the magazine's 2013 Create the Future design contest.

With a total height of 26 metres, it rotates around a vertical axis and does not require a tower or central column which means it is half the weight of a conventional turbine.

Inventor Glen Lux said: "It is also much quieter because the blades rotate slower – a maximum of 35 metres per second compared with 80 metres a second or more for the blade tips on conventional turbines – and they are not subject to the tower shadow.

"Conventional turbines rotates approximately 30 per cent faster and as each blade passes through the tower shadow it makes a 'whooshing' sound which can be disturbing to people and animals.

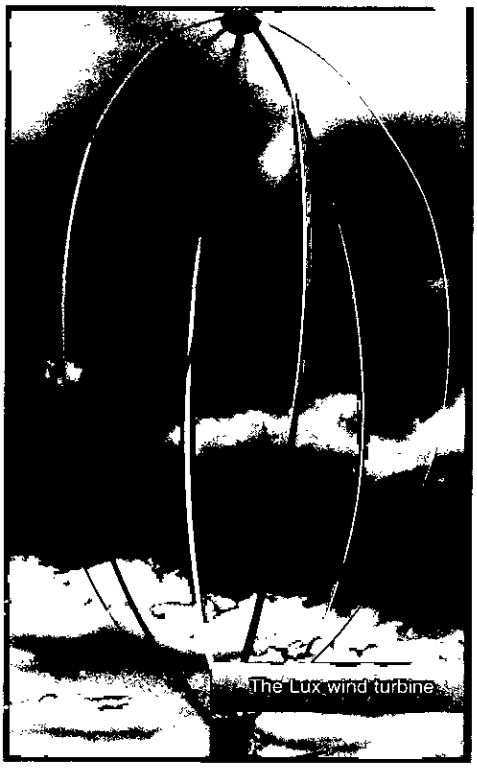
"With a conventional turbine the mechanical components are located at the top of the tower, so the sound travels further and sound insulation is difficult. With my turbine these components are at ground level, so the sound does not travel as far, and they can be easily and economically sound insulated."

Other key environmental benefits include a 90 per cent reduction in the land required because they can be set much closer together. They are also far more visible to bats and birds.

Mr Lux, who has been working on the project since 2002, is hoping that the award will finally spark interest from investors so he can take the technology to market.

"It's very frustrating on my part to see that there's a better solution and people are so reluctant to help," he said.

For more details go to **http://luxwindpower.com/**


The Lux wind turbine

All quiet at the music café

Troldtekt acoustic panels have been used in the design of the music café at the Snape Maltings music centre, Aldeburgh, which was founded by composer Benjamin Britten.

The café, part of architects Haworth Tompkins' phased extension of the creative campus, has been created by converting a former granary store into a cafe and reception point for artists and staff.

In order to reduce noise reverberation, the architects have used 160m² of fine natural wood Troldtekt panels to create an attractive and high performance acoustic ceiling.

Troldtekt panels, widely specified for ceilings and walls in potentially, noisy environments, are made from 100% natural wood fibres mixed with cement. Their benefits include high sound absorption, high durability, natural breathability, low cost life cycle performance and sustainability. Their sustainability was recently recognised with certification at Silver level within the Cradle to Cradle concept.

For more details ring **0844 8114877** or visit **www@troldtekt.co.uk**


The music café

Panels improve school acoustics

Acoustics in the sports hall at Durants School, Enfield, have been significantly improved by the installation by SRS of suspended Sonata Vario panels.

The company also used similar panels to iron out acoustics problems at a sports hall used by Hazeltots Pre-School in Guildford.

For more information: ring **01204 380074**, email **info@soundreduction.co.uk** or visit **www.soundreduction.co.uk**


The new ceiling at Hazeltots' Pre-School

Cirrus Research helps to protect race car workers from excessive noise

Cirrus Research has helped protect workers at a leading racing car engine maker from excessive noise.

The company was called in by Northampton-based Ilmoor Engineering when it won a big contact to build V6 engines for the US IndyCar championship, which meant additional machine tools had to be installed in the main machine shop, increasing noise levels.

To determine whether workers were being exposed to levels above 80 dB(A), Cirrus carried out an occupational noise exposure survey using a doseBadge, a wireless personal noise dosemeter.

The measurements revealed that there were several points throughout the day when noise exposure levels would greatly exceed this limit, with the level hitting 110 dB(A) on one occasion.

As an interim measure, Ilmor issued immediate instructions to operators directly affected to wear their existing hearing protection for the complete shift, not just when loading and unloading work.

After analysing the graphical traces produced by the doseBadge, it was also suspected that the principle reason for the rise was due to the increased use of air guns.

A more detailed investigation into the noise generated by the guns was undertaken using a Cirrus Optimus Red sound level meter, and after analysis of both sets of data Ilmor was able modify its manufacturing processes, taking noise levels back down to previous levels.

● Cirrus is continuing its North American expansion strategy with the appointment of two new distributors for the US. Don Wolf & Associates has been appointed to cover southern California while MEDI has responsibility for the northern part of the state.

Cirrus has three other distributors in the US – A J Abrams (New York State, Pennsylvania and the north eastern states), ISI (Ohio and surrounding regions) and OHD (the south east and central southern states). It plans to appoint more in the next few months.

James Tingay, Marketing Manager, said: "The US is an important market for us and one that is currently growing faster than any of our other international markets. With our additional distribution partners we are very confident that the sales momentum will continue to new records in 2014 and beyond."

For more information visit: **www.cirrusresearch.co.uk**


A doseBadge in action

Updated noise mapping software from Brüel & Kjær

All mapped out: Predictor-LimA

Brüel & Kjær's latest version of its environmental noise mapping software, Predictor-LimA, is available to download.

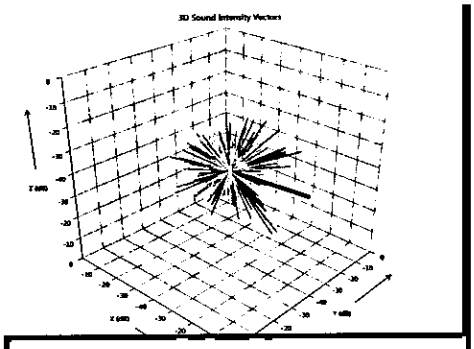
This updated release has a bigger calculation capacity for configurations 7810-C/D/E/F, which now support Plus sized models. It has a new, entry-level configuration called Predictor-LimA ISO Standard Type 7810-I; this helps the user to keep costs down when calculating smaller industrial noise projects.

Predictor's network modelling licence now also supports server calculations, on one dedicated PC in the network. This, says the company, makes the solution even more powerful and cost effective for small businesses and universities, by allowing one Predictor licence to be used as a calculation engine for models made on a number of different PCs. This enables several people to work on noise models at once and initiate calculations from their own PC.

Brüel & Kjær's customers with valid contracts will be able to upgrade and receive a new licence, which enables them full use of the software, when they request it via the company's Predictor-LimA Technical Support customer web portal.

The new version is available for customers to download on Brüel & Kjær's website: **www.bksv.com/7810**

New measurement system will 'aid room acoustics understanding'



3D sound intensity vectors

Marshall Day Acoustics has released a new measurement system that it says promises to provide a dramatic step forward in being able to understand the acoustics of rooms.

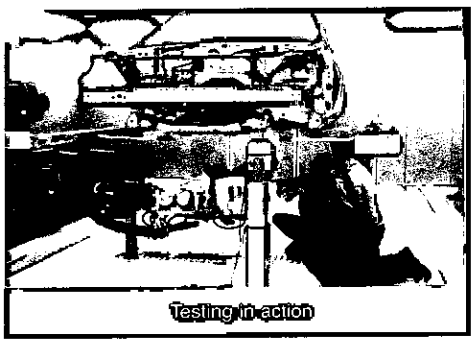
The IRIS system comprises a tetrahedral microphone that can resolve the sound field into different directions, and software that can analyse the signals from the four microphones and present the information in "a simple yet elegant way that aids one's understanding of the behaviour of the sound field".

The system has been under development for nearly three years but it has its origins in the efforts by many researchers over the last 60 years to understand the factors that affect people's appreciation of speech and music performed in concert halls, opera houses, lecture theatres and all the wide variety of spaces that are used for performance and communication.

The system uses existing readily available hardware, and the software runs on low cost laptop computers, "thus providing a system that is affordable for consultants and educational institutes".

For more details go to **http://www.iris.co.nz/**

Robot laser scanning vibrometer will be a UK first



Testing in action

A joint project between the University of Leicester and Polytec UK will provide the UK's first commercial 3D non-contact laser vibration scanning measurement and modal-analysis centre. It has been developed specifically to service the automotive, aerospace and space sectors.

Opening in May, the ASDEC (Advanced Structural Dynamics Evaluation Collaborative) research centre in Nuneaton will be the only such facility in the UK providing 3D full-field scanning measurement services and the only one in Europe to provide modal analysis, modeling and certification services.

This capability will be provided by the range and spatial resolution of Polytec's laser Doppler systems, enabling automatic 3D scans of structures at the centre as well as vibration field scans at end-user sites.

This high-tech non-contact technology enables the diagnostics and large-area dynamic measurements to be performed in hours compared with the longer turn-around times of traditional multi-channel accelerometery (typically measured in terms of days, weeks or even months).

ASDEC is initially funded by a £1 million grant from the UK Government's Regional Growth Fund and by an ERDF structured grant to support Small and Medium Enterprise (SME) access to the centre. When fully operational, ASDEC is expected to create 250 new jobs in the UK.

The advanced vibration measurement and analysis will cut the time required for new product development, testing, analysis and, ultimately, time to market. For product development, this approach also allows an enhanced upfront pre-test diagnostics, improved Mac address comparison data, early product de-risking, and greatly reduced development time and costs.

Joe Armstrong, Polytec Sales Manager, said: "This new resource will help UK innovative and cutting edge companies by offering large area structural dynamic measurements with both high resolution and high accuracy for improved finite-element analysis (FEA) validation. For example, it can fully measure and characterize a full body in white for an automotive supplier.

"There is no equivalent robot laser scanning vibrometer elsewhere in the UK. Its key operational element is laser Doppler vibrometry enabling us to measure velocity rather than acceleration. Typically, other systems that are available use a 'comparison' approach – without the vibrometer.

For more details go to **www.polytec-ltd.co.uk**

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Committee meetings 2014

DAY	DATE	TIME	MEETING
Thursday	23 January	10.30	Membership
Thursday	6 February	11.00	Publications
Thursday	13 February	11.00	Medals & Awards
Thursday	13 February	1.30	Executive
Thursday	27 February	10.30	Engineering Division
Tuesday	4 March	10.30	Diploma Examiners
Thursday	**6 March**	**11.00**	**Council**
Monday	7 April	11.00	Research Co-ordination
Tuesday	8 April	10.30	CCWPNA Examiners
Tuesday	8 April	1.30	CCWPNA Committee
Thursday	10 April	11.30	Meetings
Thursday	1 May	10.30	Membership
Thursday	15 May	11.00	Publications
Wednesday	21 May	10.30	CMOHAV Examiners
Wednesday	21 May	1.30	CMOHAV Committee
Thursday	22 May	11.00	Executive
Tuesday	27 May	10.30	ASBA Examiners
Tuesday	27 May	1.30	ASBA Committee
Thursday	29 May	10.30	Engineering Division
Thursday	**12 June**	**11.00**	**Council**
Wednesday	18 June	10.30	CCENM Examiners
Wednesday	18 June	1.30	CCENM Committee
Thursday	19 June	10.30	Distance Learning Tutors WG
Thursday	19 June	1.30	Education
Thursday	17 July	11.30	Meetings
Tuesday	5 August	10.30	Diploma Moderators Meeting
Thursday	14 August	10.30	Membership
Thursday	4 September	11.00	Executive
Thursday	**11 September**	**11.00**	**Council**
Thursday	25 September	10.30	Engineering Division
Monday	29 September	11.00	Research Co-ordination
Thursday	16 October	10.30	Diploma Tutors and Examiners
Thursday	16 October	1.30	Education
Thursday	23 October	11.00	Publications
Thursday	30 October	10.30	Membership
Tuesday	4 November	10.30	ASBA Examiners
Tuesday	4 November	1.30	ASBA Committee
Thursday	6 November	11.30	Meetings
Thursday	13 November	11.00	Executive
Wednesday	19 November	10.30	CCENM Examiners
Wednesday	19 November	1.30	CCENM Committee
Thursday	20 November	11.00	Publications
Tuesday	2 December	10.30	CCWPNA Examiners
Tuesday	2 December	1.30	CCWPNA Committee
Thursday	4 December	11.00	Council

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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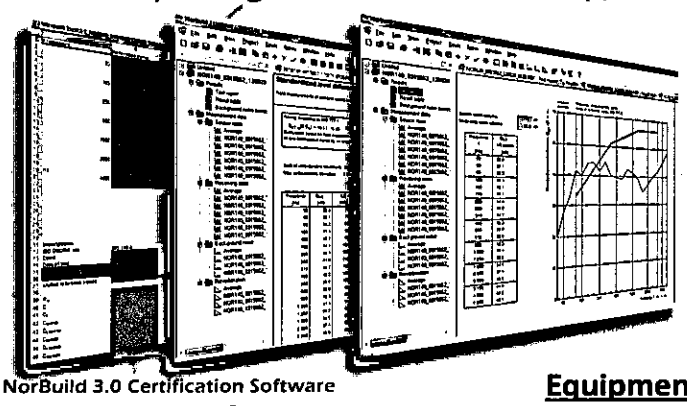

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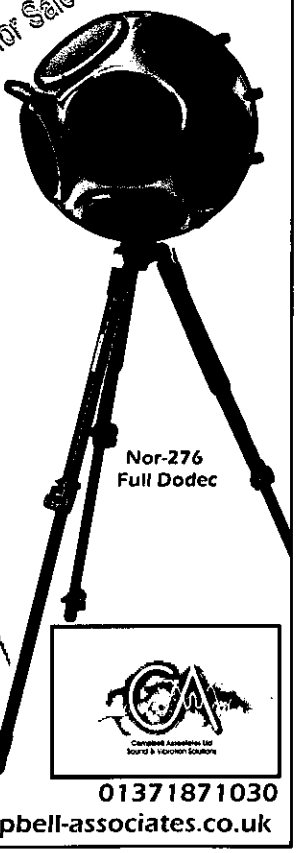

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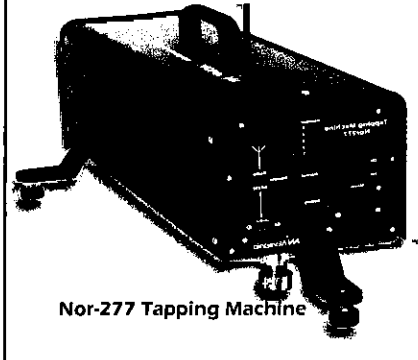

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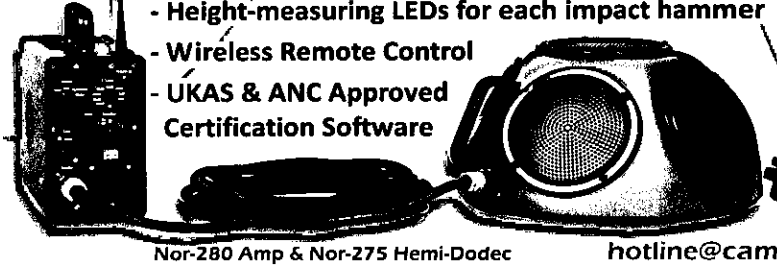

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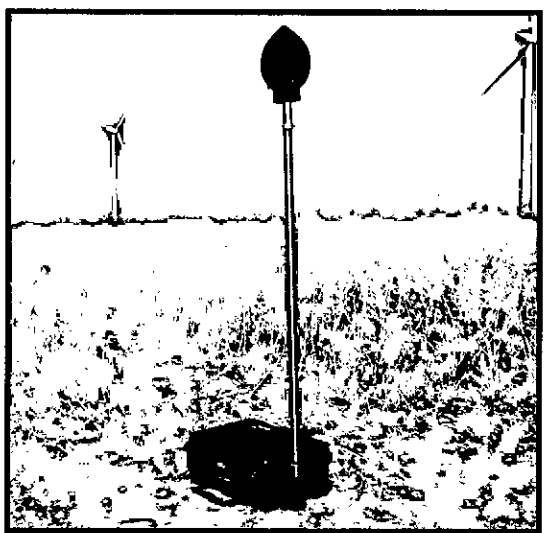

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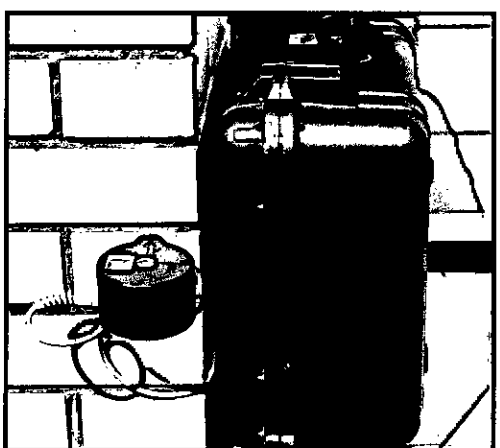

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