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ACOUSTICS BULLETIN

in this issue... **Noise from shale gas exploration**

plus... **Acoustics on large infrastructure projects**

Auralisation: sound design for our sound environment

Case study: acoustic design at the St James Centre, St Helier, Jersey

Are old timers past their peaks (L_{Cpk} that is)?

Institute of Acoustics

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Front cover photograph: Shale gas exploration

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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.

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Instrumentation Group
When shall we three measure again – in thunder, lightning or rain
Moreton-in-Marsh

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Dear Members

As we enter summer, it is time to review the first half of the year and look forward to the second half. It will also be time for a handover as we approach our AGM in early September, in Executive and Council, when I transfer the baton to Jo Webb.

We are now, with Jo leading the process, progressing with the Educational Review and have started to tie this into our strategy going forward. This will be the next key step in our vision and will ensure we continue to lay a solid foundation for the future.

As part of our continued focus on developing the Institute's profile and ensuring we deliver services for tomorrow's professional, I am pleased we have a successor to Peter Wheeler as Engineering Manager and welcome aboard Blane Judd (see page 16 for more details). I urge you to consider the benefits of registration via the Institute with the Engineering Council.

Some time ago we sponsored the film *In Pursuit of Silence* to support our strategy to promote acoustics to the general public. The film just had its sold out UK premiere at the Sheffield International Documentary Festival and we have learned that it was awarded runner up for the Storytelling and Innovation Award at the festival. The screenings to date have been warmly received by audiences and journalists alike. Distribution plans are being clarified for the film as it continues playing at festivals around the world. For a full list of screenings as they are confirmed, visit http://pursuitofsilence.com/screenings

Time has flown over the last two years and it has been a pleasure and honour to serve as President. I have been fortunate to preside over the 40th anniversary celebrations with Leo Beranek, who gave the opening keynote lecture. It has also been my pleasure to present medals and awards to a number of worthy recipients for their devotion and commitment to excellence in acoustics and to the Institute. Acoustics can be served in many ways, and the individuals recognised for their exceptional accomplishments and outstanding performance continue to serve as an inspiration for us all.

Looking forward, the Institute is in great shape, with a great team, a defined strategy and a solid financial position to enable us to carry on the good work in the future. We are to host ICSV24 (International Congress on Sound and Vibration) in London next year; this shows trust by the organisers that we are able to deliver, and based on this success we are currently bidding for Internoise in 2019.

Executive and Council will soon be led by Jo Webb as President and Barry Gibbs as President Elect. As they step into their new roles, I wish them every success and I, over the next two years as Immediate Past President, along with the rest of Exec and Council, will give them every support.

My sincere thanks and appreciation goes to Bridget Shields, who will, after six years through the posts of President Elect, President and Immediate Past President, be stepping down. Her knowledge, help and support to all has been of great reassurance.

My one disappointment is that I did not have time to visit all the branches and groups. It is to this dedicated band of volunteers, along with all the committee members past and present, to whom, as the life blood of the Institute I express my gratitude. The good news is that we have initiated a regular annual meeting with all the chairmen and secretaries to ensure that communication is cascaded to all members, along with the e-newsletter and the Bulletin.

Andrew Carnegie said "Teamwork is the ability to work together toward a common vision, the ability to direct individual accomplishments toward organisational objectives". Your individual abilities and accomplishments are the key to our continued success. Without each of you, our 'team' could not exist. Your efforts bring a variety of talents and through your persistence, hard work and devotion we are a 'presence' in the field of acoustics.

I look forward to seeing many of you at the Autumn Conference in September.

William Egan, President

Acoustics on large infrastructure projects

By Chris Wood

In May some 100 of us were fortunate enough to attend this sell-out conference at the Royal Society, London, as organised by the London Branch. The Royal Society, as on previous occasions, proved to be a great venue. The speakers delivered, too, with a good mix of topics and practical and technical information.

The two morning sessions were chaired by Stephen Turner (Stephen Turner Acoustics), which, following an introduction from the lead organiser, Louise Beamish (WSP | Parsons Brinkerhoff), were kicked off by the quartet of Andrew Bird (Crossrail Noise and Vibration Specialist), David Keeley (Crossrail Historic Building Specialist), Rick Methold (Southdowns Environmental) and Richard Holbrook (Costain Skanska JV) on the topic of *Vibration management and listed buildings*, with additional authors named as Colin Cobbing (Arup), Suzanne Bryon (Crossrail Environmental Advisor), Graham Aubrey and Kenneth Hill (Costain Skanska JV).

On account of the constrained nature and scale of the site, and its proximity to a number of different types of receptors – including the focus of the presentation, the Grade I listed MacMillan House – Crossrail Paddington Station was described as one of the more "exciting" stations. It was identified that there is an absence of guidance in terms of listed buildings and vibration, leading Crossrail to develop a precautionary approach, including a "screening" limit of 3 mm/s (broadly based on guidance from the superseded BS 5228-4:1992) and various controls.

A substantial amount of work was undertaken to prepare for the key works – the main activity being the removal of the top 2 m of the (concrete) diaphragm wall (which was reinforced in places) – including condition monitoring, vibration monitoring inside and outside the building, carrying out vibration risk assessments and on site trials. The latter comprised vibration measurements at various distances during the use of a range of excavator mounted breakers. From these a schedule was developed of what breakers could be used in which locations. There remained, though, a risk of the limit being exceeded, and so measures to limit or eliminate the need for breaking were explored.

The best (practicable) regime, depending on the presence of reinforcement, was determined to be a combination of over-excavating (to reduce the amount of ground that could provide a path for the vibration), coring and hydraulic bursting, wire sawing, limited breaking to split larger chunks produced by the bursting, and the use of the most appropriate bucket size to avoid snagging on the reinforcement.

Continuous real-time monitoring, training, the on-site presence of specialists, and close cooperation between the noise and vibration, heritage and construction teams, were also highlighted as crucial to the successful completion of the works. It was also noted that whilst the construction costs were substantially higher compared with simply using heavy breakers, the cost of having got it wrong would likely have been far higher.

Next up was David Owen (Arup) on the *Delivery of operational airborne sound, noise and vibration assessment for HS2 Phase 1 Environmental Statement*. Following a brief reminder of the extent of HS2, with Phase 1 alone having been divided into 26 "community forum areas", David moved on to present possibly the busiest slide PowerPoint has ever been used to produce! Which wasn't presenting the prediction methodology in detail, for example, but rather the number of documents that David and his colleagues are responsible for producing or feeding into – such is the scale and significance of the scheme and associated knock-on effects.

Like the other presenters, David highlighted the importance of the interface between disciplines, which, in the case of HS2, included those covering air quality, agriculture, community, ecology, heritage and landscape and visual. Recommendations, included co-location (including with the client), sharing skills and modelling files, as well as the need to plan ahead (and have a Plan B!), identify topic milestones, consult with stakeholders and peers, and to make use of GIS/CAD specialist and those that actually enjoy proof reading!

The elements and assumptions associated with the five source model were described – the model having first been development in the '90s for HS1 (i.e. the CTRL), and used instead of CRN, for example. Given what should be achievable in terms of mitigation,

Louise Beamish welcomes delegates

Richard Holbrook

The conference begins

David Owen

either as per current examples in Europe and the Far East, or what's likely to be achievable in the next 10 years before the route is operational. For example, compared with European TSI (Technical Specifications for Interoperability) compliant trains, adopting the slick design of the pantographs and recesses/ wells of the Asian trains, improvements of -10 dB and -4 dB have been assumed when the pantographs are in the lowered and raised positions, respectively.

Aspects of the (empirical) model were described, including the "forcing" and "filtering" factors, with speed requiring the most research owing to the large number of factors involved. Other key titbits included that there would be up to 18 trains per hour in each direction (so one every 1½ minutes), with speeds in the region of 330-360 km/h, and a design speed of 400 km/h.

After more coffee, Gail Hitchens and Humphrey Roberts-Powell (Jacobs) gave HS2 a run for its money in terms of scale in the form of a case study on Wylfa Newydd (though David may beg to differ?!), a new nuclear generating station of 2,700 MW, speaking on the topic of *Maximising value with multipurpose monitoring*. Introduced by Gail, the main site is 380 hectares, which is the equivalent of 281 football pitches. The scheme includes a marine off-loading facility, highway improvements, park and ride facility and accommodation for workers, laboratory and control centre, as well as visitor and logistics centres. Also, the construction site footprint is larger than that of the station, with a programme circa10 years, and estimated to require in the region of 8-10 thousand construction workers. So naturally there were/ are a number of receptors to consider, in addition to dwellings, including a Special Area of Conservation, several SSSIs and heritage sites. And thus, equally naturally for this day and age, in addition to the Development Consent Order application, a number of other applications were required, whilst a Neighbourhood Support Strategy (including a Disturbance Mitigation Plan) was also prepared.

A brief overview of the relevant guidance was provided, which included Minerals Technical Advice Note (MTAN) Wales 1: Aggregates (March 2004) on account of the scale and duration of the required earthworks – some 8-13 million cubic metres – as well as the usual suspects of BS 5228, CRTN, DMRB, BS 4142, WHO Guidelines and BS 8233 – all of which needing to be taken into account in terms of the data captured during the baseline survey. Which is where Humphrey took to the stage to provide a useful guide to the challenges associated with surveys, which are many and varied at the best of times, but especially around changes in guidance, such as, say, in the year 2014! Challenges can, therefore, take the form of changing guidance – which is a prompt to try and future proof data – conflicting or unclear guidance, scrutiny by interested parties, access and security, seasonality, weather conditions, etc. etc. Humphrey described the sound level meters adopted for the baseline monitoring, which, apart from being the ones in the cupboard, were capable of fine resolution measurement periods, something that it was felt the survey and assessments demanded.

Following a table identifying the differences between analogue and digital processing – highlighting that perhaps we don't make the most of the capability of modern meters – charts were presented showing the differences between L_{Aeq} and L_{AF} measurements at 100 ms – the former shown to be the more dynamic of the two; though, overall (period) differences would be relatively small (i.e. points of a dB). And whilst there are definite benefits to essentially measuring "everything" – such as being able to cover the requirements of a wide range of guidance, spotting atypical events, comparison with met. conditions – you do need the storage capacity and software to match, and there is such a thing as too much choice.

The slot before lunch was taken by another tag-team in the form of Sue Fitton and Richard Morris (National Grid), both MIOA, speaking on the topic of the *Operational noise assessment for the Hinkley Point C Connection Project*. Now I don't suppose many prior to the presentation were too aware of the ins and outs of Overhead Line (OHL) noise, but owing to a very clear explanation, with the presentation including an audio recording and moving 3D model simulation, the subject was made very accessible.

Following an introduction to National Grid, which also owns and operates electricity and gas assets in the US, the Hinkley Point C Connection Project and operation noise assessment were outlined. Interestingly, it will be the first project to use the competition winning T-Pylon, as opposed to the traditional Lattice Pylon, which will be used to support the 47 route km of 400 kV OHLs. There will also be 8 km of underground cable and a new substation, all required to connect to a new nuclear station in Somerset.

Prior to the DCO application being submitted in May 2014, there was a five year period of development and consultation, which included 56 public exhibitions (attended by some 6,500 people). There followed a six month examination period, including P8

Gail Hitchens

Humphrey Roberts-Powell

A break in proceedings

P7

160 pages of written questions (44 questions on noise), four open floor hearings, 13 issue specific hearings, including several on noise.

In terms of OHL noise, it was explained that this occurs/varies when irregularities on the surface of the "conductors" (i.e. bare wires) cause localised enhancement of electric stress, enough to cause electrical breakdown in the surrounding air. Where, in addition to rain drops, such irregularities can be in the form of bird droppings and dust, whilst the effects can vary depending on operating voltage and conductor bundle and phase geometry.

The audio recording sounded like electrical interference, being made up of a combination of a "crackle" and a "hum", but where the former can be masked by rainfall noise, and with the latter typically being at 200 Hz (the 2nd and principle harmonic of 50 Hz).

So, on to the assessment; which, unlike most assessments, focused on wet conditions, rather than avoiding them. Applicable policy and guidance was taken to be National Policy Statement for Energy (EN1) and National Policy Statement Electricity Networks Infrastructure (EN5), which includes alternative assessment methods for rain-induced noise, including TR(T)94 (1993) (A Method for Assessing the Community Response to Overhead Line Noise, National Grid). This references BS 4142:1990, but with the methodology still aligned with the latest version.

Whilst some baseline measurements were made, to account for the length of the scheme, with multiple route options being considered, the position was taken to assume a minimum night-time background level of 30 dB for the assessment. The modelling was contracted out to Bureau Veritas, with the model being influenced by in-house calculations based on historic measurements, with corrections applied to account for the character of the noise, and the level and duration of rainfall. Conservative magnitude of effect criteria were determined for the project, whilst dwellings were treated as "medium" sensitivity, leaving the "high" category for any receptors considered particularly sensitive. Using the magnitude of effect scale, the results were presented graphically for ease of visual analysis.

Following a question on mitigation, we were told to watch this space. National Grid is looking to set up tests to further investigate strand shapes, surface properties, etc. whilst newer materials are becoming available that may mean it's viable to sheath the conductors, but it's not straightforward.

After lunch, and under the chairmanship of Oliver Bewes (Arup), Emma Greenland (WSP | Parsons Brinkerhoff) spoke on the topic of *PA noise overspill from rail stations*, with Jorge De Avillez and Andrew Steele (WSP | Parsons Brinkerhoff) noted as co-authors.

Emma explained that, in the majority of cases, the PA design requires coverage conformity with specific standards, mainly relying on speech transmission index, which is dependent not just on sound pressure level, but also on signal-to-noise ratio and reverberation time. In some situations, however, the better the speech intelligibility, the greater the potential for community noise annoyance. The provision of adequate speech intelligibility, therefore, needs to be finely balanced with control of environmental noise overspill to noise-sensitive receptors.

In the absence of statutory guidelines for PA noise emissions, Emma explained that BS 4142 style assessments are often applied, but experience shows that a higher level of complexity is often required since PA system emissions track a fluctuating ambient noise level (via an ambient noise sensor) and depend on operational factors, such as PA announcement type and duration, etc. PA noise emissions from existing nearby rail stations may also need to be quantified and considered as part of the assessment.

This led Emma on to provide a useful overview of applicable modelling methods and associated software packages. 3D Raytracing modelling packages such as Odeon and CATT came out on top due to a greater coverage of the applicable modelling elements, including the ability to predict outdoor propagation at "nearby" receptors. Understandably, noise mapping software (such as CadnaA and SoundPLAN) can't predict in terms of STIs or provide auralisations, whilst EASE (an example of loudspeaker software) isn't geared up for accounting for outdoor propagation.

Case studies were discussed to contrast the difference between primary (high risk) and secondary (low risk) situations and the assessment approach applied in each case.

Emma rounded the presentation off with some recommendations. Naturally, noise overspill should be assessed as earlier as possible (e.g. during concept design), when there's more capacity to change finishes, loudspeaker types and positions, etc. The design criteria should be scrutinised and relevant to the situation; the prediction method should be selected carefully; STI design should be included to assess for loudspeaker redundancy; the SNR should be optimised; whilst the use of alternative STI (BS EN 60268-16) Qualification Bands can be worth considering.

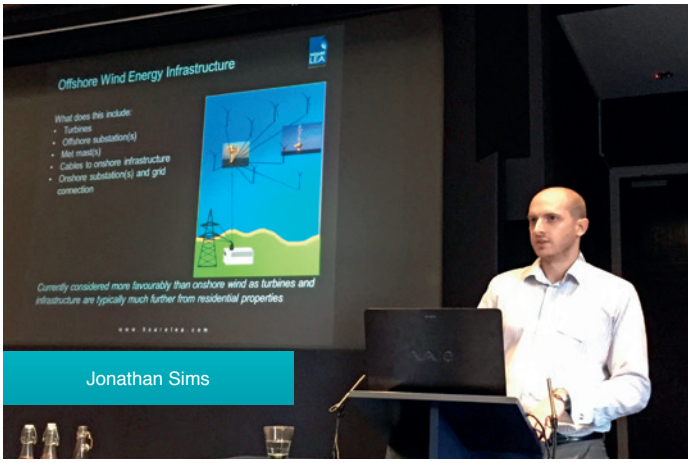
Next Jonathan Sims (Hoare Lea Acoustics) presented on *The assessment of noise from construction of offshore renewable energy infrastructure*, presumably something of a relatively niche area of experience. Jonathan pointed out that due to typical distances of 5 km to 30 km from the coast line, operational noise isn't generally an issue (the typical SWL of an offshore turbine being c115 dB), but that, despite such distances, complaints can occur during the installation piled foundations using impact means (when SWLs can be 140+ dB).

Jonathan has measured noise levels in the region of 45 dB $L_{Aeq,100ms}$ from piling approximately 20 km from the shore, whilst, due to the low frequency (100 Hz) and impulsive nature (with hammer blows every 2 seconds typically), the piling can be clearly audible even when the piling $L_{Aeq,T}$ is below the ambient $L_{Aeq,T}$. The situation is not helped by the fact that the piling can only take place under calm sea conditions and low winds, and so often takes place at night, for up to around four hours at a time (and possibly for several weeks during good weather). Factors influencing the received conditions also include downwind refraction, possibly with the assistance of a low level jet, and the acoustically reflective surface of the sea.

In terms of predicting piling noise, and, seemingly, in order of preference, the pros and cons of ISO 9613, ISO 13474, the IOA SGN6 and the Parabolic Equation (PE) method were

P10

Richard Morris



Jonathan Sims

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P8

presented. The cons of ISO 9613 were presented as being that the source(s) generally fall outside the scope, that met. effects only considered in general terms, and that ground absorption effects are only considered approximately. The cons of ISO 13474 were considered to be that it is primarily intended for predictions from explosives/gunfire, the requirement to know excess attenuation for different met. conditions/ground types, and also the requirement to know the probability of different met. conditions occurring. There were considered to be fewer cons with SGN6 – it is strictly only valid of specific met. conditions and for propagation over water (not water onto land) – whilst the pros were that it is very simple and quick to use, and with very few input parameters required. Lastly, the PE model appeared to come out on top technically, allowing for assessment of the effects of different sound speed and terrain profiles and ground impedance, but had the distinct cons of the calculations being per frequency, being generally slower/ more complex, with propagation angle limitation and there being an absence of commercially available software.

Following a brief discussion on assessment methodology, Jonathan described the long-term monitoring he was involved with at four positions over three years, which looked very impressive indeed (not a piece of gaffer tape in sight!). The equipment included Class 1 sound level meters mounted on the dwellings' façades using custom built brackets, PCs (also mounted externally) for local storage and remote access, broadband landline connections and mains power. Whilst the equipment logged dBA and 1/3 octave band data at 100 ms intervals, as well as recording audio for 2 minutes every 10 minutes – which sounds like an awful lot more even than the >100 million data points claimed earlier in the day.

It was asked at the end what mitigation measures are available. Those Jonathan could think of at the time were a softer dolly (i.e. a means of cushioning the blows), but which tends to slow progress; the use of a jacket around the hammer/ pile, but which he's not yet seen applied; and piling in wind conditions away from the shore (however, unless installing turbines off the west coast, this is rarely likely to be practicable).

After coffee, Richard Perkins (WSP | Parsons Brinkerhoff) used his experience (including that gained on the A487 Caernarfon bypass and the East-West Railway Phase 2 scheme) to cover the topic of *The trials and tribulations of noise and vibration assessment for linear projects*, and offer some advice.

Richard highlighted the DMRB-based stages for road scheme (noting that changes are due, hopefully including guidance on determining the significance of impacts) and the equivalent GRIP (Guide to Rail Investment Process) for rail schemes.

Challenges for road schemes can be associated with: defining the study area – historically an easy exercise based on a single threshold of 300 m from the scheme, now a relatively complex process requiring knowledge of the traffic flow changes; obtaining the traffic data (in the right format and without errors); modelling the existing and future conditions (requiring existing and proposed topographical data); and identifying receptors (with limitations to Address Point data). Richard believes that there is a need to educate transport planners so that they better understand our typical data requirements, whilst it was noted that speed data, in particular (which can be very low or subject to significant changes), can produce interesting results and requires sanity checking.

Challenges for rail schemes are broadly the same as for road schemes, but with the added dimension of vibration, whilst there is likely to be an absence of flow and/or source data, particularly when not directly working for the rail scheme. Which may or may not be due to the fact that, as David Owen highlighted earlier, the scheme may not be fixed at the time the EIA is being undertaken.

Richard identified the need to refer to planning policy (including NPPF and NPSE) and determine significance, and thus define LOAELs and SOAELs. Following a reminder of the definition of these descriptors, Richard presented examples of LOAELs and SOAELs for vibration and for noise outside residential and non-residential buildings, noting that more research in to health effects and LOAELs and SOAELs is required, and that we should keep our ears to the ground in terms of guidance and best practice.

Richard Perkins

Richard stated that what matters is the mitigation strategy, with there being the requirement to not just reduce impacts, but improve on existing conditions, and to say why mitigation hasn't been adopted, if this is the case, which may be due to non-noise factors. Certainly, where schemes go to inquiry, any lack of consideration will be found out. Hence there is a need to get involved early, to be proactive, and put our flag up to ensure optimum alignment and use of cuttings etc. We should be taking advantage of "easy wins".

And finally… Victor Krylov (Department of Aeronautical & Automotive Engineering, Loughborough University) treated us to a very interesting presentation on the *Assessment of locations along the proposed HS2 routes that are likely to experience ground vibration boom from high-speed trains* (with Victor's colleague, Brad Lewis, noted as co-author). Victor was quick to point out that the assessment was both preliminary and purely academic exercise at this stage. A proposal has been submitted to undertake a detailed assessment.

According to Victor's first slide, Ground Vibration Boom (GVB) is a physical phenomenon associated with a dramatic increase in the level of railway-generated ground vibrations that can occur when the train speed exceeds the velocity of Rayleigh surface waves in the supporting ground. It was first predicted theoretically by Victor in 1994, and observed experimentally on a newly built high-speed railway line in Sweden (not by Victor) in 1998.

GVB is similar to the well-known phenomenon of sonic boom (which occurs when the aircraft speed exceeds the velocity of sound in air), but whereas there is relatively little variation in sound velocity in the air, the Rayleigh wave velocity varies significantly depending on the geological properties of the ground. Sensitive locations in terms of HS2, therefore, are where the ground is soft and marshy, where wave velocity is very low.

Based on the available geological information, the Rayleigh wave velocities were predicted along the HS2 routes. These were compared to the expected train speeds, which were estimated based on a maximum speed of 400 km/h and the likely rates of acceleration and deceleration. This identified several sensitive locations, mostly on the route between Birmingham and Manchester, where the soil classification is described as Glaciofluvial and Aeolian Drift. At these locations, the Rayleigh wave velocity is calculated to be 83 m/s (or c300 km/h), which is below the assumed train speed of 111 m/s (or 400 km/h; although, we were informed earlier that operational speeds are more likely to be in the region of 330-360 km/h, but which are still in excess of the calculated wave velocity). In such locations, it is thought that vibration levels could be potentially unacceptable.

Possible mitigation measures were presented to be: reduced train speed at key locations; concrete slab foundations, stiffening the soil underneath and in the vicinity of the tracks; and using open or in-filled isolating trenches (which need only be a metre or two deep given the type of wave in question).

My thanks to all the presenters, the London Branch and Linda Canty for their time and efforts in providing such an informative and well run conference.

Acoustic research challenges into the 21st century

In one of the more unusual meetings run by the Institute, about 90 delegates gathered at the Royal Society in April 2016 to discuss the issue of acoustic research. The morning session comprised a series of invited contributions from practitioners in the research sector. After lunch, some 50 delegates participated in a workshop session (the total number had to be limited because of space considerations).

An issue of increasing concern to the IOA's Research Coordination Committee (RCC) is the funding priority placed on acoustics, both by the Research Councils UK and other funding bodies. The RCC believes that the long term consequence of any potential reduction in funding would lead not only to a shortfall in the availability of subject matter expertise in acoustics but also to a reduction in the perceived status and profile of acoustics as a subject. This latter issue of profile additionally raised the wider question as to what is the current perception of acoustics to the wider public, and how well those outside the subject appreciate the degree to which acoustic research impacts on so many aspects of everyday life. For example, how many people only consider acoustics negatively when they are faced with the impacts of noise, either through personal experience or through press coverage of topics such as noisy neighbours or proposed infrastructure development? Indeed, a further question then arises as to how effective is the acoustics community itself at disseminating knowledge between its different disciplines.

It was with the foregoing in mind that the RCC instigated this one-day conference and workshop at the Royal Society, with a view to drawing together acousticians from a wide range of disciplines to consider the research challenges currently facing acoustics. It is the first stage in developing strategies for improving the value and impact of acoustics research, along with achieving wider visibility of acoustics as a subject.

The detailed organisation of the event was undertaken by Professor Kirill Horoshenkov, of the University of Sheffield and chairman of the RCC, and Dr Andrew Bullmore from Hoare Lea Acoustics. While delegates were waiting for the proceedings to commence, they enjoyed some specially commissioned short films about the history of sound, featuring Dr Mike Goldsmith, formerly of the National Physical Laboratory (NPL), and made in conjunction with Hoare Lea Acoustics.

Professor Horoshenkov introduced the morning session by observing the complexity of the current funding regime, with acoustics arguably being spread over the seven research councils. This theme was picked up by the first speaker, Professor Dame Anne Dowling of Cambridge University, who believed that no single research council felt it had ownership of acoustics. She felt that the profession might be guilty of sub-dividing itself too much so that there was no strong voice for acoustics and that the subject was sub-critical with respect to the research councils. She felt that there was no obvious network to link academic researchers and industry and observed that acoustics was paradoxically so ubiquitous that it was almost invisible as a profession. She, too, noted the complexity of the current arrangements, but wondered whether the possible merging of the research councils under a single banner may provide an opportunity for acoustics to gain a higher profile.

The second speaker was Dr Neil Viner of the Engineering and Physical Sciences Research Council (EPSRC). Dr Viner provided some background to the EPSRC, stating that it had one vision, two goals and three strategies. He said that the EPSRC felt they owned acoustics and that the EPSRC support for acoustics had quadrupled since 2010. He presented two impact case studies underpinned by acoustics related research and outlined the EPSRC Engineering focus for the next few years. Dr Viner noted that the government is investing £1.5 billion in the form of the Global Challenges Fund to support international research and development, and acoustics as a discipline should be able to benefit from this opportunity. Other elements of its focus were a research strategy, an international agenda and talent development. He concluded by noting that acoustics and related fields were pervasive, with broad and diverse application and that collaboration between the EPSRC, universities, users and other sponsors would, over time, lead to success.

The opening session concluded with Mark Jefferies, Chief of University Liaison at Rolls Royce. He confirmed that Rolls Royce was interested in acoustics research because it made a difference to its business. He described the development of aircraft engine noise mitigation and how there was now a need to balance CO_2, NOx and noise emissions. He pointed out that there was a cost/quality balance to be struck regarding testing, and that computational aeroacoustics greatly reduces the number of tests needed. Mark also noted that Rolls Royce was one of the top companies cited in the last Research Excellence Framework, 2014.

He also described the company's involvement with non-destructive testing and a project involving "Acoustic Tweezers"[1]

After a coffee break, Professor Tim Leighton from the University of Southampton gave one of his customary flamboyant presentations, showing how acoustics was "cool". His main observation was that new and exciting research tended not to secure funding but that this type of work was highly likely to generate both impact and new products. Indeed, sales of the products he has developed have helped to fund studentships and acted as a means of enabling reinvestment into further research. He felt that acoustics was perceived as a service subject and that what we are now seeking are increments to the established technology. But there are new opportunities and new issues. He finished his presentation by showing the prevalence of cases of complaints about external ultrasound associated with measurable sources, stressing the need for the development of new acoustic technologies to be supported by research into possible unintended effects.

Professor Leighton was followed by another industry presentation, from Aaron Hankinson of Jaguar Land Rover (JLR). He confirmed that investment was essential in vibro-acoustics and sound design R&D and showed what JLR was doing in this area including its £150 million investment in the new R&D centre. He emphasised the importance of recognising the connectivity of the world and that vehicles were transitioning into a connected device that can transport people. He advocated thinking wide, thinking big and bringing dynamism in research. One concern he had was the age profile of the current researchers and the need for continuity of knowledge and understanding going forward. He identified a range of issues that support the need for an acoustics R&D focus in the UK. These included there being too few companies and academia supporting technology development and there being a critical shortage of prototyping capability. He recognised that it all came down to money, but he also pointed out the difference between the UK, EU and Asia in its research structure. He suggested that there was a clear correlation between industrial growth, supply base and R&D growth in other countries, especially EU/Germany and that it is not clear in the UK. He noted that in particular, outside of JLR, we have not had that growth.

Professor Trevor Cox of the University of Salford discussed current research in audio. In this field he noted that what consumers and companies want is a better experience (which does not always mean better sound). That means that research has to extend beyond physics, electronics and computer science into the fields of psychology and neuroscience. He raised the issue that acoustics impacts so many other areas of research; therefore, it should stop being perceived as a service discipline. The question he then raised was how to achieve this status.

The penultimate paper of the morning came from Dr Marcia Isakson of the Applied Research Laboratories at the University of Texas. Her starting point was the *Lindsay Wheel of Acoustics*[2] P14

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P12

published in the mid-sixties. She then gave examples of how developments in a certain field can lead to a re-evaluation of fundamental acoustic principles that can, in turn, lead to developments in another field. She noted that whilst inter-disciplinary research is on-going, there can be many improvements. In speculating on how to facilitate interdisciplinary research, she felt that a variety of measures was available including cross-discipline meetings and workshops, better use of social media and more open source publishing.

The morning concluded with a presentation from Dr Sheila Turner of the National Institute of Health Research (NIHR). The focus of her talk was to advertise a call for research topics addressing the question: *What interventions are effective at reducing negative effects on health and wellbeing associated with noise in the living environment?* The deadline for submissions is 15 August 2016 and further details can be found here: http://www.nets.nihr.ac.uk/funding/phr-commissioned

The afternoon workshop session was led by Dr Andrew Bullmore. The delegates were divided amongst six tables and in two separate sessions were asked to consider the following issues. The first session asked:

- What are the key research challenges facing acoustics in the UK?
- How do these align with the UK's research priority areas?
- What is needed to maintain/develop international leadership for acoustics related research in the UK?
- Are acoustics research challenges global enough to help the RCUK seek more funding from the government?

The following questions were considered in the second session:

- Could higher research impact be achieved through the development of a formal acoustics research network aimed at linking funding bodies, academic institutions and non-academic partners?
- Do we have the right research infrastructure and funding to deliver a significant non-academic impact?

The main themes that emerged were:

- The importance of a strong voice for acoustics.
- The importance of thoroughly understanding and engaging with the system to maximise the leverage from the various funding sources.
- Addressing the fact that separate acoustic disciplines tend to operate in silos, and the importance of inter-disciplinary / multi-disciplinary working (including relevant NGOs). It was noted that some acoustics related proposals tended to be too narrowly focused even within acoustics. It was unclear whether this was related to a problem of funding for inter-disciplinary research or a reluctance to collaborate.
- Whether there is sufficient general understanding of the very wide-ranging impact of acoustics.
- That some areas of acoustics can be positive (e.g. in product development) but others can be seen as negative, (e.g. understanding the adverse health effects of noise exposure). Furthermore, there is a risk that, for some, acoustics is only about the negative aspect of noise.
- There is clearly scope for a UK network that could learn from existing multi-national networks in specific areas.
- Are there examples from elsewhere that could be used as a model, e.g. the way the Acoustical Society of America operates?
- Does the IOA have the most appropriate groupings for its specialist disciplines? For example, the IOA covers psychoacoustics, but there is no psychoacoustics group in the IOA.
- Is there a need for acoustics research to have a better status? Could this be achieved through a funded network? It was felt by some that, too often, acoustics related proposals were graded too low by prioritisation panels to secure funding in comparison with proposals in more mainstream engineering.
- Is there a prospect of achieving anything like what has been secured by the mathematics community? For example, a "Rayleigh" Institute hub equivalent to the Smith Institute and a touring problem-solving workshop (which perhaps could be attached to other IOA meetings) or something equivalent to the "Maths Inspiration" initiative, which reaches out to large numbers of school children through events held in venues such as theatres.
- Should the IOA be more outward looking, e.g. joint meetings with other institutes?
- And, finally, there was a generic point about barriers to collaboration with industry referring to the legalistic approach of universities to intellectual property rights.

The meeting was successful and thought provoking. The IOA's RCC will now deliberate on the points made and will make suggestions on how the IOA can help to meet "the acoustic research challenges in the 21st century".

This report was compiled by Stephen Turner, Kirill Horoshenkov, Keith Attenborough, Abigail Bristow, Duncan Williams and Andrew Bullmore of the IOA's RCC.

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The acoustics of unconventional onshore oil and gas

By Laurent Galbrun and Alistair Somerville

In April the IOA Scottish Branch organised a conference entitled *The acoustics of unconventional onshore oil and gas* at The Lighthouse, Glasgow, with the aim of providing an insight into the acoustics of hydraulic fracturing. The event was attended by 47 delegates, and consisted of seven 30-minute presentations allocated across three sessions. A 45-minute panel discussion followed the sessions.

The conference was chaired by Alistair Somerville (Scottish Branch Chairman) for the first session, Dr Laurent Galbrun (Heriot-Watt University) for the second session and Professor Robin Mackenzie (Robin Mackenzie Partnership) for the third session. Most presenters took part in the panel discussion, which was chaired by Robin Mackenzie.

Claude Voelker, of Arcus Consultancy Services, gave the first presentation entitled *Overview of unconventional onshore oil and gas industry*. This provided an introduction to the topic by discussing the need for gas and what is meant by the term "unconventional". It was pointed out that there are currently more than 2,000 onshore wells drilled in the UK, and hydraulic fracturing has been used in more than 200 wells to date, with no issues. The presentation illustrated the availability of shale gas and coal bed methane (CBM) in the UK, as well as drilling and hydraulic stimulation techniques. In particular, it was noted that hydraulic fracturing is a conventional drilling technique that has been used over the last 60 years to extract gas from shale rock. The technique is therefore not unconventional, it is rather the type of rock being

treated that is different (low permeability of reservoirs from which gas is extracted, as opposed to the porous reservoirs of conventional gas); hydraulic fracturing increases permeability and the rate of gas release. Finally, it was stated that the UK has a strong regulatory regime for exploratory activities and more than 50 years of experience of regulating the onshore oil and gas industry. Consequently, Claude Voelker argued that it should be possible to manage risks, as long as operational best practices are implemented and enforced through strong regulation.

The second talk was given by Jonathan Corney, Professor of Design and Manufacture at the University of Strathclyde, and was entitled *What would green hydraulic fracturing look like?* An overview of the hydraulic fracturing process was given initially, followed by a discussion about noise sources. In particular, pumps and large trucks used in the process were discussed, and it was pointed out how improved designs (e.g. smaller pumps with improved efficiency and replacement of diesel engines with electrical engines) can both reduce noise and provide savings. It was also noted that annoyance is often wrongly attributed to the hydraulic fracturing process, which is intermittent, instead of the drilling operations, which are continuous.

Emma Taylor, Senior Policy Officer at the Scottish Environment Protection Agency (SEPA), presented on *The SEPA approach to 'unconventionals'*, a presentation co-authored by Jim McIntyre, PPC/COMAH Specialist Inspector at SEPA. This presentation highlighted the complexity of the regulatory framework involved in 'unconventional' extraction and SEPA's role in these processes. They simply act as statutory consultees to planning applications. It was noted that the Scottish Government has issued a moratorium on onshore unconventional oil and gas development to allow time for research to be carried out in order to assess a range of associated impacts. A report from an expert scientific panel is already available on the subject (published in 2014). This presentation closed the first session which was aimed at providing an introduction and background to the conference's topic.

Claude Voelker of Arcus Consultancy Services

The second session focused on sources of noise, vibration and control. The first presentation of this session was given by Steve Fraser of The Airshed, and was entitled *Onshore oil and gas case studies – practical difficulties in assessment*. In terms of noise criteria, it was suggested that hydraulic fracturing operations are more akin to construction so BS 5228:2014 should apply, whilst it is not reasonable to apply BS 4142:2014 for short-term appraisal of well operations. The appraisal of well drilling operations is expected to last 20 - 30 days, although main issues tend to be associated to temporary well drilling. A noise survey showed how LAeq levels measured in the vicinity of a drill rig (26 m) varied between 60 dB to 80 dB, depending on the rotation speed of the drill. Survey data and predictions also showed that distances of at least 500 m from the sources examined would be required to comply with the WHO night-time guidelines. The mitigation measures suggested included site selection, bunds and screens, site layout, selection of quieter plant, screening top drive, and temporary relocation.

The next presentation, *Lessons from decades of onshore oil and gas exploration – noise characteristics and control techniques*, P16

P15

was by Simon Stephenson, Technical Director at RPS Planning and Development. This highlighted the importance of learning from drilling and production in quiet areas of the UK over the last few decades. Furthermore, it was argued that there was no need for new noise guidelines or policy for fracking, as the existing framework can be used. Examples relating to the Planning Practice Guidance on Minerals (PPG-M) were given to substantiate this claim. Some operational sites have successfully mitigated noise to limits of 28 dBA at distances of 500 m, and new technologies can be very quiet. A review of the noise characteristics of different types of rigs (diesel, hydraulic, electric), mud pumps, generators and other machinery was given, together with the use of enclosures. Finally, it was stated that, in terms of noise emission, there was no reason why any drilling and hydraulic fracturing should not be able to gain consent, as long as appropriate mitigation is applied.

After lunch, the third session examined *The Lancashire County Council case*. The first presentation was given by Andy MacKenzie, of Hayes McKenzie, and was entitled *The Lancashire County Council position*. This reviewed planning applications for two proposed locations (Preston New Road and Roseacre Wood) which were refused consent by planning committees. In the Roseacre Wood site, the drilling operations were predicted to produce 40-42 dB L_{Aeq}, whilst hydraulic fracturing (few hours in weekdays, day-time only) had a predicted level of around 55 dB L_{Aeq}. Mitigation reduced predicted noise at night to 37 dB L_{Aeq}, following which officers had no objection on noise. In fact, reasons for refusal did not include noise. At the Preston New Road site, mitigation reduced predicted noise at night to 39 dB L_{Aeq}. Following this, officers had no objection on noise, but noise was mentioned amongst the reasons for refusal. A range of relevant guidance documents was listed, and it was argued that the main areas of debate are currently around the interpretation of assessment guidance. The final position of the Lancashire County Council (LCC) is that the relevant guidance is the Planning Practice Guidance on Minerals (PPG-M). According to PPG-M, a day-time limit of 55 dB L_{Aeq} is acceptable, whilst the night-time limit is 42 dB L_{Aeq}. However, the latter has not been considered to be appropriate by the LCC, which has proposed a night-time limit of 37 dB L_{Aeq}. Furthermore, LCC supports proposal by the Preston New Road Action Group for a separate weekend day-time limit of 45 dB L_{Aeq}. (See Andy McKenzie's technical contribution on fracking on page 44).

The LCC case was further discussed by David Hiller, from Arup, in the presentation entitled *The Lancashire shale gas: the developer's perspective* (Co-author: Colin Cobbing, Arup). It was clarified that the planning applications were for exploration only. The principal noise sources identified in the sites were: main rig and hydraulic power unit, shale shakers, generators and mud pumps. The following mitigation measures were proposed to control noise: 4m solid site hoarding, doors closed and sound absorbing treatment to shale shaker enclosures, sound absorption in enclosures to generators, including louvres, acoustic enclosure of mud pumps, and rubber bushings to reduce pipework vibration. These

The panel: (left to right) Jonathan Corney, Claude Voelker, Robin Mackenzie, David Hiller, Simon Stephenson and Jim McIntyre

mitigation measures achieved a 40 dB L_{Aeq} at Roseacre Wood and a 42 dB L_{Aeq} at Preston New Road. However, despite these being below WHO and PPG-M guidelines, LCC refused on noise grounds. Further mitigation measures could achieve a 37 dB L_{Aeq} at Roseacre Wood and a 39 dB L_{Aeq} at Preston New Road, although these were noted as expensive and complex mitigation measures. Following that, LCC officers recommended approval but members refused. The main issue was around night-time noise from drilling.

Finally, Claude Voelker, Jonathan Corney, Jim McIntyre, Simon Stephenson and David Hiller took part in the panel discussion chaired by Robin Mackenzie. Most of the questions focused on the use and interpretation of the guidance available, and in particular on noise levels. Presenters agreed that guidance documents are available and applicable to hydraulic fracturing, but there was no clear agreement on which one might be the most appropriate. Simon Stephenson indicated that the use of BS 5228 is an anomaly, unlike PPG-M which was used in the LCC case. The focus on noise limits was also pointed out as potentially misleading, as these tend to rely on yearly averages that are not applicable to shorter operations. Furthermore, complaints tend to relate to noise characteristics (e.g. low frequencies or whining noise) rather than absolute levels. David Hiller argued that fracking is seen as an unpleasant activity and consequently noise is more easily highlighted as a problem when compared to conventional drilling activities, but this should not be the case. It was agreed that a wide range of noise control solutions are available and well known, however this does not guarantee obtaining planning permission. Noise exposure of workers was also discussed, and it was pointed out that noise levels are normally not greater than 80 dBA on well pads, but can be higher than 100 dBA inside enclosed spaces. Finally, it was noted that we are still at very early stages in the exploration of hydraulic fracturing and it is currently not possible to say how many wells might be used for such operations in the future.

Alistair Somerville would like to thank all speakers and those involved in helping him organise and run this meeting. Particular thanks go to Laurent Galbrun and Michael Reid for their significant support.

Blane Judd appointed as new Institute Engineering Manager

Blane Judd is the new IOA Engineering Manager, succeeding Peter Wheeler who retired earlier this year. His key responsibility will be to encourage and oversee the registration of members with the Engineering Council as either CEng or IEng.

Commenting on the appointment, he said: "I have been involved in professional engineering institutions both as a volunteer and employee for a number of years. I look forward to working with the staff and members of the Institute, to support the advancement of the science of this often overlooked but extremely important area of engineering."

Blane is Executive Director of BLTK Consulting, which provides support to global businesses on strategic engagement and development. For the last two years he has led the campaign to raise the profile of engineering technicians in the UK as Chief Executive of EngTechNow on behalf of the Institution of Engineering Technology, the Institution of Civil Engineers and the Institution of Mechanical Engineers.

He is a Chartered Engineer; a Fellow of the Institution of Engineering and Technology; Chartered Institution of Building Services Engineers; Chartered Institute of Plumbing and Heating

Engineering; Royal Society of Arts; Royal Institution, Institute of Leadership and Management and a member of the Institute of Directors. He is a Freeman of the City of London and a Liveryman of the Worshipful Company of Plumbers. He has an Honours degree in Integrated Engineering from Nottingham Trent University. He chairs the IET Built Environment Sector Committee which contributes to thought leadership for that sector of engineering.

Prior to the EngTechNow campaign he advised on strategic engagement for organisations including the City and Guilds of London Institute, the Institute of Leadership and Management and the Norway Institute of Technology. He led the rebranding and repositioning of one of the largest UK Trade Associations, as its Group Chief Executive to grow the membership. As Chief Executive and Secretary of the Institute of Plumbing and Heating Engineering, Blane successfully petitioned for a Royal Charter, leading its rebranding to the Chartered Institute of Plumbing and Heating Engineering (CIPHE).

He was an elected member of the Engineering Council Senate at the time that it restructured into the Engineering Technology Board and the Engineering Council, leading the drive for the Registrants Board to ensure continuation of registrant views during the period of transition. Between 2008 and 2011 he served as an Executive Board member of the World Plumbing Council. He remains an individual member.

Blane Judd

Married with two grown-up sons, his main interest away from work is rugby. He was a keen player before becoming an avid supporter having hung up his boots after a 10 year period of coaching and refereeing to encourage young players into the game.

The future implementation of ISO 1996 and BS 7445 in the UK

By Phil Dunbavin and Stephen Turner

The third edition of *ISO 1996-1:2016: Acoustics – Description, measurement and assessment of environmental noise – Part 1 Basic quantities and assessment procedures* was published by the International Standards Organisation (ISO) on 1 March 2016, replacing the previous version. The other parts of the standard are currently being revised and prepared for publication by ISO.

When the first version of ISO 1996 was published, it was adopted by British Standards Institution (BSI) through the publication of BS 7445 which was then identical to the corresponding version of ISO 1996.

When the second version of ISO 1996-1 was published in 2003, the UK sub-committee EH/1/3 had serious concerns about some of the content. Consequently the corresponding revision of BS 7445–1, also published in 2003, did not reflect the changes to the content of ISO 1996 and instead was a re-issue of the original version.

During the latest revision of ISO 1996-1, representatives of the UK Sub-committee EH/1/3 liaised with the relevant ISO committee ISO/TC 43, Acoustics, sub-committee SC1, Noise. Concerns about the content of the new version were raised by our representatives throughout the process and when it came to the final vote on the new version, the UK voted against its adoption, along with The Netherlands and Norway. Of those states eligible to vote, only 55% approved the revised standard. Nevertheless, this level of support was sufficient to enable the ISO to publish this third edition of ISO 1996-1.

Given this situation, the UK sub-committee has agreed that the new version of ISO 1996 Part 1 should not be adopted. Instead, it was agreed to commence work separately revising BS 7445 Parts 1, 2 and 3. This will mean that the new versions of the BS 7445 series will not necessarily have any of the same content of the ISO 1996 series.

The view of the UK sub-committee is that the revised ISO 1996 series should not be used as a reference document in the UK. Further, the revision of the BS 7445 series will make it clear in the foreword that it is BS 7445 that should be used as a reference document in the UK instead of the unadopted ISO 1996 series.

Phil Dunbavin is Chairman of BSI committee EH/1/3 and Stephen Turner is a committee member of EH/1/3.

Public Health Outcomes Framework consultation decision

In the March/April 2016 edition of the Bulletin, there was an article about the Public Health Outcomes Framework (PHOF). It described the framework and the fact that it includes a noise indicator. It also mentioned a consultation that was held last year, reviewing the content of the framework. The article also contained the Institute's response to the consultation.

In April 2016, the Department for Health published the outcome of this consultation and confirmed that the noise indicator would remain part of the framework, which is what was sought by the Institute. It is understood that the contribution of the IOA alongside that of other organisations such as the Chartered Institute of Environmental Health, the Noise Abatement Society and Environmental Protection UK was instrumental in securing this result.

What 'a blast': Senior Members' Group AGM

By Ralph Weston

The sixth AGM of the Senior Members' Group (SMG) took place with a half-day meeting in the IOA headquarters at St Albans. The Chairman (Ralph Weston), Secretary (Mike Forrest) and 11 members were present. The routine items on the agenda were disposed of quickly and the committee was re-elected en bloc. Geoff Kerry, Vice-president groups and branches, is due to retire shortly and will be replaced by Graham Parry. Ralph Weston thanked Geoff for all his help and advice during his term of office.

There was some discussion on the terms of reference and it was noted that the group may want to put forward some proposals at the next revision.

Following the formal meeting there was a lively discussion on CPD. Geoff Kerry was congratulated on the history book which has now been published with every member receiving a copy. Members were reminded that archive material is always welcome and that history marches on, so it is helpful to keep full records including photos of work in progress.

The future programme also gave rise to lively discussion and it concluded it would be helpful if meetings included a place of interest. Meetings are always open to all IOA members. Travel is a constant problem (especially for senior members living abroad), not only in terms of time but cost of rail fares.

The meeting gets under way

The members' page on the IOA website will be especially valuable. Ralph Weston is at present re-writing the public page, giving brief details of the group. Once this has been written, there is more scope for more detailed information amounting to several pages in which the committee can report on its meetings and future plans. The full minutes of this AGM will be on the members' page. The SMG is responsible for the members' page, so watch out for it on the IOA website.

The AGM was followed by a presentation of a talk by Dr Rodger Munt FIOA on *Modelling the blast from guns.*

Valuable lessons learned at mock planning inquiry

By Alex Foster

Southern Branch and the Young Members' Group staged a mock planning inquiry in the council chamber of Basingstoke & Deane Borough Council in April.

The venue was chosen to provide members, who may not have previously witnessed a public inquiry, with a condensed but accurate portrayal of the proceedings.

Graham Parry (ACCON UK), who was to play the role of the inquiry inspector, started with a detailed introduction into the planning appeal procedure and the current regulatory framework. The importance of "regular and continuing dialogue between the main parties" was highlighted as key to ensuring clarity of the main issues, and that the appeal system "should be used as a last resort, not a bargaining chip". Ultimately, in the inquiry, it is the responsibility of each of the respective parties to provide "clear, precise and comprehensive" reasoning for their opinions, and to provide the inspectorate with all the relevant information in order to assist them in reaching a decision. Emphasis was placed on adherence to the appeal procedure, and the unwritten rules of professionalism, there to ensure a proper, reasoned and fair hearing.

The inquiry itself was based around a fictional planning appeal case study. A planning application for residential development on vacant land adjacent to a transportation route and nearby industrial and office uses was refused consent on the grounds of the questionable integrity of the supporting acoustic report.

David Denham (Basingstoke & Deane Borough Council) played the role of the council's lawyer and James Glen (Southdowns Environmental Consultants) the role of the environmental health officer (EHO) who had refused the application.

Peter Rogers (Sustainable Acoustics) played the role of the appellants' lawyer and Alex Foster (Clarke Saunders Associates) the role of the developers' acoustic consultant, who had written the report in question.

The lawyers began with their opening statements, outlining central arguments and summarising the reasons they believed the inspector should rule in their favour.

The local authority's lawyer then guided the EHO through questioning of the submitted evidence. The EHO first drew attention to the apparent inadequacies of the acoustic report, including the omission of key information such as the date and time of the survey. Refusal was, however, ultimately dependent on the outcome of the BS 4142: 2014 assessment, showing the Rating Level of the nearby industrial noise source to exceed the local authority criteria of 5dB below background LA90 level. Provision for mitigation of potential future impact on the proposed development was also deemed insufficient.

Then came the adversarial cross-examination. The appellants' lawyer opened with queries regarding the EHO's credentials. "Not even a swimming badge" was the final remark. Also highlighted was the lack of understanding demonstrated by the local authority in interpreting the British Standards in question, and furthermore, confusing standards with guidance documentation. The EHO defended himself well and deflected responsibility as the assessment showed non-compliance with existing local authority planning policy. Following the cross-examination, the inspector had the opportunity to question the EHO and clarify any outstanding issues.

It was then the consultants' turn to be questioned. Guided by his lawyer, the consultant started by stating that his report was intended as a summary report, provided to the client for information purposes, and in addition to a full acoustic report, which the client had not submitted to the appeal. The consultant conceded that the summary report could be considered inadequate for P20

P18

the purposes of a planning application, but affirmed his integrity as a practitioner should not be questioned, and that the survey and assessment were well considered and thorough, and undertaken in full accordance with relevant standards and good practice guidance. Following a brief description of the survey undertaken, the conclusion that the site was suitable for development was clearly reiterated.

Unfortunately, David fell ill midway through proceedings and could not continue with the cross-examination. Instead, Peter stepped in to represent the local authority and moved to the opposite side of the chamber. This meant the consultant had to suffer alone through a barrage of questions from a now hostile lawyer, privy to prior backstage plotting, and an EHO who simply had very reasonable objections to the quality of the acoustic report he had prepared objections to. So defensive was the MIOA BSc MPhil PhD DipL MBA CPhys certified consultant, he eventually insulted every EHO in the room, drawing gasps when he effectively claimed that, in his experience, perhaps even the date and time were concepts too complex for EHOs to comprehend. The fiery exchange ended with the assertion that, despite the inadequacy of the "summary" report, the site was perfectly suitable for residential development with appropriate mitigation.

The inspector then questioned the consultant before reaching his final judgment. In ruling in favour of the appellant, he overruled the local authority's refusal on the basis that, subject to conditions being imposed, appropriate mitigation would enable the proposed development site to be suitable for residential development.

The feedback on the event has been overwhelmingly positive. Comments were made on the theatricality of the proceedings, which surprised some members, yet whilst the humour may have been somewhat exaggerated, apparently it is not that far from what has been experienced by some of the more seasoned members in attendance.

Personally, playing the role of an exceptionally qualified (if obnoxious) expert witness, yet having only practised as an assistant consultant myself for less than three years, I can confirm that it was indeed a daunting yet thoroughly enjoyable experience! Of course, I was just acting out the role of an expert witness, but even in my junior position, this type of assessment would be considered rudimentary, and detailed knowledge of the standards and guidance in question is expected. I did, however, find it remarkable how much I second-guessed my own arguments, in anticipation of a rebuttal, only to be thrown off with a completely different line of questioning. It was quite disconcerting, but confirms the sentiment that you don't truly know something it until you have to try and explain it.

Having experienced just a taste of the real thing, I can appreciate the advice: "proper preparation should get most competent people through the 'ordeal'." Certainly a recurring theme in subsequent discussions with the participants was to "be prepared for the unexpected", and this was definitely highlighted on the night. Special thanks goes to the branch committee and the Young Members' Group for organising such a well-received event.

London Branch reports

Sound insulation testing issues

By Dan Doherty

In February the branch welcomed Russell Richardson, representing the Association of Noise Consultants, to discuss common sound insulation testing issues.

Russell is the current IOA Hon Secretary, prior to which he sat on the board of the Association of Noise Consultants for several years. As the Senior Examiner for the ANC Registration Scheme, Russell leads the team of examiners responsible for auditing and witnessing testers carrying out sound insulation testing under the scheme. The aim of the evening was to present common testing and construction issues and to facilitate a wider discussion amongst the audience.

The discussion began with Russell outlining the third-party accreditation requirements of Approved Document E and the various options for this which are available to testers in the different parts of the UK, including the ANC Registration Scheme, UKAS accreditation (both UK-wide) and the IOA scheme (in Scotland). This also included an introduction to the new Sound Insulation Testing Register for Ireland, SITRI, developed by the IOA/ANC, in relation to the new minimum acoustic performance standards for Ireland.

In relation to common build issues, the audience were treated to some excellent photos of both good and bad practice, including some interesting images taken with a bore-scope, as a less intrusive means of investigation. Some common mistakes were simple errors, such as the use of the wrong type of wall-ties or the wrong type of insulation. Other common problems could be avoided by maintaining a clean working site and good workmanship, for example, using guttering to maintain a clean cavity between leaves of brickwork. It was clear that some issues could have been avoided fairly easily but unfortunately were expensive to rectify.

The need for early involvement in the architectural design was highlighted – some early design decisions will ultimately limit the achievable sound insulation on site. Some examples of good and bad design drawings were shown.

Regarding the pre-completion testing itself, there was a discussion about the upcoming replacement of the ISO 140 series with the ISO 16283 series. The differences between the two sets of standards were discussed, for example, the need to use loudspeakers with certain directivity characteristics (a requirement that would not be satisfied with a cabinet loudspeaker), the additional guidelines to handheld measurements (a method which previous research has shown to be at least as accurate as using fixed microphone positions), and the need to consider uncertainty.

Practical issues discovered while carrying out the test were discussed, with murmurs of agreement (test rooms full of doors and other junk, contractors making a racket) and giggles from the audience (testers getting stuck in rooms with no door handles…). A common observation of testers was that the moving microphone method could generate noise as the tester moves around – the familiar swish of high-visibility coats is something that should be avoided. Russell reminded the audience that any noise – audible or otherwise – which might be generated during receive room measurements should also be present during background noise measurements in order to be relevant. Recommendations were to be prepared and to try and get an understanding of the site before arriving by getting the client to fill in a site readiness checklist. The risk of additional fees from abortive visits should motivate the client.

After the presentation, the audience took part in a discussion

Builders need to be educated so they understand common acoustics issues

including about how the overall process could be improved. There was a debate about the need to educate builders on site so that they understand common acoustics issues. In Russell's experience people on site were receptive to learning about acoustics and common problems could be avoided with a quick chat. Another suggestion was to hold design team meetings on-site, with those carrying out the work.

Finally, Russell invited the audience to the ANC conference in Birmingham on 18 October, which will provide delegates with an opportunity to look into sound insulation issues in further detail.

The branch would like to thank Russell for taking time out of his busy schedule to join us in what proved to be an engaging topic.

Stage by the sea

By Olly Bewes

In March Jason Flanagan and Paul Bavister of Flanagan Lawrence Architects introduced the branch to four novel designs for outdoor acoustic shells.

The presentation started by describing the motivation and development of the Soundforms prototype, a mobile performance shell constructed from a small lightweight structure which can be erected to provide weather protection as well as improved sound quality at outdoor events. Unlike a typical festival truss structure, which provides good weather protection to performers, but terrible acoustics, the prototype's acoustics were designed by Arup to provide a degree of natural acoustics on the platform for the performers and enhanced projection and sound level for audiences of 500 – 700 people. This means that the shell lends itself well to modest outdoor acoustic performances and not just amplified sound.

The debut test concert for Soundforms included a performance from Grace Francis and, despite the location on the London City Airport flight path, the natural acoustic of the prototype was deemed to be a resounding success.

This led to the commissioning of the Soundforms prototype as the bandstand for the London 2012 Olympics where the shell hosted about 2,000 events.

The presenters then went on to describe how the concept was developed and chosen for a 10,000-seat waterfront concert venue on San Diego Bay and recently won a competition design a roof for the stage and 3000 seat amphitheatre for the Szczecin Summer Theatre in Poland.

Finally a unique design for an acoustic shell and shelter sited in a sunken garden beside the beach in Littlehampton was presented. The design incorporates two shells facing in opposite directions. One shell faces the town and forms a principal bandstand. The other shell faces the beach and forms a more intimate structure as a shelter for listening to the sound of the sea or for buskers to perform facing the promenade. The beautiful white structure was constructed using sprayed concrete for less than the cost of an off-the-shelf bandstand.

The presentation provoked many questions from the audience with most questions preceded by praise of the impressive looks of each of the structures.

More information about Soundforms can be found at **http://www.soundforms.co.uk/** .

The branch would like to thank Jason and Paul for an interesting and thought-provoking presentation and WSP Parsons Brinckerhoff for providing the venue, as they did in February.

Topics and speakers for the evening meetings are generally identified and organised by branch committee, but we always welcome new ideas and suggestions for future presentations. If you have any ideas or suggestions, or may even like to give a presentation yourself, please contact the committee (Nicola Stedman-Jones: **stedmann@rpsgroup.com** or **nathan-nicola@talktalk.net**).

Soundforms in actions

Avatar therapy for the relief of auditory hallucinations in schizophrenia

By Gordon Hunter

This year's AGM of the Speech and Hearing Group was accompanied by a fascinating and very well-attended talk on the application of speech processing technology to avatar therapy for the treatment of schizophrenia by Professor Mark Huckvale of University College London, a topic which has received considerable media attention recently.

Mark described his projects on this topic, proposed by and in collaboration with Professor Julian Leff of the Institute of Psychiatry, King's College Hospital, London. About 1% of people worldwide suffer from some form of schizophrenia, of whom about 30% experience "auditory halucinations" (commonly known as "hearing voices"). Many such cases prove resistant to treatment by medication, and patients find themselves with severely impaired lives, feeling persecuted, often ruining their employment and relationships, and putting them at greatly increased risk of suicide.

Avatar therapy is a form of cognitive behavioural therapy, designed to complement more conventional approaches, and certainly not to replace these. Patients frequently describe themselves as "feeling helpless" when experiencing the voices. The aim of avatar therapy is to encourage the patients to assert themselves, by "standing up to" and confronting the persecutory voice, in order to help the patient gain confidence and feel less dominated by the "voices". The purpose of the avatar – a simulated, possibly grotesque, head which appears to speak – is to help the patient associate the voice with a physical being, outside his or her head, rather than inside it. A qualified therapist talks through the avatar, with the therapist's speech being distorted by a speech processing system. In the preparatory sessions, the patient is invited to describe the properties of each "voice" he or she hears, and then is played some examples, and the therapist is able to adjust various processing parameters, such as pitch, spectral tilt and "roughness" or voice, until the patient agrees that the voice being played sounds sufficiently similar to the one they perceive. The patient is also allowed to choose aspects of the avatar's physical appearance, starting from a basic set of head and face prototypes, including relatively normal human heads, plus examples of clowns, demons, etc, but is also able to modify more subtle features. During a sequence of therapy sessions, as the patient gets more used to the system, the avatar's utterances to the patient become less abusive and more supportive as the patient responds, helping the patient to build his or her self-esteem. Initial pilot clinical trials of the system on a set of 16 patients proved highly successful, with three patients saying they no longer "heard voices" at all, and all reporting an improvement in their condition – lower frequency and severity of their hallucinations. A further, larger scale controlled clinical trial is currently in progress.

In addition to giving a thorough description of the clinical background to the project, Mark went into detail about the audio-visual processing involved. Digital spectrograms of the therapist's speech are produced using an MFCC approach (12 coefficients + 12 Delta coefficients + Energy + Delta Energy), and the spectral and pitch parameters of these adjusted to modify the speaker's voice to sound more like the persecutory "voice" perceived by the patient. This is achieved using a Linear Prediction Vocoder, allowing warping of the LP spectrum and pitch scaling. The MFCC coefficients for each spoken phoneme are also converted into "visemes" (the visual cues corresponding to a person speaking those phonemes), which are displayed on the animated head of the avatar.

Mark and his team are currently developing a "user friendly" version of the system which, if granted approval as an authorised "medical device", should be usable by qualified therapists in any clinic, making the system of practical value to a large number of therapists and their patients.

Mark's talk prompted a large number of questions, comments and lively discussion, which continued informally at a local pub after the official end of the meeting.

Instrumentation Corner

Are old timers past their peaks (L_{Cpk} that is)?

By Ian Campbell

For many years now the Noise at Work Regulations in the UK have set specific maximum limits for peak C weighted sound pressure levels that employees and contractors can be exposed to; there has also been a revision of the regulations that have reduced these permitted peak exposure levels. Over these years there have also been many design improvements in sound level meters and even a complete revision of the standards that these instruments have to comply with. However there are still many old instruments being used to determine compliance with the revised regulations. This has prompted a quick look back to see how some of these "legacy" sound level meters would perform in today's litigious environment.

The first problem would be to consider the type of waveforms that can give rise to these high peak values; these can arise from many different sources ranging from percussive impacts to cartridge fixing tools. It follows therefore that they can have very different waveforms that are as much due to the initial event as the acoustic environment in which the subject is working at the time of the risk assessment. In order to characterise the performance of an instrument is would be necessary to specify a standard test waveform that would be used to perform a test. It is in this area that the standards have changed, although consideration was given to the backwards compatibility of the standards during the revision.

The initial standards for sound level meters go back into the previous century and in their final version were contained in BS EN 60651 and 60804 standards and these described type 0, 1, 2 and 3 meters. All of these variants had similar nominal values but with widening tolerances as the type number increased. As far as peak measurements were concerned they were only mandatory

in type 0 instruments and hence the standard contained a test to confirm that these peak measurements were correct. These type 0 meters were very rare beasts indeed and only a few manufacturers actually made any of these "Laboratory Standard" meters. The Noise at Work Regulations specified type 1 or 2 instruments may be used to make these peak measurements as they are far more practical for field measurements. As a result type 1 and 2 instruments were produced with "optional" peak measurement modes. When it comes to the legal metrology considerations of using these instruments the BS 7580 standard specified the regular laboratory verifications that would be required. This standard had to accept that as peak measurement was not specified for these type 1 and 2 meters a meter could be certified to the standard as type 1 or 2 if its peak measurement mode did not work as the standard does not require it to be tested. So BS 7580 states that if a peak measurement mode was provided it must be tested to the peak test as set out for the type 0 instruments. If it failed a note must be made on the certificate to confirm that the meter complies with the standard but that it is not suitable for peak sound level measurements. The standard test was to compare the difference between a 10 ms reference square pulse and 100 µs test pulse in both +ve and –ve directions with a limit set of < -2 dB difference in either polarity. So risk assessments made using any of these legacy sound level meters needs to be reviewed to check the calibration certification to ensure that the peak function has been tested to confirm that it was measuring correctly.

It is interesting to note that the test was made with a signal that could not possibly be produced by a microphone, so in the revision of the standards the tests were changed to use a single cycle of 8k Hz sine wave and +ve and –ve half cycle of 500 Hz sine waves. In theory the tests are quite different and hence depending on the design of the instrument could give different results. To check this out a 15-year- old meter originally manufactured to the BS EN 60651 and 60804 standards was tested to both the old and new tests. The meter in question has an independent pattern evaluation certificate so is typical of "first division" meters in current use but it should be noted that there are many instruments of this age in use that have never had any independent test to confirm that they actually meet the standards claimed. These tests were repeated five times and a repeatability calculated. The average of the five tests are shown in the tables below. P24

Pulse duration	Pulse polarity	Reference value, dB	Measured dB	Tolerance dB	Error, abs dB	Error relative
10 ms	+ve	109.00	109.16	2.00	0.16	-1.46
100 µs	+ve	109.00	107.70		-1.30	
10 ms	-ve	109.00	109.10	2.00	0.10	-1.26
100 µs	-ve	109.00	107.84		-1.16	

Old BS 7580 Peak Test on Legacy Sound Level Meter

P23

Average of the five tests to the old standard.

The uncertainty due to repeatability of the relative error was 0.1 dB.

Note the reference level reads around 0.1 dB higher than it should

Pulse			Level, dB				
Polarity	Type	Hz	Reference, dB		Measured value	Limit	Deviation
			RMS	Peak			
-	1 cycle	8000	126	129.4	128.06	2.4	-1.34
+ve	½ cycle	500	129	131.4	130.44	1.4	-0.96
-ve	½ cycle	500	129	131.4	130.3	1.4	-1.10

New BS 61672 Ed1 Peak Test on Legacy Sound Level Meter

Average of the five tests to the new standard.

The uncertainty due to repeatability of the 8k Hz error was 0.22 dB and of the 500 Hz half cycle 0.1 dB.

It appears that the meter passes both tests and with similar deviations from the nominal values. Both can therefore be used to make peak noise risk assessments but it is worth bearing in mind the fact that readings are around 1 dB lower than the nominal value expected.

These legacy sound level meters make extensive use of analogue technology, now of course this has been replaced by digital methods of processing the signal. To look at the difference that this would make a more modern version of the same meter that has a fully digital method of capturing and storing the peak values was also tested to the new standard and its results are shown in the final table. In this case digital implementation of the peak circuits halves the errors and also brings about improvements in the measurement uncertainty.

Pulse			Level, dB				
Polarity	Type	Hz	Reference, dB		Measured value	Limit	Deviation
			RMS	Peak			
-	1 cycle	8000	126	129.4	128.66	2.4	-0.74
+ve	½ cycle	500	129	131.4	131.3	1.4	-0.10
-ve	½ cycle	500	129	131.4	131.3	1.4	-0.10

New BS 61672 Ed1 Peak Test on Modern (Digital) Sound Level Meter

Replacing analogue electronics with digital capture and storage for the peak circuits

The uncertainty due to repeatability of the 8k Hz was 0.1 dB and the 500 Hz 0.0 dB

Going back to the legacy sound level meter tested it would appear as long as due allowance is made for their age there is no reason why these older meters should not continue to be used for these risk assessments. However, care needs to be taken to ensure that these older meters have had their peak performance correctly evaluated in accordance with the requirements of BS 7580; and if so old analogue meters can be used alongside their modern digital equivalents with adequate precision for determining L_{Cpk} values.

However bear in mind that these comments are based on tests on one single instrument taken from our equipment cupboard at random. Note this meter has pattern evaluation certification and has been kept in calibration for all of its working life; as such it is an example of an instrument from the "top draw". There are many legacy instruments out there that have not had any independent audit to confirm compliance with the measurement standards and hence may struggle to provide results that conform to the requirements of the Noise at Work Regulations. Results given here are therefore intended to give an example of how things may have changed over the life of the Noise at Work Regulations and each individual case has to be considered on the merits of the data available.

Drop forges are one source of high peak levels

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

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RIBA underlines the importance of good acoustics in school design

Good acoustics are essential in schools for "effective learning, pupil engagement and well-being", says the Royal Institute of British Architects (RIBA).

In a hard-hitting new report entitled *Better spaces for learning*, it says that too many UK school buildings are dangerous and dilapidated, causing children to underperform and teachers to quit.

In stating that it "pays to invest in good design", it lists good acoustics as one of nine essential design elements. Others include good quality natural light, simple, natural ventilation systems, thermal comfort and control over temperature and pupil sense of ownership.

"Good school design has a positive impact on education outcomes and can contribute to a significant uplift in academic progression in primary and secondary schools," it says.

"The POE (Post-Occupancy Evaluation) research we commissioned found a number of examples of how good design can positively impact pupil attainment and behaviour. The impact of design on pupil behaviour, engagement, well-being, and learning were especially marked."

Writing in the foreword, RIBA President Jane Duncan said: "Every pupil deserves a place at a good school. This is a key Government objective, but is becoming harder to achieve in the face of budget pressures and increasing numbers of children entering the education system. With limited funding available to provide extra school places and many existing schools in need of overhaul, there could not be a better time to look more closely at how excellent design can help the Government's capital funding programme deliver better value for money."

On calling for the collection of more data on the performance of existing school buildings to assist with the design of the next generation, she said: "School building design has fallen off the education policy agenda. We call on the Government to carry out a review of its school building programme…our pupils, teachers, parents and taxpayers deserve top mark schools."

Good classroom acoustics are essential, says RIBA

Researchers use light and sound waves to control electron state

US physicists have combined light and sound to control electron states in an atom-like system, providing a new tool in efforts to move toward quantum-computing systems.

The work was done on diamond topped with a layer of zinc oxide containing electrical conductors and performed at a temperature of 8 degrees Kelvin (-445.27 Fahrenheit, -265.15 Celsius) – just above absolute zero.

Using sound waves known as surface acoustic waves to change electron states could foster data transfer between quantum bits, the researcher said. The interaction of qubits, as is the case with binary bits in current computing, is seen as vital in building advanced systems.

"Computer chips in today's systems are based on electrical circuits," said Hailin Wang, a professor in the University of Oregon Department of Physics and member of the Oregon Center for Optical, Molecular and Quantum Science. "What we have accomplished could lead to a new architecture—a new way—to design a computer chip. Instead of using electrical circuits we incorporate sound waves on a chip, with our eyes on acoustic circuits and also on potential applications in tomorrow's quantum computers."

The research focused on a goal of quantum-computing research—taking advantage of defects in diamond known as nitrogen vacancy centres, where a nitrogen atom substitutes for a carbon atom adjacent to a missing carbon atom. These defects are, in effect, artificial atoms that can be used as qubits.

It is in these centres where scientists want to harness control of the spin, or electron states, of qubits. Professor Wang's lab is among many around the world looking to incorporate sound waves.

"We've brought in sound waves that we can drive into the diamond itself," said the study's lead author D Andrew Golter, a research associate in Professor Wang's lab. "We can tune the pitch to just the right frequency that lets us control the quantum state."

To add sound waves, researchers built a tiny speaker on the surface of diamond. Sound caused the diamond and zinc oxide layer to crunch up and expand back and forth. The sound wave travels across the surface of the diamond and interacts with the NV centre. There, the researchers used lasers to monitor light being emitted, which allowed them to confirm electron states had been changed.

"You want qubits to be either on or off," said Mr Golter. "We use sound and light to switch them between different states. Light works well for some contexts, but it is sometimes hard to work with. If two qubits are in different locations and we want them to talk to each other, it is difficult to get light to go from one to the other. Light moves fast and can be hard to control. Sound is much slower, and it is easier to make it travel within this material because it automatically travels through solid matter."

In essence, using this new tool based on both light and sound can help create logic gates – the building blocks of digital circuitry – that serve to let qubits talk with one another, Professor Wang said. "You can, in principle, use the sound waves to entangle two qubits," he said. "For quantum computers you need this."

For a solid material such as a chip, sound may be an ideal tool for building a network of interacting atoms, with sound waves carrying information from one atom to the next, Mr Golter said.

Pipe maker fined £200,000 over staff HAVS failings

A pipe manufacturing company based in Newport, South Wales has been fined £200,000 for safety failings after seven reported cases of Hand Arm Vibration Syndrome (HAVS) or Carpal Tunnel Syndrome (CTS).

Newport Crown Court heard that employees of Asset International used vibrating tools without proper training or practical controls to reduce vibration risk.

An investigation by the Health and Safety Executive (HSE) found no sufficient risk assessment or health surveillance had been carried out.

Asset International Limited, of Stevenson Street, Newport, was also ordered to pay costs of £27,724 after pleading guilty to offences under Regulations 5,6,7, and 8 of the Control of Vibration at Work Regulations 2005.

HSE inspector Joanne Carter said after the hearing: "The serious and irreversible risks from Hand Arm Vibration Syndrome caused by work with vibrating tools are well known and guidance has been in place since the early 1990s.

"This case shows there is no excuse for not putting in place a management system which includes risk assessment, control measures, health surveillance and information and training to reduce these risks to as low a level as is reasonably practicable."

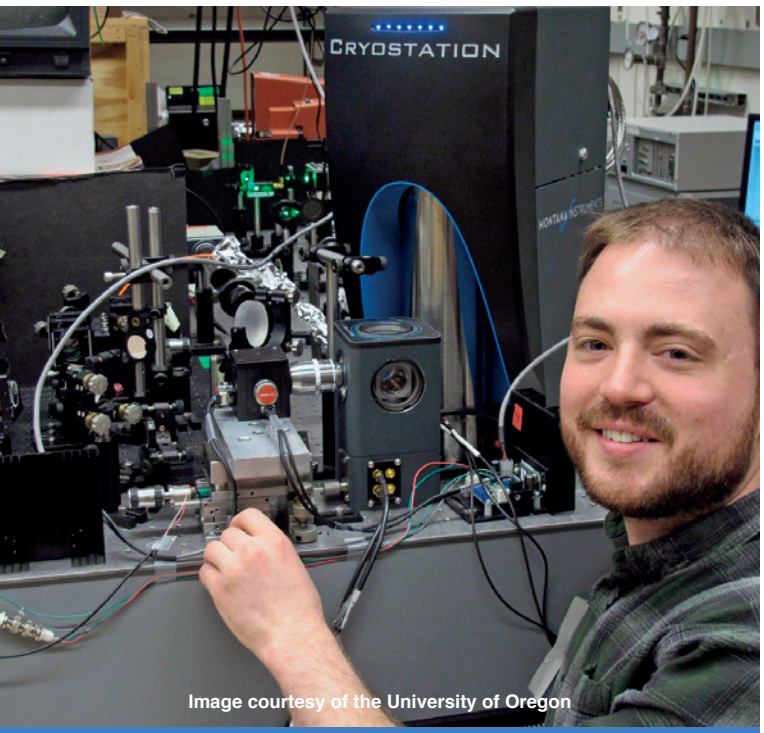


Image courtesy of the University of Oregon

D Andrew Golter who led the project in which sound waves were combined with light waves to control the electronic state

Shaken, not stirred: micro-vibration device tests ESA satellites

The European Space Agency (ESA) has added a micro-vibration test instrument developed by the National Physical Laboratory (NPL) to its satellite testing facilities. The instrument measures vibrations caused by satellite subsystems, to limit their effects on measurements made from space.

Satellites are vulnerable to vibrations, as they reduce the resolution of images and the accuracy of measurements made over great distances. You may have experienced a similar effect if you've ever tried to take a photo with a zoom lens and an unsteady hand.

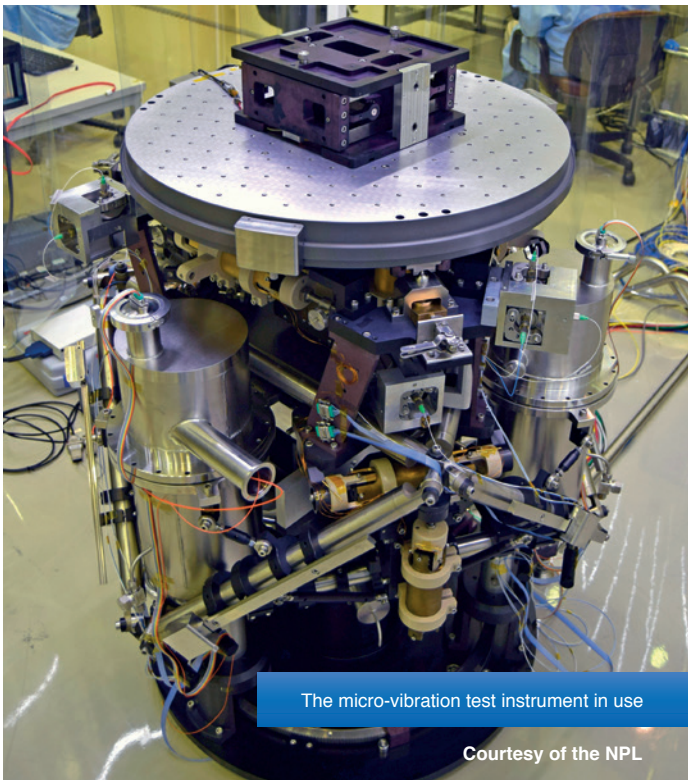
Many common elements of satellites can create vibrations, such as spinning reaction wheels, solar array drives and rotating cryocoolers – ESA needs to be able to test and correct for these jitters to improve the accuracy of its Earth observations.

To make such testing possible, NPL has developed a micro-vibration platform for ESA that can measure vibrations made by subsystems to an unprecedented degree of accuracy – so sensitive it can measure the force of a single dropped feather. The platform also generates small, controlled forces and torques to shake satellite instruments and components in six degrees of freedom (6DoF).

The lower section of the platform isolates it from vibrations from the surrounding environment, such as footsteps and even waves from the nearby North Sea, allowing the upper section to measure micronewton-scale vibrations free from interference. The platform is housed in a tent to limit perturbations caused by airflow, and can also be used in a vacuum. The instrument will be used to measure and correct for internal vibrations, and to test satellite components under a range of controlled vibration conditions.

The 6DoF microvibration platform, which will be used by ESA at its European Space Research and Technology Centre in Noordwijk, Netherlands, is the culmination of five years' work by Charlie Jarvis, Dan Veal and Ben Hughes from NPL.

Dan Veal, NPL Instruments Business Manager, said: "This facility is the result of five years of hard work and partnership between NPL and ESA. It demonstrates NPL's capability to design and commission commercial-grade instruments, and will help give confidence to ESA and the European space community in the critical area of micro-vibration measurement."



The micro-vibration test instrument in use

Courtesy of the NPL

New research brings 'smart hands' closer to reality

Using your skin as a touchscreen has been brought a step closer after UK scientists successfully created tactile sensations on the palm using ultrasound sent through the hand.

The University of Sussex-led study is the first to find a way for users to feel what they are doing when interacting with displays projected on their hand.

This solves one of the biggest challenges for technology companies who see the human body, particularly the hand, as the ideal display extension for the next generation of smartwatches and other smart devices.

Current ideas rely on vibrations or pins, which both need contact with the palm to work, interrupting the display.

However, this new innovation, called SkinHaptics, sends sensations to the palm from the other side of the hand, leaving the palm free to display the screen.

The device uses "time-reversal" processing to send ultrasound waves through the hand. This technique is effectively like ripples in water but in reverse – the waves become more targeted as they travel through the hand, ending at a precise point on the palm.

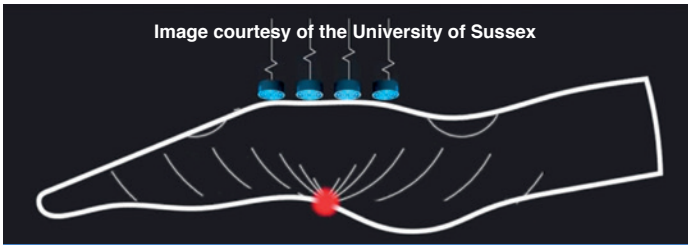
It draws on a rapidly growing field of technology called haptics, which is the science of applying touch sensation and control to interaction with computers and technology.

Professor Sriram Subramanian, who leads the research team, says that technologies will inevitably need to engage other senses, such as touch, as we enter what designers are calling an "eye-free" age of technology.

He said: "Wearables are already big business and will only get bigger. But as we wear technology more, it gets smaller and we look at it less, and therefore multisensory capabilities become much more important.

"If you imagine you are on your bike and want to change the volume control on your smartwatch, the interaction space on the watch is very small. So companies are looking at how to extend this space to the hand of the user.

"What we offer people is the ability to feel their actions when they are interacting with the hand."



The SkinHaptics device sends ultrasound through the hand to precise points on the palm, paving the way for next-generation smart technology that uses your own skin as a touchscreen.

German project to study wind turbines' noise and vibration impact

A new project has set out to discover the impact of noise and vibrations from wind turbines.

The South-German WindForS research cluster, comprising seven universities and research institutions from Baden-Württemberg and Bavaria in Germany, has initiated the TremAc project, short for Objective Criteria for Vibration and Noise Emissions of Inland Wind Power Plants cooperation project.

Funded by the Germany Ministry for Economic Affairs and Energy, the project intends to study how wind turbines produce noise and vibrations, how they are related, and how they can be better foreseen and reduced. The project will aim to improve the planning, development, and acceptance of wind power plants, while developing objective criteria for the sound and vibration emissions.

"We want to compute the complete chain of effects from the plant to the population," said Theodoros Triantafyllidis, project coordinator and head of the Institute of Soil Mechanics and Rock Mechanics at Karlsruhe Institute of Technology.

Researchers will study the interaction of acoustic and seismic vibrations of wind power plants, and develop a model to compute both emissions. The researchers will measure acoustic signals in the atmosphere, and seismic signals in the ground, for both a single wind turbine and for an entire wind farm. The neighbouring communities will also be interviewed using environmental medicine and psychological questionnaires.

The researchers say they will therefore be able to compare objective observations from the wind turbines with human subjective observations. According to the Karlsruhe Institute of Technology, the study of emission and perception of noise and vibrations has been conducted separately, in most cases.

"This is far too limited in scope to understand why neighbours complain of inconveniences caused by wind power plants even though the required limit values are observed and people should not hear anything physiologically," said Professor Triantafyllidis, explaining why the interaction between subjective and objective is so important.

Impact: the new study will examine wind turbine noise effects

Rock on: an acoustic analysis of Freddie Mercury's voice

An international team of experts has carried out a detailed investigation into the vocal range of rock star Freddie Mercury,

The study in *Logopedics Phoniatrics Vocology* set out with the ambitious task of analysing the voice of the Queen vocalist who died in 1991.By selecting archive recordings, as well as using a rock singer to imitate, a team of Austrian, Czech and Swedish authors discovered some interesting findings about the voice once described as "a force of nature with the velocity of a hurricane".

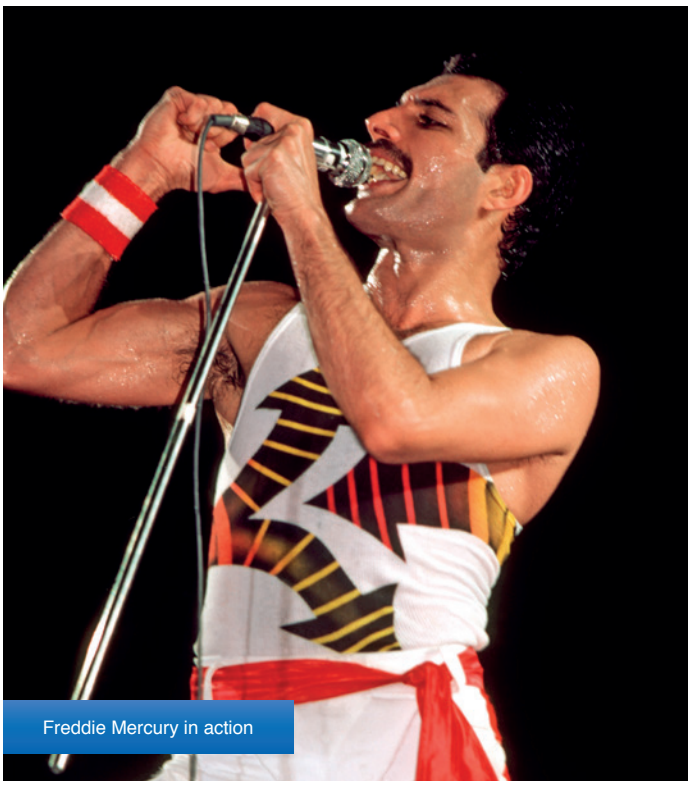
There had been speculation that Mercury's range was over four octaves but this could not be substantiated by the study. The lead author, Austrian voice scientist Christian Herbst, states that Mercury's voice range was "normal for a healthy adult – not more, not less".

Contrary to his popular image, he was probably a baritone who sang as a tenor with exceptional control over his voice production technique. He is known to have rejected an offer to sing as baritone in an opera duet with singer Montserrat Caballé because he worried that his fans knew him only as a rock singer and would not recognise his voice in baritone.

In many ways, this deeper scholarly interest and analysis of Mercury's voice moves to affirm many of the singer's stage persona traits. In particular, the study examined the intentional distortion Mercury used to produce so-called "growl" sounds. With a rock singer imitating this special type of singing, the authors filmed his larynx with a high-speed camera at more than 4,000 frames per second, giving them an understanding of what Mercury would have done physiologically while singing these "distorted" notes. The authors could thus reconstruct how Freddie Mercury, in his flamboyant and eccentric stage persona, drove his vocal system to its limits.

What they found was an intriguing physical phenomenon called subharmonics. This is seen in a more extreme way in Tuvan throat singing where not only the vocal folds vibrate, but also a pair of tissue structures called ventricular folds, which are not normally used for speaking or classical singing. Mercury's more fragile side is also fitting with his hallmark vibrato (a rapid, slight variation in pitch). Most pop/rock singers maintain a regular vibrato, whilst his was more irregular, and unusually fast.

This report is based on one that appeared in *Phys.org*



Freddie Mercury in action

Rifle vibration measurements aid shooters to be more accurate

French engineering student Raphaël Chevalier has developed a device that helps Olympic prone shooters improve their accuracy by up to 24%.

Rifle shooting is a precise science where the combination of barrel and ammunition affects the bullet's accuracy. This is mainly due to the gun's 'kick', also known as recoil, as the bullet fires: transverse vibrations result from recoil forces in the rifle imparting on the back of the barrel. These vibrations cause a variation in shot accuracy.

Raphaël got the idea to develop a system and corresponding technique for analysing and predicting how rifles perform with certain ammunition. Once Raphaël had his methodology in place, he needed some help testing the system, gathering data and analysing the results, so contacted Brüel & Kjær.

"When I explained my research project to them, they responded enthusiastically," said Raphaël. "They sent Henri Gérenton, who is an application engineer, to meet with us at INSEP (France's National Institute of Sport and Physical Education) and do a half-day measurement session."

To capture the data they needed, Henri and Raphaël placed two accelerometers – one vertically and one horizontally – at the extremity of the gun barrel and then recorded time signals of the shots, in order to reconstruct the motion of the muzzle and the muzzle jump (the tendency of the front end of the firearm to rise up after firing).

The signals were recorded using Brüel & Kjær's LAN-XI data acquisition hardware and PULSE™ Time Data Recorder software. They made as many recordings as possible in order to increase their statistics and changed parameters such as the gun barrel, the ammunition, the gun itself in a systematic way, to achieve a more nuanced view of their results.

"Thanks to the measurements done by Brüel & Kjær, we have been able to determine the relative impact of some of the parameters on vibration and confirm the efficacy of different types of rifles and gear," explained Raphaël. "That means we were able to calibrate my system for optimising the barrel-to-ammunition match that will improve shooters' gear accuracy during training."

For more details go to **http://goo.gl/z5nw0D**

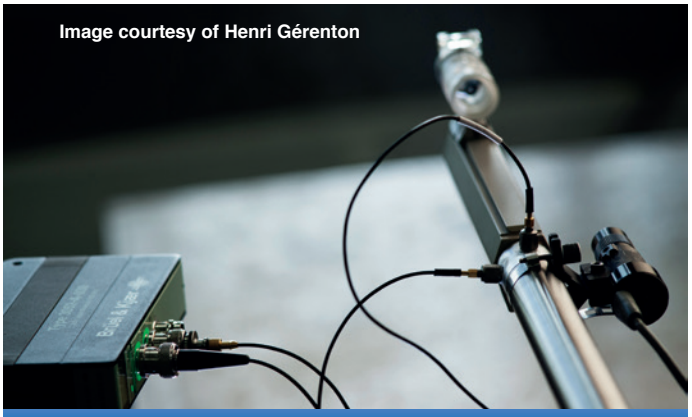


Image courtesy of Henri Gérenton

A .22 long rifle carbine with two accelerometers connected to data acquisition and recording equipment

Image courtesy of Raphaël Chevalier

Engineering student Raphaël Chevalier demonstrates shooting in prone position

New headphones can pick and choose outside noises

A tiny hearing device roughly the size and shape of an earbud will make it possible to select which parts of the outside world part become part of your earphone experience.

This is possible thanks to augmented hearing IQbuds being developed by researchers at Curtin University, Australia and their industry partners Nuheara.

They say users who wear the IQbuds will be able to benefit from the ability to manage sounds from their surroundings.

The Bluetooth-enabled tiny buds will play streamed content from everything from music to podcasts.

At the same time the highly advanced signal processing capabilities contained in the device will make it possible to effectively cut out surrounding noises such as road and traffic noise and even background babble in a café or at home.

The new earbuds in action

But, if the wearer does something as subtle as turning their head the IQbuds can incorporate the sound coming from that direction.

The release will also mean for the first time a smartphone connectable device, with sophisticated sound augmentation capabilities, can be purchased off the shelf by consumers.

The relatively low-cost device is the first stage of a futuristic plan to develop the device for the gaming world, says Professor Kevin Fynn, Curtin Head of School of Electrical Engineering and Computing.

"The ultimate aim is to develop IQbuds into a device that incorporates the technology into a virtual reality experience," he said.

"This means when you move your head audio of the wearers' desire is streamed directly into the 3D virtual world."

3D audio has not kept pace with 3D visual because developing the technology to create a multi-dimensional audio environment is a much more difficult thing to do, he said

"The device will advance in the virtual direction as technology permits because to do this a computer or recorded audio stream needs to be replayed into the virtual space and tracked."

Project team leader Professor Sven Nordholm says the team's work is at the forefront of research in the audio technology area, because the science is understanding how you perceive the environment around you.

"The device allows some sounds to be heard better than others," he said.

He says the device will have a broad range of applications including in the hearing aid market.

"We especially expect the device will be beneficial to people with the beginnings of hearing loss," he said.

This report is based on one that first appeared in *Phys.org*

Revealed: the startling cost of hearing loss from noise at work

A new report from the United States has underlined the dangers to hearing from noise at work.

Occupational hearing loss, primarily caused by high noise exposure, is the most common US work-related illness. Approximately 22 million US workers are exposed to hazardous occupational noise.

The Atlanta-based Centers for Disease for Disease Control and Prevention (CDC) found that the mining sector had the highest prevalence of workers with any impairment (17%) and with moderate or worse impairment (3%), followed by the construction sector (any impairment = 16%, moderate or worse impairment = 3%), and the manufacturing sector (14% and 2%). The public safety sector, which includes police protection, fire protection (including wildland firefighters), corrections, and ambulance services, had the lowest prevalence of workers with any impairment (7%).

Across all industries, 2.53 healthy years were lost annually per 1,000 noise-exposed workers. Mild impairment accounted for 52% of all healthy years lost and moderate impairment accounted for 27%. Workers in the mining and construction sectors lost 3.45 and 3.09 healthy years per 1,000 workers, respectively. Overall, 66% of the sample worked in the manufacturing sector and represented 70% of healthy years lost by all workers. Public safety workers lost 1.30 healthy years per 1,000 workers, the fewest among all workers.

The authors used data from an earlier survey conducted by the National Institute for Occupational Safety and Health – the Occupational Hearing Loss Surveillance Project. While this method allowed them to look at a large sample size of employees, it might also mean their findings underestimate how dangerous to our hearing these jobs could be, the authors noted. The workers recruited for the project were simply those who agreed to participate, rather than a representative slice of U.S. noise-exposed workers. Secondly, the formulas they used to determine hearing impairment and its impact on productivity were conservative, which might have further driven down their numbers.

What is certain is that employers could be doing a lot more to protect their workers. Although construction workers were the most likely to be hearing-impaired after miners, the industry does not require routine testing as with the latter, which might delay or prevent employees from receiving the early care they need. Likewise, while only a third of manufacturing workers are regularly exposed to noise – compared with 76 percent of miners – the industry has many more total workers than either construction or mining, according to the authors. Indeed, 66 percent of those who had hearing loss in the study worked in manufacturing. As the authors noted, even a mild amount of hearing loss can have dramatic effects on our physical and mental health.

"Occupational hearing loss is a permanent but entirely preventable condition with today's hearing loss prevention strategies and technology," they concluded. "Concurrent with prevention efforts, early detection of hearing loss by consistent annual audiometric testing, and intervention to preclude further loss (e.g., refitting hearing protection, training), are critical."

Hearing protection is a must for workers

New approach for studying turbulence could help develop quieter jets

Researchers from the University of Minnesota in the US have developed a new approach for studying jet turbulence.

Their findings, published in the journal *Physics of Fluids*, helps explain why jets are so loud, and could suggest new approaches for turning down the volume.

This also led to the discovery of new coherent modes – parts of the fluid that flow in predictable patterns – associated with the dynamics of high-speed jets.

"Back during the 1960s, it was shown that coherent parts of turbulent fluctuations inside jets are connected to instability wavepackets, which are linked to noise," said Joseph Nichols, an assistant professor of aerospace engineering and mechanics at the university.

"A wavepacket is an oscillation that repeats if you look at it over short time and length scales, but when you zoom out you can see it varies slowly over a long distance."

This slow variation, for example, may be caused by the jet spreading out downstream. "The same basic principle applies to amplitude modulation [AM] radio, where modulation of a high-frequency carrier wave communicates information about low-frequency speech patterns," he said.

"In jet noise, this carrier wave is driven by fluid instabilities that feed on the energy contained inside the jet. Instead of encoding speech patterns, however, the amplitude modulation of instability wavepackets determines the efficiency and spatial direction at which sound is released from jet turbulence."

In recent years, other researchers computed instability wavepackets and found that they predicted peak jet noise for supersonic jets.

"For high-speed subsonic jets, however, the theory breaks down – underestimating sound pressure levels by at least two orders of magnitude," Professor Nichols said. "A prevailing view underlying current industry-standard jet noise prediction codes is that fine-scale turbulence is responsible for this missing sound, and that this

phenomenon can only be modelled statistically."

In stark contrast, Professor Nichols and colleagues looked at turbulent jets through the lens of the whole system, rather than individual components.

Mihailo Jovanovi, an associate professor of electrical and computer engineering, said: "We treat high-speed turbulent jets as amplifiers that take turbulent fluctuations inside the jet as inputs and give back sound in the region far away from the jet as outputs.

"And we use this mathematical framework to identify modes that induce large input-output amplification and generate loud noise."

The interdisciplinary research team confirmed the existence of these new modes using high-fidelity simulations of high-speed jets.

The researchers numerically solved the compressible Navier-Stokes equations, which describe the motion of viscous fluids, by subdividing a high-speed jet flow into hundreds of millions of small pieces.

Jinah Jeun, a graduate student in aerospace engineering and mechanics, said: "Each of these small pieces communicates with neighbouring pieces to build up a picture of the large range of scales of turbulent motion."

Running such a simulation can require hundreds of thousands of computer processors, simultaneously, on some of the most powerful supercomputers in the "Although high-fidelity simulations consume millions of CPU-hours, we apply our new analysis to extract from them information needed to construct accurate reduced-order models that can be run in minutes on a laptop useful for aeroacoustic design," Mr Jeun said.

In terms of applications for the group's work, reducing jet noise has a large impact on the health and safety of airport personnel as well as on communities surrounding airports.

Their computations also enable an understanding of physics phenomena that are inaccessible experimentally, for example because they happen in an extreme environment that can't be outfitted with sensors.

"Input-output analysis, for example, may be applied to figure out how upstream turbulence inside the nozzle affects flow downstream," Mr Jeun noted.

New research could lead to quieter jets

These simulation and analysis techniques can be applied to other problems, such as understanding instabilities in the wakes of wind turbines, investigating acoustic-flame interactions for the design of safer and more efficient combustion, and explaining shock-induced transition in hypersonic boundary layers.

Heathrow noise is seriously affecting children's maths skills, warns MP

Noise from Heathrow is seriously affecting children's achievements at school , an MP has warned.

Pupils' mathematical performance drops in direct correlation with the increase in noise closer the airport, according to Ruth Cadbury .

The Brentford and Isleworth MP also told how night flights were depriving constituents of sleep and impairing their ability to work effectively.

Speaking in a parliamentary debate about aircraft noise, Ms Cadbury said: "Over 90% of children educated in Hounslow borough's schools, nurseries and colleges are directly affected by aircraft noise, and 90% of Hounslow teachers believe that aircraft noise affects children's ability to concentrate and learn.

"Noise level is significantly related to mathematical performance. As noise increases by contour band, performance drops by 0.73 of a mark."

She also quoted constituents who complained about night flights ruining their sleep patterns and making it "impossible to live or work effectively when sleep deprived".

Aircraft noise is affecting children's performance at school

Twenty-four schools near Heathrow will be offered improved ventilation, as part of a new programme launched by the airport. This offer will complement the airport's £4.8 million Community Building Noise Insulation Scheme (CBNIS), completed last year, and the adobe building program to support outdoor learning spaces, both of which were celebrated at the launch of the ventilation programme at Hounslow Heath Infant and Nursery school yesterday.

The ventilation programme will be phased in over the next three years and will be open to schools that received noise insulation including double-glazing and replacement windows through CBNIS. This insulation has reduced noise by on average 6 decibels in each classroom when the windows are closed. Additional ventilation in these classrooms will allow schools to maintain the benefits of the insulation by keeping the windows shut, while being able to provide a more comfortable teaching environment.

This offer follows a pilot programme run at two local schools, Hounslow Heath Infant and Nursery School and Springwell Junior School, which both completed in 2014 and have received positive feedback. In total 17 schools in Hounslow will now be eligible for the ventilation offer, one in Ealing and in later stages six in Slough, Spelthorne, Windsor and Richmond.

While insulation can significantly reduce noise levels inside buildings, the benefits do not extend outside. To resolve this issue, Heathrow's provided funding for schools under the flight paths to install adobe buildings, eco-friendly domes which provide noise respite from overhead aircraft, whilst still retaining a feeling of being outside. Five adobe buildings will be funded this year, and ultimately, Heathrow has committed to invest almost £1.8 million in 21 adobe buildings.

Kop that! It's a hat-trick of wins for Bickerdicke Allen in the Acoustics Cup

Bickerdicke Allen Partners are the football kings of acoustics again after winning the Campbell Associates Acoustics Cup for the third year running.

In the fifth staging of the competition, they beat RBA Acoustics 4-0 in the final, while Sandy Brown won the plate competition by defeating Sharps Redmore 1-0.

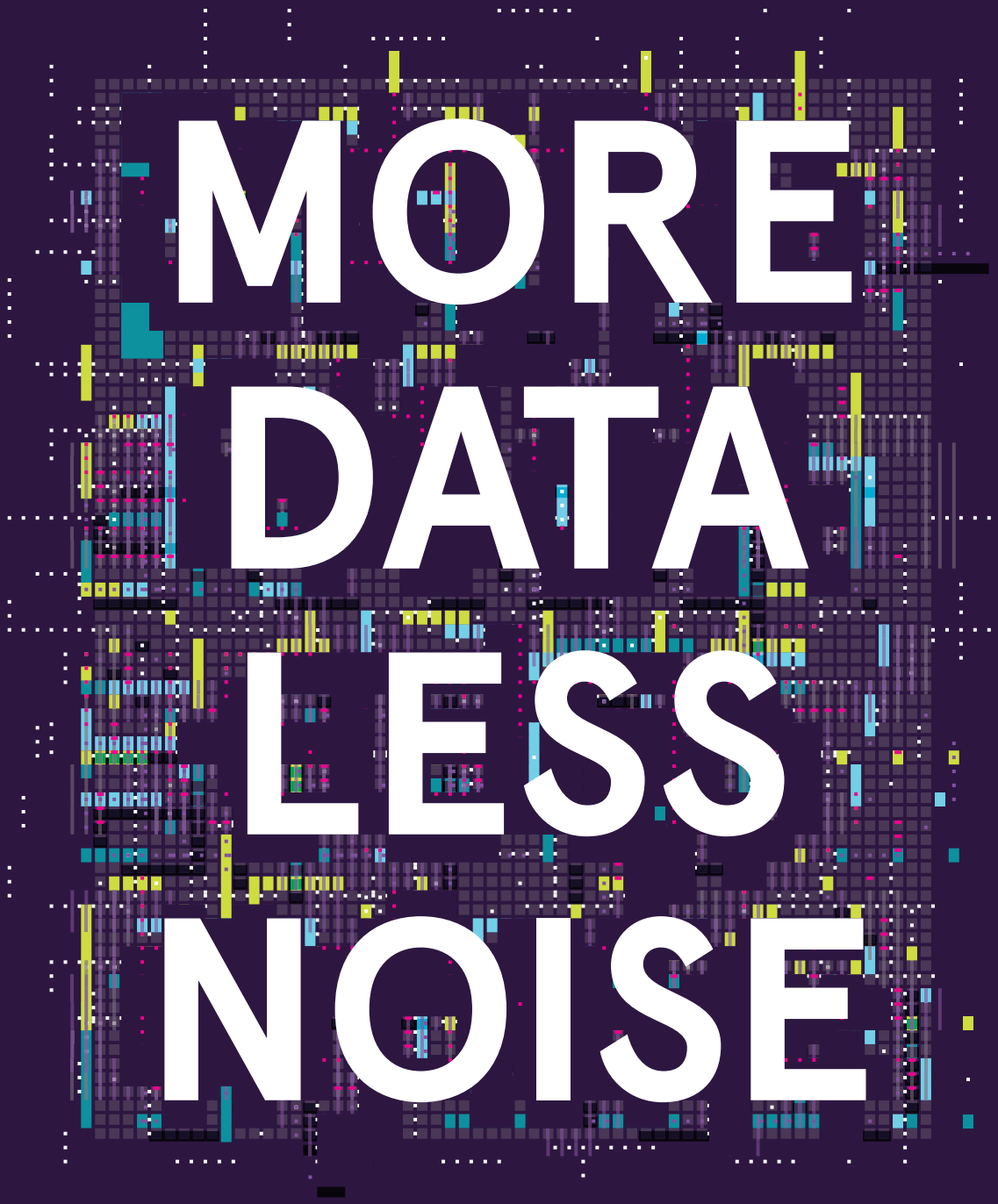
Sean Graham of Bickerdicke Allen and Alex Wyatt of RBA were named as players of the tournament and they shared the "Golden Boot" trophy for scoring the most goals.

A record 11 teams from the acoustics industry took part and helped to raise more than £970 for the Alzheimer's Society. Over the five years the event has raised more than £4,000 for charity.

Please contact **john@campbell-associates.co.uk** if you would like to enter a team for the 2017 event.

The Bickerdicke Allen squad

The Sandy Brown squad



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New technology banishes ambient 'babble' from cochlear implants

Innovative noise reduction technology has been developed to help wearers of cochlear implants and hearing aids hear what someone is saying to them over the "babble" of other talkers.

Known as SEDA (for Speech Enhancement using Decomposition Approach), it decomposes a speech signal into waveforms that differ not just in frequency (the number of oscillations per second) but also in how many oscillations each wave contains. The traditional method to analyze a speech signal decomposes the signal into distinct frequency bands, like a prism that separates sunlight into a rainbow of colours.

SEDA has been developed by Roozbeh Soleymani, an electrical engineering doctoral student at New York University, with Professors Ivan Selesnick and David Landsberger in the NYU Tandon Department of Electrical and Computer Engineering and the NYU Langone Department of Otolaryngology, respectively.

"Some waveforms in the SEDA process comprise many oscillations while other comprise just one," said Professor Selesnick. "Waveforms with few oscillations are less sensitive to babble, and SEDA is based on this underlying principle," said Mr Soleymani. Professor Selesnick added that this powerful signal analysis method was practical only now because of the computational power available in electronic devices today.

New technology will help cut out background "babble"

The potential uses for SEDA, for which a US patent application has been submitted, go way beyond helping the hearing impaired. "While it was originally conceived for improving performance with cochlear implants (which it does very well), I can imagine the market might even be bigger in a mobile phone arena," said Professor Landsberger.

MP calls on Government to adopt 'quiet cities' strategy

Loud conversations on telephones and emergency vehicles using their sirens after midnight should be discouraged to help create quiet towns and cities, an MP has said.

Conservative Mark Pritchard also wants "polite notices" on public transport to suggest people set their phones on vibrate or silent, while ministers should work with manufacturers to stop doors on vehicles making a noise when they are shut.

The MP for the Wrekin, Shropshire suggested other ways to reduce noise pollution, including Government departments working to encourage "low noise tyres" for vehicles and "silent road surfaces".

He added there should be a "national conversation about how we make this country quieter".

Moving a debate at Westminster, Mr Pritchard said: "The right to some respite from noise, constant noise, needs to be a central feature of Government policy, part of its strategy, not a by-product of another Government policy, a consequence of that policy.

"From my own observations, I think the Government should work with motor manufacturers to encourage all cars and vehicles to have linings which stop their doors making noises when they are slammed shut.

"A simple rubber lining would make a huge difference – metal on metal makes noise.

"Slamming doors are even an issue in the House of Commons. Where the doors are lined the doors close quietly, where they're not lined they slam and they create noise pollution.

"Emergency vehicles should reduce using their very loud sirens after midnight. The blue flashing lights alert people enough of their presence in the dark and discretion should be allowed."

Mr Pritchard went on: "Perhaps on public transport systems should we set polite notices – we can't compel people to do things – but can we encourage people through polite notices asking people to set their phones on to vibrate or silent?"

Environment Minister Rory Stewart said the Government was engaging with the idea of a quiet cities, but it was a local authority lead. "It is important that the idea of a smart city, a green city or, in this case, a quiet city is locally driven. It is about how an area brands itself and thinks about itself and what its values might be.

"Our colleagues in the Department for Communities and Local Government have proposed coinciding the idea of pocket parks and green areas in cities with the idea of quiet areas, where there would be prohibitions on creating noise."

Quiet please: ambulances 'should turn off sirens after midnight'

Auralisation: sound design for our sound environment

By Damian Murphy

According to a UK Health Protection Agency Report from 2009, 30% of us express dissatisfaction with the noise in our environment, whether from roads, rail, aircraft, or just from living in a seemingly ever busy and every louder world. Yet the levels of sound recorded do not reach intensities that are directly damaging to our hearing. Environmental noise is one of the main causes of environmental distress in terms of the number of complaints received with more than 30% of the EU population exposed to noise levels above the World Health Organisation's recommendation.

The soundscape of our environment helps us to better understand the world we live in, and has a direct effect on our health and wellbeing. Human society has battled with the concept of excessive noise since hitting one rock against another produced some of the first tools, and yet the complete absence of sound in our environment can prove to be equally unsettling. If the presence of sound, both wanted and unwanted, is something that cannot be avoided, how might we design our environment with a view to improving sound quality rather than reducing sound *quantity?* One method that helps to address this issue for our environmental soundscape is auralisation.

Auralisation – the audio equivalent of digital visualisation – enables us to listen to virtual acoustic environments that are yet to be built, and although commonly used in the design of acoustically critical spaces such as concert halls, it is now also finding its place in environmental acoustic design and assessment.

Virtual acoustics and auralisation

We have come to accept and appreciate visualisation as an art form via the modern use of computer graphics in film, television and video games. Computer visualizations are easy to comprehend and appreciate, and they can impart such a sense of quality that we accept them as some form of reality, be they based on actual real-world scenes or an imaginary subject or landscape. Recreating the auditory equivalent using auralisation, however, is in many ways a much more complex process. A soundscape is a constantly changing, ephemeral experience with few fixed points of reference (unlike a visual landscape), and our perception and understanding of it can depend on many different aspects – our own personal sound experiences; the choices made by the designers in presenting the audio material to the listener; whether this is for personal listening (headphones) or shared experience over multiple loudspeakers (as in the cinema) – but the results can leave an impression after images have long since faded. Our ears and brain are finely tuned interpreters of many competing streams of complex auditory information, and are sensitive to a broad range of acoustic sensations, both in terms of frequency and dynamic range.

One formal definition of auralisation is as follows:

"...the process of rendering audible by physical or mathematical modelling, the sound field of a source in space, in such a way as to simulate the binaural listening experience at a given position in the modelled space." (Vorländer, 2008).

P40

P39

The starting point is a model of a particular environment. The classic example, from where much of this research has originated, is a concert hall. Into this environment, we place a sound source (for instance, an opera singer, in the example of a concert hall) at a particular location (on the stage) and a *listener* (situated a given seat in the auditorium). We then wish to recreate for this listener the *binaural listening experience* of the opera singer on the stage of the modelled concert hall, as heard from their seat. More rigorously we wish to recreate the acoustic pressure sensations at each of the listener's eardrums. This requires acoustic knowledge about the sound source – the properties of the human voice when singing opera; the directions in which the sound travels, and how these properties vary over time or with frequency. Knowledge of the sound source propagation paths through the concert hall is necessary, including: the distance travelled before arriving at the listener's ears, changes imparted through interactions with a wall or an object within the room, and the effect of air as the medium on the sound waves passing through it. It is also important to have information about the listener's head and ears – the size and shape of the outer ears (pinnae); whether the listener moves their head or remains static. Finally, this modelled sound needs be presented to the listener – over headphones or over two (stereo) or more (surround-sound) loudspeakers; if loudspeakers are to be used, will the listener be positioned in the middle of them at the *sweet-spot* or in a non-optimal seating position as part of a wider audience (as in cinema presentation). Auralisation separates the experience of listening to a sound within a given environment into these constituent acoustic elements, from sound source to listener's ear, and how the same effect can be reproduced over an audio system. As a result this whole listening process can be better understood, and with understanding comes the ability to control, reshape and re-imagine this listening experience.

Modelling and measurement

Acoustic modelling is generally used in auralisation to predict the sound propagation paths in a space that does not as yet exist, and so is a key design process in the development of new performing arts venues, where acoustic quality is critical. It is also used to predict the acoustic consequences for refurbishments planned in existing venues. Traditionally, the model might in fact be a reduced scale construction of the actual building, complete with miniature loudspeakers (for sound sources) and microphones (for the listener's ears), with the audio signals scaled up in frequency accordingly to compensate for the change in physical dimensions (Polack et al, 2003). Such techniques are now rarely used due to the high level of skill needed in the construction, the time required to build them, the high costs involved and the limitations of the miniature audio systems used.

Computer-based acoustic modelling is therefore much more established, based on 3D computer aided design techniques, and makes it possible to use a computer-based visualisation and from this generate an auralisation. Despite the flexibility that this implies (it is much easier to edit, change and experiment with the design of a computer based environment than with a comparable scale model, or even the real thing), the accuracy of the result is still only as good as the mathematical techniques that are used to describe how sound behaves within this virtual 3D space. As yet there is no perfect solution for this problem. Most existing commercial software makes use of one or more geometric acoustic modelling techniques (Savioja and Svensson, 2015). Here, sound is assumed to travel in straight lines, similar to a ray-of-light, and sound paths are calculated from source to listener based on how these predicted paths interact with the surrounding geometry of the environment and reflect from walls and objects. The result is a close approximation to the impulse response of the modelled environment, for a given set of conditions, although results at low frequencies are often less accurate, as geometric acoustic methods are less able to model the wave-like behaviour of sound at these frequencies. This problem is an area of active research (Southern et al., 2012), and an alternative approach is to use a numerical method to solve the underlying equations of wave motion. Although more accurate, such methods are too expensive computationally to offer a complete solution, taking hours, days, or weeks to arrive at the final result, and hence hybrid methods, taking advantage of both approaches, and driven by subjective, rather than objective, assessment metrics, are also an area of current research (Southern et al, 2013).

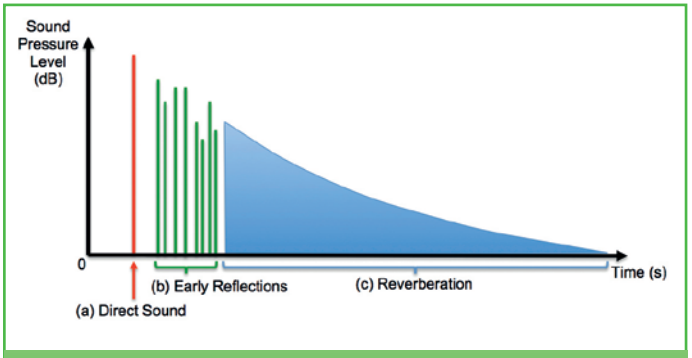

Figure 1: The echogram profile of a typical impulse response from an enclosed space, demonstrating how a short, impulsive sound – like a handclap, balloon pop or gun-shot – at the source position arrives at the measurement position in three stages: (a) the direct sound arrives via the straight line path between sound source and measurement position, arriving a short time after the sound source has stopped; (b) the early reflections arrive via the next longest paths from source to measurement position, involving one or more reflections from the main surrounding walls, where some additional energy will be lost due to sound absorption; (c) the reverberation or exponential reverberant decay, where it is no longer possible to detect distinct reflections due to the density of arrival of many reflections via many paths, involving reflections from multiple walls.

Despite there being limitations to the methods used in acoustic modelling, it is still possible to get very close to an optimal result, and certainly to a point that the resulting auralisations are considered to be perceptually plausible, or "good enough".

Acoustic measurement for auralisation is the real-world equivalent of acoustic modelling. As with computer based modelling, the goal is to obtain a set of acoustic impulse responses from the measured space that can be used for further analysis, to better understand how the space has an impact on sounds heard within it, or for auralisation. Although it is possible to arrive at an approximation of the acoustic impulse response by using a balloon pop or starter pistol as the sound source excitation, recorded at the required listener position, it is much more common to use an analytical signal played back through a loudspeaker. The method presented in (Farina and Ayalon, 2003) based on an exponential sine wave sweep through all frequencies of interest (typically 22Hz to 22kHz to cover the complete audio spectrum) is now widely used, with additional post-measurement processing applied to inverse filter the sweep signal to arrive at the required impulse response.

The loudspeaker used as the sound source is of some importance for an optimal result. Acoustic standards recommend an omnidirectional loudspeaker so that the measured space is excited equally in all directions, although this is more usually applied for acoustic analysis rather than auralisation. Omnidirectional loudspeakers are often not ideal for auralisation – they have a non-flat frequency response that will colour the excitation signal and therefore also the recorded measurement, and at wavelengths comparable or shorter than the loudspeaker driver diameter, become highly directional. Furthermore, auralisation is designed to simulate a specific sound played back in the measured space and the most commonly used acoustic signals (e.g. speech, musical instruments) have a particular directional characteristic. Hence an omnidirectional loudspeaker over-illuminates the environment with acoustic energy in a way that real acoustic sound sources rarely do. For this reason, studio monitor speakers are often used – they have a typically flat and extended frequency response, and a directional characteristic that is generally uniform with frequency. If a more omnidirectional excitation is required, it is possible to orientate the loudspeaker to different directions, repeat the measurement process, and sum across the results obtained (Shelley et al, 2013). Some equalisation of the recorded

measurements might then be needed to account for too much bass energy in the resultant sum as such loudspeakers tend to be more omnidirectional in this frequency range in any case.

A combination of microphones at the listener position to record the signal propagating through the space from the source loudspeaker makes it possible to capture a large amount of impulse response data in one pass. This approach was pioneered in (Farina and Ayalon, 2003), where a stereo microphone pair, a binaural dummy head microphone and an Ambisonic B-format Soundfield microphone are used together in combination with a rotating turntable to automate the measurement process. This microphone array takes 36 sets of measurements over eight-channels at 10-degree intervals. An alternative version was used in (Murphy, 2005), (Murphy, 2006), and in this configuration a Soundfield microphone is positioned on a boom arm, 1m from the centre axis of the automated rotating turntable. A single Neumann KM140 cardioid microphone is situated with the capsule end 10.4 cm from the centre axis, essentially one half of an ORTF stereo microphone pair. A rotation increment of 5-degrees is used and this simplifies the system used in (Farina and Ayalon, 2003) but still enables the 72 sets of five-channel impulse response information to be combined for a wide variety of surround-sound auralisation or acoustic analysis options.

If outdoor environments are to be captured in this way, the measurement system should be simplified further for the sake of portability, and good results can be achieved with a single Soundfield microphone. A Soundfield microphone consists of a four-channel coincident array of microphone capsules that spatially samples the acoustic field at a given point. It is compact and easy to use, does not require complex calibration, and gives flexible rendering options for decoding the impulse response measurements for many types of speaker configuration, including binaural sound via a further post-processing and signal transformation stage. Soundfield microphone recordings/measurements also form the basis of parametric spatial audio rendering techniques (Merimaa and Pulkki, 2005), (Berge and Barrett, 2010) that have the potential to give better spatial accuracy for a wider group of listeners within a loudspeaker array, without having to resort to microphones based on more complex spatial arrangements and higher channel counts.

Analysis

The fundamental quantity used to characterise, define or gain information about the acoustic qualities of a particular space that can be obtained from an impulse response is reverberation time. *Reverberation time* (or RT60) is formally defined as the time it takes (in seconds) for a steady state signal to attenuate by 60 decibels once the sound source has stopped. This is usually derived from an impulse response measurement using the Schroeder energy decay curve, calculated from the backwards integration of the squared impulse response. Other acoustic parameters can also be derived from an impulse response measurement, and are commonly used to provide additional detail in the acoustic characterisation of a particular space. These parameters form an important part of the modern architectural design process and have been documented in the relevant international standard (ISO3382-1, 2009). However, it is also possible to interrogate this digital data in other meaningful ways. Analysing the frequency content of such time varying impulse response measurements helps to reveal how low frequency sound behaves, and whether there are specific resonances that might act to influence or colour how sound is perceived. If spatial impulse response measurements are available, as obtained from a Soundfield microphone, it is also possible to conduct a reflection analysis to detect from which directions, and hence from which walls, specific sound reflections come from.

Auralisation

Once an impulse response has been obtained from either a measurement or a model, it can be used to process any audio signal or sound recording. Ideally this source signal should be completely anechoic – that is, having no reflections or acoustic environment information imprinted on it already – and this P42

P41

is what is generally known as *auralisation*, as articulated in the definition quoted from (Vorländer, 2008) above. This auralisation process results in the original anechoic source sound being heard as if it were played back in the measured or modelled space, at the position of the source from the perspective of the listener. This auralisation may be rendered in any number of ways, from basic mono, through to full binaural reproduction over headphones, or surround-sound listening for a larger audience over a multi-loudspeaker array. The audio rendering of an acoustic space with impulse responses obtained from either a measurement or a model is also known as convolution reverberation, as the audio signal processing theory used to facilitate this is known as convolution. There is little actual difference in terminology in this respect, although auralisation generally refers to the recreation of a particular sound event in a particular environment, whereas *convolution reverberation* is a technique more generally applied in music production or computer based composition. In the latter case, an aesthetically pleasing creative result is usually the goal, rather than a more exact virtual model of an actual physical process.

Auralisation in practice

The noisy world we live in clearly has a negative impact on our lives – and this is by no means a new problem. Auralisation can help us to design environments with a more carefully considered sound quality, and to encourage all of us to engage more positively with our everyday soundscape due to its significant potential as a means of dissemination and for developing our understanding of the consequences of acoustic design. It is estimated that more than 25,000 people have listened to the award winning auralisation demonstrations of the proposed HS2 train line created by Arup Acoustics[1]. These auralisations have enabled government, MPs, and most importantly, those communities most directly affected by the proposed train line, to listen to what these potentially significant changes in their normal acoustic environment will sound like. As a consequence they are more useful, more understandable, and potentially have more impact for the general public than traditional engineering acoustic environmental impact assessments.

Auralisation is therefore now becoming a key part of the modern architectural and environmental engineering design process. The techniques used enable proposed buildings and spaces, from concert halls and classrooms, to major interventions in the landscape and countryside that surrounds us, to be auditioned and tested for the acoustic impact such developments will have on our day-to-day lives.

Applying auralisation methodologies to open-air environments, however, presents distinct challenges: a concert hall is an enclosed and controlled space – the outdoor soundscape has many more features to consider, consisting of traffic, aircraft, birds, people talking, static and moving sources, and more involved sound propagation paths interacting with a complex and potentially changing environment, often over significant distances. This can be much more difficult to simulate accurately, and interactively, so that the listener feels that they are part of the virtual environment we create. However, auralisation research is advancing to the point where we can get this correct, and start to produce believable virtual experiences. When headphone based auralisation is combined with recent widespread developments in virtual reality, the result is a much more stable, immersive and believable multi-sensory experience, removing the need for bespoke multi-speaker listening rooms, so that the final result can be delivered easily to a much wider audience, including client groups and the general public, using readily available and portable technology[2].

In addition to helping improve the design of our sound environment, auralisation also helps us to engage more positively with our soundscape, through collaborations with artists and sound designers, historians and archaeologists interested in our acoustic heritage, as well as the creative industries, all of whom can help to inform and design the content delivered to the end user. As in the case of HS2, auralisation can give politicians and policy makers a valuable new perspective on the impact of important infrastructure developments, such as rail, road or airport developments, but we also use these methods to produce new music, make computer games more immersive and exciting, produce new artwork and help to bring past environments to life through a better understanding of the sound world that would have existed at the time.

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Case study: acoustic design at the St James Centre, St Helier, Jersey

By Gaël Vilatarsana

The St James Centre is the new home of Jersey Youth Service. The project involved the conversion of the listed 19th century St James Church into a performance venue, incorporating a multi-purpose auditorium, together with music and media facilities, therefore posing the challenge of respecting and retaining heritage, while creating an excellent acoustic environment.

Hoare Lea Acoustics undertook the acoustic design of the two music rehearsal rooms, recording studio and radio broadcasting room, all located on the balcony of the church.

Challenges

The listed balcony is formed by a raked timber structure located above the aisles and rear of the church. Below, on the ground floor, a 179-seat multi-purpose auditorium was to be created. The design required separation of amplified music spaces from the auditorium. The client had high expectations for sound insulation between rooms, but also wanted the balcony's timber panelling, arched ceilings and steel columns to remain untouched and exposed.

The client advised a possible commercial use of the auditorium and the aspiration for the music rehearsal rooms to achieve inaudibility to the auditorium. This was despite anticipated noise levels of up to 115 dB(A) in the rooms.

Solution

Direct adjacencies horizontally and vertically between ground and first floor spaces meant that innovative and robust sound insulation design alone would not be sufficient. Questioning the 115 dB(A) brief and managing expectations of audibility were crucial.

Initial investigations demonstrated a background noise level of NR23 inside the church from road traffic. Windows already had secondary glazing for thermal control and noise break-in and break-out was not to be a design matter.

The architect agreed to include a corridor along the edge of the balcony to create a buffer zone. However, the internal roof remained a direct transmission path. Treatment was therefore specified as two independent rows of posi-joists with triple layers of plasterboard both sides and a heavy resiliently suspended ceiling below, predicted to achieve Rw 76 dB.

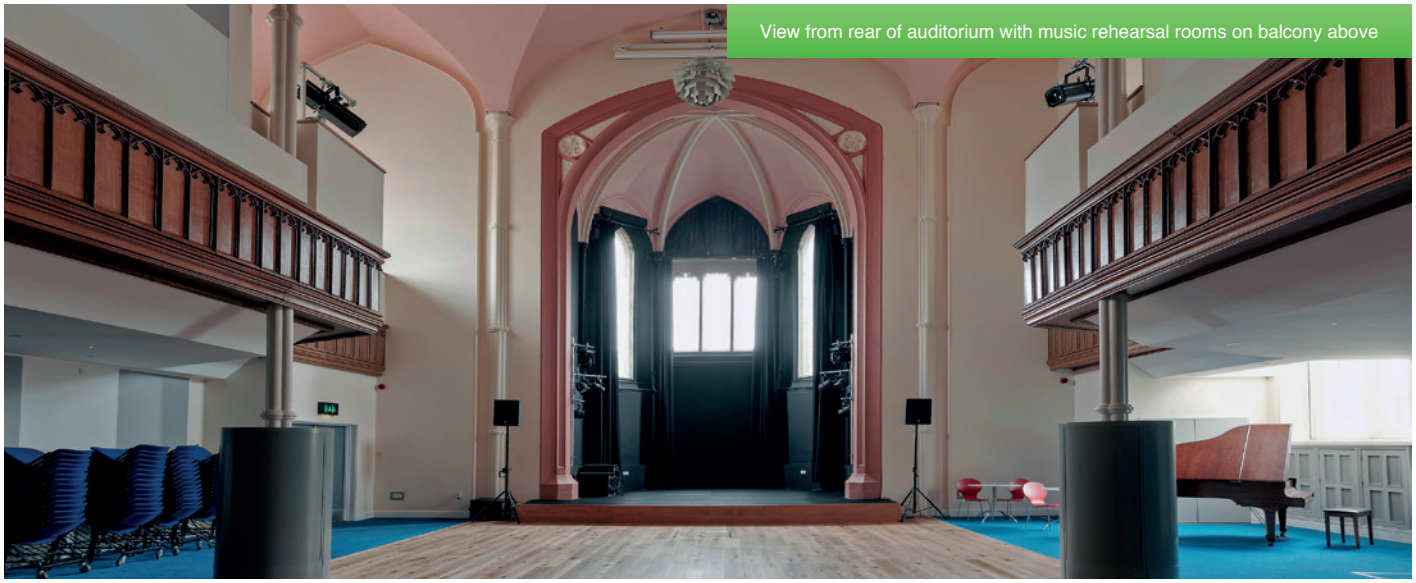
Contrary to the brief, and due to limitations of the building for flanking sound control, the conclusion of the study was that inaudibility would not be achieved and music noise levels in the region of 30 dB(A) in the auditorium were likely to result.

Increasing the performance standards in terms of DnT,w would not necessarily provide satisfaction due to the low frequency content of amplified music.

Action was taken to communicate the design intent and, to help the client make an informed decision, an audio demonstration

P44

First floor entrance to rehearsal rooms



View from rear of auditorium with music rehearsal rooms on balcony above

P43 was devised. A track was played, filtered to simulate the attenuation of the proposed construction. Loudspeakers were positioned on the first floor balcony where the music rooms were intended, with the client on the ground floor where the auditorium seats would be positioned. The loudspeaker output was adjusted to 30 dB(A) at the client's position. Considering the background noise level was NR 23, the client confirmed that up to 30 dB(A) music noise contribution was just acceptable, although lower would be preferable.

Furthermore, measurements of live amplified music showed that band practice sound pressure levels 2m from a stage would produce Leq,T 108 dB(A) in a typical size rehearsal room. Design developments focused on detailing the sound insulation. Higher performance partitions were specified, but the sound insulation design at low frequencies still needed improvement. The room within-a-room design was enhanced by swapping the twin metal frame partition to timber studs and using the studs as a supporting structure for the internal roof, so that the upper row of posi-joists were supported from the outer timber frame, and the lower row of posi-joists were supported from the inner. This innovative approach removed the need for structural steel and ensured the inner box, and all services supported off it, were not bridged to the side of the partition exposed to the auditorium.

Success

At handover, formal sound insulation tests demonstrated DnT,w 79 dB and D63Hz 47 dB between the first floor music rehearsal rooms and the auditorium. An audio demonstration took place, in which the same track as in the original demonstration was played (this time unfiltered) at 108 dB(A) in a rehearsal room. This showed that the contribution in the auditorium had been reduced to just 25 dB(A), much to the client's satisfaction.

***Gaël Vilatarsana**, an Associate at Hoare Lea Acoustics, has worked as lead acoustic consultant on projects in the healthcare, education, commercial and residential sectors. In recent years, his work has focused on higher education projects in Oxford and Cambridge, as well as conversion projects for amplified music use, such as the St James project above which was the winner of the sound insulation category at the ANC Acoustic Awards 2015.*

Noise from shale gas exploration

By Andy McKenzie

Very basic overview of shale gas extraction

The extraction of shale gas using hydraulic fracturing techniques, also known as "unconventional" gas extraction but more commonly as "fracking", has attracted a great deal of public attention. Essentially it is similar to "conventional" onshore methane gas extraction whereby reserves are "mined" using a combination of drilling and pumping to get the methane gas to the surface for onward transmission, storage and use.

The big difference between conventional and unconventional extraction is the location of the gas deposits and the additional measures required to extract it. Conventional gas is trapped in pockets in coal seams which lie about 500 metres below the surface. Coal is permeable and the gas can be recovered more easily. Shale gas, like oil, however, lies much deeper and is trapped within the shale or mudstone layer which lies between 2,500 and 5,000 metres below the surface. In order to extract the gas, the shale, or mudstone, has to be fractured by injecting the surrounding area with a combination of water, chemicals and minerals at very higher pressure through perforations in the well bore before it is possible to recover it to the surface.

The earliest fracking wells were drilled purely vertically but, since the 1990s, once the vertical drill has reached a certain depth it will turn to extend horizontally for significant distances to maximise extraction from a single well-head on the surface. The drilled bore is lined with a steel casing to transmit the fracturing fluid into the shale, return any flowback to the surface and for the eventual retrieval of the gas. It is perforated by detonations along its horizontal length to let the fracturing fluid out and return the flowback mixture to the surface as necessary and re-sealed before the fracturing operations recommence at the next point along the horizontal bore.

Noise sources

The noise from shale gas extraction comes purely from the equipment and processes located on the surface and consists of that from the following operations:

- Formation of the site access roads/tracks and the well pad
- Drilling of the well bores
- Operation of the fracturing pumps and associated equipment
- Construction of connection to the gas grid
- Ancillary and supporting plant
- Site restoration as required when operations are complete.

The equipment required for the short-term construction and restoration processes is standard construction plant (excavators, loaders, dump trucks, concrete mixer trucks, vibratory or non-vibratory rollers etc). For the longer term drilling operations, the equipment required consists of the main drilling rig which has a hydraulically or electrically powered top drive [See image] which moves up and down the drilling rig as each section of the drill string is bored into the ground. Aside from the drive itself, noise comes from the generators or compressors used to power it together with mud pumps and shale shakers and their associated power requirements. The fracturing process uses high pressure fracturing pumps, again with their associated power requirements.

The pumps and other equipment are generally spread around the rig itself and can be individually acoustically treated by a combination of enclosure, lagging and anti-vibration mounts. Screening of larger areas can be provided, for critical directions, by strategic placing of ISO containers which make for an easily available, if somewhat rudimentary, modular screening system. In extreme circumstances screening of the entire drilling rig may be necessary.

Although noise predictions can be straightforward with knowledge about the planned equipment distribution on the site, sound power level data may be more difficult to come by for more specialised equipment and operations due to the current lack of horizontally bored fracking sites in the UK. It is of particular note that the horizontal drilling proposed for many intended sites, once the shale depth has been reached, can be significantly noisier than for vertical drilling.

Noise planning

Once up to date information has been obtained on the intended equipment, there is nothing unconventional about assessing the noise and noise sources. What can, however, be of particular concern is the fact that drilling / extraction sites are often located in rural areas where noise from other (background) sources are low. The drilling operation, in particular, needs to be continuous day and night for operational reasons and may extend for months at a time. Siting of the drilling rig and all surface works is therefore crucial to minimise the effects on the nearest noise sensitive properties which should be at distances sufficient to prevent noise disturbance to residents at night. The fracking operation itself is not usually carried out at night but is likely to be noisier.

Shale gas or oil extraction is considered under the minerals planning regime and planning applications for the surface works are consequently judged by the relevant minerals planning authority (MPA). Consent for the underground processes are determined by the government Department for Energy and Climate Change (DECC) and the Environment Agency and are not considered by the MPA. Planning for the surface works therefore needs to have specific regard to the Planning Practice Guidance on Minerals (PPG-M)[1] which has a specific section on planning for hydro-carbon extraction although no separate noise advice, beyond that contained in the main 'noise emissions' section, is provided.

P46

A top drive

P45

The noise emissions section of PPG-M defines separate limits on noise for day-time (0700-1900), evening (1900-2200) and night-time (2200-0700) periods. The day-time limit is set at 10 dB above the $L_{A90,1hr}$ background noise level although how this background level is set, bearing in mind typical variation in background noise level, is not defined. Some variation is allowed to avoid *imposing unreasonable burdens on the mineral operator* but the limit should be as close to this a possible and should not exceed 55 dB L_{Aeq}. The evening limit is similar but there is no variation allowed for a perceived 'unreasonable burden'. At night, the limit should be set *to reduce to a minimum any adverse impacts, without imposing unreasonable burdens on the mineral operator, subject to a maximum of 42 dB* L_{Aeq}. This last item can be particularly challenging in the case of shale gas drilling if inappropriate sites are selected for development, due to the requirement for the 24 hour drilling operation. The lack of a specified lower limiting value is not helpful although it could be expected to be informed by good sense and what would be required to provide a good standard of night-time noise environment in the specific circumstances under consideration. It is almost inevitable, however, that there will be at least some debate as to what constitutes an "unreasonable burden" in terms of additional mitigation beyond what would normally be considered practicable for the drilling operation.

It is notable that the Wytch Farm oil field in Dorset has been operating with wellheads within a designated Area of Outstanding Natural Beauty since 1973, with the inclusion of fracturing operations. It is clear that with appropriate noise reduction technology in place that noise targets can be met even in very sensitive areas providing the necessary budget is made available.

LOAELs and SOAELs

Hayes McKenzie recently took part in the public inquiry which was held in February and early March 2016 to consider applications for two shale gas exploration sites in Lancashire, acting on behalf of Lancashire County Council; the relevant minerals planning authority. As discussed in the previous section, the planning authority can only consider the application on its specific planning merits, such as appearance of the equipment in the landscape, noise, traffic, effects on cultural heritage etc. Hence the inquiry was also only able to cover these issues; what goes on under the ground is not open to debate as part of the planning process.

A good deal of the debate on noise came down to consideration of what constitutes the lowest observed adverse effect level, the significant observed adverse effect level, as referred to in the Noise Policy Statement for England[2], and indeed the unacceptable adverse effect level which was introduced as an additional criterion by Planning Practice Guidance on Noise (PPG-N)[3] and the relevance of these to the night-time limit. This was, in turn, informed by discussion of sleep disturbance effects and the relevance of the various WHO publications on this issue[4,5,6]. The crux of the sleep disturbance discussions is, as in many similar cases, not the level of disturbance to a sleeping person from noise from transportation, on which the majority of sleep effects research is based, but the effect on individuals who may be woken by other sources, and their ability to be able to return to sleep in the face of an audible noise which they may have significant objection to. The Inspector in this case, and the Secretary of State to whom she will make her report, will need to consider this carefully.

BS 5228 and BS 4142

Despite the clear remit for shale gas extraction to be judged according to PPG-M, a distinction has been made by some between the longevity of operation for a conventional (surface) minerals site and the length of time for which the noisier operations of drilling and fracturing will occur on a shale gas or oil extraction site. The reduced timescale of the occurrence of noisy activities gives rise to a further debate as to whether it is appropriate to use noise assessment guidance aimed at long-term mineral extraction for assessment of the drilling and fracturing process required for shale gas extraction or whether it would be more appropriate to use noise guidance such as BS5228[7] which is aimed at construction work which tends to be shorter term in duration.

Irrespective of the above, there is a certain amount of overlap between the two guidance documents with BS5228 referring to "open sites" which are defined in the standard as a *site where there is significant outdoor excavation, levelling or deposition of material.* Examples are provided of *quarries, mineral extraction sites, an opencast coal site or other site where an operator is involved in the outdoor winning or working of minerals* with an additional note that *waste disposal sites and long term construction projects can, in most cases, be treated as open sites*. This advice has the clear potential to introduce a certain amount of ambiguity into whether even a conventional (surface) minerals site should be assessed using the guidance in BS 5228 or that in PPG-M but since the potential significance criteria presented at Appendix E of BS 5228 are only presented as examples this may be irrelevant.

BS 4142[8], similarly, has the potential to provide additional useful guidance with shale gas drilling falling under its general umbrella of *industrial and commercial sound* but the situation is much more clear cut here with sources *falling within the scopes of other standards or guidance* specifically being scoped out of its remit.

Conclusions

There is clearly a requirement for detailed noise assessments to be carried out on sites identified for shale gas exploration and extraction. This is likely to increase following the recent planning consent by North Yorkshire County Council and due to the unequivocal support for the shale gas and oil industries by the current UK Government. Careful attention needs to be paid to the noise limits to be applied, particularly at night due to the necessity for continuous 24 hour drilling for long periods but also during the day when background noise levels can be low in rural areas and when the noisier fracking operations are carried out. Impact should be minimised either by development of wellhead sites which are at sufficient distance from nearby housing and other noise sensitive receptors, or by appropriate selection of plant and noise reduction technology to allow distances to decrease with consequent increase in costs.

Andy McKenzie *is a director and principal consultant at Hayes McKenzie and manages its Salisbury office. He graduated from the ISVR in 1981 and has worked in acoustics ever since; firstly in Sydney, Australia, then as a research assistant and research fellow at ISVR before setting up Hayes McKenzie with Malcolm Hayes in 1991. He is a Fellow of the Institute of Acoustics and Hayes McKenzie are members of the Association of Noise Consultants and sponsor members of the IOA. He likes playing the diatonic accordion and various items of percussion equipment as well as dabbling in small scale high quality sound re-enforcement.*

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Addiscombe to develop noise control guidelines for offshore installations

The Energy Institute has commissioned Addiscombe Environmental Consultants Limited (AECL) to develop a practical guidance document describing clear principles for the reduction or control of transmitted noise and vibration on offshore installations.

AECL Technical Director Graham Cowling said: "UK regulations which apply to offshore installations require the control of noise to be managed where it affects the workers at work and rest. Historically there are some good practical solutions available to control or reduce noise levels whether at the key design stage, during refit or retrofitting to existing structures; however there are very few publications on this subject and an information gap was perceived."

The guidelines, which are due to be published this autumn, will be aimed at management and safety personnel, to be used when designing new offshore installations or carrying out refurbishments on existing installations.

Graham Cowling

New Bolton base for Miller Goodall to serve expanding client list

Miller Goodall, formerly Miller Goodall Environmental Services, has relocated to new premises in Egerton, Bolton.

The move and name change are part of a development and rebranding programme, which will also include a new website to be launched later this year.

Since the acoustics and air quality consultancy was launched in 2004, business has grown every year and staff numbers now total 13. Working with architects, planners, developers and local authorities across the North West, the firm's client base includes Manchester Metropolitan University, Rossendale Borough Council and Barnfield Construction.

In recent months it has been involved with some major projects in the area, including noise assessments for road schemes on behalf of Jacobs UK, the conversion of premises and apartments into flats and a café in Bolton town centre, and the redevelopment of the Cutacre site from a mining slagheap to a country park and business estate.

Directors Jo Miller and Lesley Goodall said: "These are exciting times for us. Bolton remains the ideal location for the company, giving us access to clients across the North West. Our move to bigger offices means we have the space and resources to continue to grow, as well as offering a great venue for our clients to visit and meet with the team."

Members of the Miller Goodall team

Merger of two top US acoustics consultancies

Two leading independent US acoustics consultancies, Acoustics By Design and Daly-Standlee & Associates, have merged.

Acoustics By Design, based in Grand Rapids, Michigan and Daly-Standlee & Associates whose offices are in Portland, Oregon, provide a full range of acoustical, noise, vibration and audio, video, and lighting consulting services to architects, engineers, facilities directors, municipalities, industrial clients and building owners.

The two firms are now rebranding to reflect their merger and expanded services, while continuing operations and serving clients with the same staff from the same locations.

Both have long histories in the acoustical consulting industry with Acoustics By Design founded in 1962 and Daly-Standlee & Associates opening in 1988 as an outgrowth of Daly Engineering, founded in 1969.

Kerrie G Standlee, President of Daly-Standlee & Associates, said: "The merger with Acoustics By Design provides a nice complement of services for our clients."

Kerrie G Standlee (left), President of Daly-Standlee & Associates, and Kenric Van Wyk, President of Acoustics By Design, finalise the deal

New website launch by dBVibro Acoustics

dBVibroAcoustics, a consulting company with focus on vibro-acoustics simulation and noise control in automotive, aerospace, railway and marine industries, has launched a news website – **www.dBVibroAcoustics.com**

"We wanted to design a website that represents the culture of dBVibroAcoustics" said Denis Blanchet, owner and principal consultant. "Our core values are to be creative, innovative, deeply knowledgeable, dynamic, a solution finder, optimistic with a long-term vision, friendly, positive, empathic. We hope our website will convey these values and give an idea of what great things we can do."

A new-look IAC rises out of the ashes of administration

A new company has risen from the ashes of Industrial Acoustics Co (IAC Ltd) which went into administration shortly before last Christmas.

IAC Acoustic Company UK, which operates from the previous company's base in Winchester, has been opened by China-based Beijing Greentec Acoustics Engineering Company.

The parent company, part of the Greentec Group of Companies, is a £27.5 million turnover publicly quoted firm with 280 employees, a 30,000m^2 factory and an acoustical R&D facility in Beijing.

IAC's UK rebirth coincides with Greentec's acquisition of IAC China, IAC Nordic, IAC Germany and IAC Australia.

Geoff Crowhurst, Managing Director of IAC-Greentec Overseas Division, said: "I am really delighted that our new owners decided that the IAC story was not over.

"Under our previous private equity owners the IAC business took a serious wrong turn in adopting a big bang strategy designed to grow the business four-fold in a short period.

"The additional layers of management and the reorganisation, closure and moving of some factories created operational chaos and at the same time increased overheads to unsustainable levels which proved fatal.

"Fundamentally the market for acoustic products is challenging but has remained generally favourable with customers who had used IAC for decades still wanting to buy IAC products and services.

"The acquisition by Greentec means that the former Industrial Acoustics Company Group is now divided into three parts under separate ownership, with some of our former colleagues in IAC America finding a new home within the Sound Seal organisation, based in Massachusetts, USA and the GT Exhaust and Maxim Silex businesses having been acquired by a trade buyer in the USA."

The newly formed IAC Greentec Overseas Division has a combined turnover of £17 million and owns all the necessary IP, drawings, design rights and licences to manufacture and sells the complete range of acoustic products previously provided under the IAC brand.

Mr Crowhurst added: "Greentec ownership brings exciting new possibilities to the new IAC Greentec Group including product test and development in the Greentec acoustical test laboratory, access to innovative noise control solutions for large power plant facilities, low cost manufacture for international projects and technology interchange for the development of both the China and European markets."

IAC Acoustics Company UK Managing Director Mike Campbell said: "We are going to grow the UK business prudently, focusing on our core IAC acoustic products and aim to provide an outstanding service to our many loyal customers. As the business expands we hope to provide employment opportunities for as many former IAC employees as we can."

IAC UK and IAC Germany have recently worked together on an order for 10 audiology chambers in Ireland which are now in manufacture. IAC Denmark has received orders for anechoic chambers from Volvo and Nokia, while IAC Germany has been asked to supply audiology rooms for the University of Munich.

Happy birthday as Vanguardia celebrates its 10th anniversary

Audio engineering and design consultancy Vanguardia is celebrating its 10th anniversary.

Formed in May 2006, it today has possession of 90% of the UK live market and provides acoustics advice at more than 70 major events a year.

It also specialises in providing expert witnesses to licence hearings, appeals and planning inquiries for venues and has successfully leveraged new and enhanced noise conditions for venues such as Hyde Park, Milton Keynes Bowl, Wembley Stadium, the Etihad Stadium, Manchester, the Wildlife Festival, the Rose Bowl, Southampton, the Aviva Stadium, Dublin and Lancashire County Cricket Club.

High profile projects include:

- The design of Wembley Stadium's acoustics and the house PA system with a brief to improve concerts' sound quality and to reduce the impact of sound on neighbouring properties
- The design of the acoustic environment of the O2 arena, London, where the task was to provide excellent acoustics while maintaining the atmosphere and limiting external noise
- The provision at the 2012 Olympics of sound and acoustic design for the main stadium, the hand ball arena and the Velodrome and the site-wide sound system. It also provided noise management and prediction/modelling, which was successfully implemented for both the Olympics and Paralympics, and it was involved in commissioning the sound system for the main stadium.

More recently Vanguardia has designed the sound system and modelled the acoustics at Tottenham Hotspur's proposed new stadium. It has also helped the stadium acquire licensing for events and designed an audio visual installation as part of a "fan" experience room.

Other projects have included the Amex Stadium for Brighton and Hove Albion FC, the Royal Albert Hall, Wimbledon Centre Court and No1 Court and the Ministry of Sound night club in London.

Today it is supporting the design for stadia being built for the 2022 FIFA World Cup in Qatar, providing the acoustic and sound system design and quality assurance for the new combined VTB arena and stadium for Dynamo Moscow, and the acoustic design for other arenas such as Brussels Expo Palais 12, Bercy Arena and Arena Zagreb.

Vanguardia has also assessed noise from major car racing circuits such as Donington Park and Yas Marina in Abu Dhabi.

Celebration time: Vanguardia's 10th anniversary party at the Ministry of Sound, London

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Since 2004, MSA has provided a bespoke recruitment service to clients and candidates working in Acoustics, Noise and Vibration. We are the UK's niche recruiter within this sector, and as a result we have developed a comprehensive understanding of the industry. We pride ourselves on specialist market knowledge and an honest approach - we are focused on getting the job done and providing best advice to clients and candidates alike.

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Dutch industrial noise control specialist Merford comes to the UK

Dutch industrial noise control specialist Merford has launched a UK operation. Based in Bicester, Oxfordshire, the company is offering its full range of products which include:

- Enclosures for noises control
- Acoustic transformers
- Acoustic louvres.

Merford was founded in The Netherlands in 1956. It is based in Gorinchem, employs some 180 people and has a focus on noise control solutions for industry, business, government and the consumer.

Gary Dawson, UK Account Manager, said there was a growing need in the UK for "innovative and cost-effective" solutions to tackle noise pollution across all industries.

"Generally speaking, noise control hasn't developed at the same pace as other fields of engineering; most noise control products manufactured today are very similar to those made in the 1950s," he said.

Merford installed sound insulating enclosures for transformers and shunt reactors at West of Duddon Sands Wind Farm, Lancashire

Ecophon roadshow visit highlights the importance of acoustics in education

The importance of acoustics in education was highlighted during a case study visit to the new £66 million City of Glasgow College Riverside Campus organised by Ecophon as part of a BB93 Roadshow.

The guest speaker was Don Oeters of Arup Acoustics, who co-authored the updated *BB93: Acoustic Design of Schools*, published by DfES in February 2015.

He was joined by Luke Robertson, project acoustician from Arup's Glasgow office, who explained that the accurate predicted reverberation time of an extremely large number of varying teaching spaces was crucial in achieving a successful design.

"We used the following steps to achieve this: the results of multiple calculation methods were compared to improve certainty; absorption coefficient data from Arup's extensive library of both laboratory and in-situ commissioning measurements, along with Ecophon data, was drawn upon; optimal positioning of the acoustic baffles, rafts and wall panels was developed with the architect to ensure maximum absorption efficiency and early testing of mock-up rooms was organised to verify the predictions," he said. "The result was close correlation between predicted and measured results, a successful design and a happy contractor and client.

Although BB93 is not mandatory in Scotland, as it is in England and Wales, it was utilised within the brief. Don Oeters explained the new changes, some of which he wrote, and which were adopted for the design.

"Criteria for sound insulation, internal ambient noise and reverberation control are similar to BB93 (2003). BB93 (2015) addresses some compliance issues including cross-ventilation from classrooms to circulation and specification of sound absorbing finishes to sports halls and gyms," he said.

"There are now defined criteria for 'Alternative Performance Standards' and refurbished rooms. Other changes include the introduction of recommended noise limits from equipment such as projectors or fume cupboards, which are described in more detail in the Institute of Acoustics and the Association of Noise Consultants online publication *Acoustics of Schools: a design guide*. Also, new standards, in line with the Equalities Act, now take into account students with a more broadly defined range of language and communication difficulties."

Thousands of Ecophon baffles and rafts were utilised as part of the acoustic and thermal strategy.

Inside the new Riverside Campus building

Max Fordham finds its voice

Max Fordham has designed the acoustics for *This is a voice*, an exhibition at the Wellcome Collection, London tracing the material quality of the voice through a number of audio installations.

The exhibition brings together a wide range of works by contemporary artists and vocalists including Matthew Herbert, Imogen Stidworthy and Joan La Barbara, punctuated by paintings, manuscripts, medical illustrations and anthropological research. The exhibits explore how meaning and emotion are conveyed by the voice through rhythm, pitch, timbre and intonation, as well as examining non-verbal forms of communication, synthesised and imagined voices.

Conceived as an acoustic journey, the exhibition space needed be physically open to allow visitors to move freely. The main acoustic challenge was therefore combining the contrasting acoustic design aspirations of generating a coherent exhibition soundscape in an open space whilst incorporating measures to control excess sound-spill between the different exhibits.

Anthony Chilton, Head of Acoustics at Max Fordham, explained how these potentially opposing requirements were met. "Our acoustic input focused on the use of materials, screening and sound isolating tunnels to reduce unintended noise leakage between the different exhibits. We advised on layouts, finishes and constructions which would create the appropriate acoustic environment for each artist's work whilst maintaining the overarching visual and sonic concept. We also contributed to the audio-visual design by using directional or localised audio systems where appropriate," he said

This is a voice runs at the Wellcome Collection, 183 Euston Road, London NW1 2BE until 31July. It is open Tuesday to Sunday. Entry is free. For more details go to **http://wellcomecollection.org/visit**

Part of the exhibition

Rocky road: Rick's 1,200 mile charity trip across Europe in a car fit for scrap

Freelance acoustic consultant Rick Downham will celebrate his 60th birthday this year... by taking part in a four-day, 1,200 mile road trip across Europe in an "old banger" costing less than £567.

He will participate in the Two Ball Banger Rally which starts in northern France in August before taking in parts of Belgium, Luxembourg, Germany, Austria, Switzerland and Italy before ending in Nice. On the way he will tackle the notorious Stelvio pass, dubbed one of the most dangerous roads in the world, and go round the Grand Prix circuit in Monaco.

Rick will travel with his brother-in-law, Alf Wimshurst, in a 1996 Toyota Celica that he has was going to scrap for parts. They have called their team Two Shady Greys, reflecting the fact they both have gone grey.

They are using the rally to raise money for research into bowel cancer, an issue that has been close to Rick's heart after the illness claimed the life of his younger brother, Arthur, three years ago.

They are selling advertising space on the car to businesses in return for a donation of £50 to the charity, and all sponsors will be placed in a draw. The winner will have their company name emblazoned across the bonnet in prime advertising spot. For more details email Rick on **rickdownham@yahoo.co.uk** . Alternatively individual donations can be made at **www.justgiving.com/2shadygreys**

Shades of grey: Rick Downham (left) and Alf Wimhurst

Vanguardia secures sole UK distribution rights to MeTrao

Vanguardia has secured sole UK distribution rights to MeTrao, a tool which it says is set to transform audio management at live events.

MeTrao, devised by Event Acoustics in The Netherlands, allows event organisers and sound engineers to meet noise control regulations while maximising the quality of audio output at the highest possible levels. Vanguardia says MeTrao is the only product on the market that not only measures all sound-related data, but also provides solutions to any arising issues.

Roly Oliver

The MeTrao audio management system

It can pinpoint which sound system, from a multi stage event, is causing the dominant noise off-site so that potential breaches of regulations can be detected in advance and avoided.

Not only does MeTrao detect the stage causing the highest levels off site, but it also establishes the frequency of the sound enabling minor adjustments to be made to the overall sound system. This permits the maximum level to be achieved at all other stages whilst meeting the critical off-site limits.

Suitable for use in halls, theatres, clubs and outdoor events, MeTrao has a number of user-friendly features:

- It uses forecast algorithms to predict potential noise level issues.
- It can be used either as a stand-alone unit or as part of a network.
- Its central digital display can provide data from several halls or stages at once.
- Data can be stored in the unit or on the internet.
- With a MeTrao data subscription, data can be read on the web browsers of a PC, tablet or mobile phone.

In order to promote the tool, Roly Oliver has joined Vanguardia in the new position as Head of Live Business from Eighth Day Sound, where he was Head of Global Sales,

In a career that has spanned a quarter of a century, he has provided sound engineering expertise to acts and artists including Manic Street Preachers, Daft Punk, Fun Lovin' Criminals, Pet Shop Boys, Red Hot Chili Peppers and Snow Patrol.

Enhanced software for Brüel & Kjær's Photon signal analyser – RT Pro 7.3

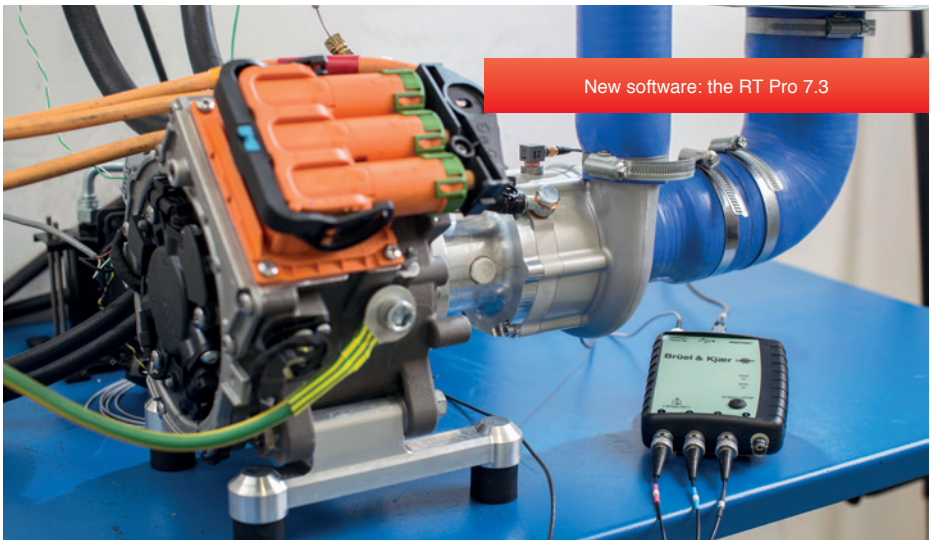
Brüel & Kjær has launched enhanced software for its Photon signal analyser – RT Pro 7.3 – to speed up noise and vibration data analysis for industrial machinery and vehicle manufacturers

The RT Pro 7.3 release provides enhanced Fast Fourier Transformation (FFT), signal analysis, 1/nth octave/acoustic analysis, modal data acquisition and swept sine measurements, making it ideal for testing acoustic and vibration in applications such as rotating machinery and automated production lines.

Powered via a USB 2.0 port and weighing less than 227g (8oz), the PHOTON+ unit operates on a notebook PC battery.

Photon+ has been designed specifically to turn any PC into an instrument-quality portable analyser that provides instant multi-channel noise and vibration results – and onsite data verification. It has two or four inputs, so users can switch the unit from single to multi-channel system.

It also has an extremely low measurement noise floor, making it ideal for performing low level acoustic and vibration tests in applications, such as aircraft cabins and vehicles.



New software: the RT Pro 7.3

For more information go to **www.bksv.com**

Audio software provides 3D sound at the Zurich Opera House

Zurich Opera House is using audio software, SpatialSound Wave from the Fraunhofer Institute for Digital Media Technology (IDMT), which enables sounds to be positioned freely in the hall so that visual and acoustic events coincide realistically. Sound technicians adjust sound effects live and enlarge spaces acoustically.

Modern opera productions depend on the singing technique of the main characters, the stage design and the musicians in the orchestra. At the same time, the directors achieve additional soundscapes with sound effects from the speaker. "Especially in modern productions, directors require us to produce various sound effects, create different spaces and connect with each other over the sound system," said Oleg Surgutschow, Sound Mixer at the Zurich Opera.

At the opera house loudspeakers are mounted on five levels. "A large and complex infrastructure that has grown historically. With classic speaker technology limits are quickly reached when wanting to achieve spacial audio effects," said René Rodigast, Head of Professional Audio at Fraunhofer IDMT. The advantage for the sound mixer is that he can edit sound effects live and create spatial, three-dimensional soundscapes – without having to change the sound system or the space for it.

The SpatialSound Wave software distributes the sounds according to the process of wave field synthesis. As a result, various speakers form a new acoustic waveform. None of the speakers plays the same signal. Each speaker complements the neighbouring one and contributes its share to the overall sound. "We only have to tell the technology in advance where each speaker is," Mr Rodigast explained. "With microphones, we measure the sound of each individual loudspeaker".

SpatialSound Wave makes the acoustic signals of the speakers into audio objects. A sound thereby receives a three-dimensional XYZ-axis and an exact position for a certain time. Sounds in a room can thereby be positioned wherever they are wanted. The calculated signal flows back into the speaker system of the opera house.

"It's no longer tied to the position of the speaker," said Mr Rodigast. It means the sound mixer no longer has to worry about his speakers; he only has to position the sounds. The volume and the natural delay of the sounds of each speaker, which are responsible for a particular sound, are automatically calculated by means of mathematical formulas. Since multiple speakers act together, they can adjust the position of the sound source. As a result, each audio signal has a fixed position in space. "The result is a stable acoustic event which is perceived in the same way from every seat in the opera house," Mr Rodigast explained.


With SpatialSound Wave, sounds are positioned in the space via the tablet. In the Zurich Opera House, the sound engineers use the software to record sound effects and spatial acoustics live.

XL2 Data Explorer software now calculates Rating Level Lr

Data Explorer Software offers wide ranging analysis and reporting on measurement data from the XL2 Sound Level Meter. The latest Data Explorer release, version 1.50, further extends the data post-processing capabilities. Tonal and impulsive sounds can now be marked automatically and penalties applied in accordance with the ISO 1996 standard. Data Explorer also calculates the Rating Level Lr for the assessment of compliance with noise limits.

The XL2 Sound Level Meter provides all the necessary broadband levels, third-octave spectra and uninterrupted audio recording for the complete measurement period. The measurement location is normally chosen as the position where the limits prescribed by the standards are most likely to be exceeded. The data is then imported into the Data Explorer Software for calculation of the average noise levels over reference time intervals.

Prominent tones or impulses cause increased annoyance. In a noise assessment, it is therefore necessary that these specific characteristics be rated accordingly. In this regard a penalty is added to the measured average sound pressure level LAeq. Data Explorer automatically identifies and marks the time periods containing the tonal and impulsive sounds. Markers label the relevant events and these may then be verified with subjective assessment by playing the recorded audio file through the PC speakers or headphones. For example, penalties applied to sounds that are actually not that annoying can be reduced or removed, while additional penalties can be added to sounds that are highly impulsive or tonal allowing the operator to assess the all-important context.

Additionally, level markers can be set for penalties to be applied to short duration high level noise events. At the same time, the contribution of extraneous noise that is not caused by the sound source under investigation can be eliminated from the calculations. To determine periods with low-frequency noise, the software automatically applies markers, for example, on the level difference between LCeq and LAeq.

After completing the noise exposure analysis, Data Explorer determines the Rating Level Lr. This corresponds to the sum of the average noise level, including penalties for tonal, impulse and special sounds. The rating level calculation is performed for all specified time intervals in accordance with ISO 1996 or using custom intervals; e.g. with 1 hour periods during the day from 07:00 to 23:00 and a shorter period of 15 min at night from 23:00 to 07:00. Separate Lr criteria for the weekend period completes the comprehensive analysis of the measured data.

The XL2 sound level meter

Armstrong's ceiling tiles aim to reach new acoustic heights

Armstrong has launched a premium ceiling tile which aims to take acoustic performance to new heights.

The Perla OP dB 40mm mineral tile combines the high sound absorption of Armstrong's OP range with the high sound attenuation of its dB range for ultimate acoustic flexibility.

Its launch is designed to help specifiers, particularly in the education sector, to reduce the amount of sound transferred from traffic routes to learning areas and also to reduce the noise of rain on lightweight roof constructions, an issue also encountered in the office sector. In this area, using the Perla OP dB tile shows a 20dB improvement compared to roof-only construction

It is therefore recommended for use in open-plan and closed-plan spaces where acoustics cannot be compromised, and in particular for spaces such as music rooms, corridors and classrooms, and individual offices and meeting rooms next to open spaces.

Performing to sound absorption Class A (a_w = 0.90), sound attenuation Dnfw 40 dB and sound reduction (single-pass) Rw 20 dB, the Perla OP dB tile can be mixed with Perla, Perla OP 0.95, Perla OP 1.00 and Perla dB tiles to solve specific acoustic requirements while maintaining the same visual.

Comprising 36% recycled content and fully recyclable, it is available as Perla OP dB board in 600mm x 600mm and 1200mm x 600mm, Tegular 600mm x 600mm and MicroLook 90 600mm x 600mm.

New heights: Armstrong's Perla OP dB ceiling tiles

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Multi-colour panel wall with decorative fins and LED lighting, London EC2

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Roof top acoustic enclosure, Brighton

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Candidates should ideally possess three or more years' experience within Acoustic Consulting, have a relevant degree and be a member of the Institute of Acoustics. Excellent communication skills are required, as is the ability to write clear and concise reports and prepare practical and innovative engineering proposals. Industry knowledge including the latest Codes of Practice and British Standards is important, and experience of using acoustic modelling software will enhance your appeal to us, as will any experience of finite element and CFD analysis. The ability to design using the standard suite of Autodesk software is also important, as is familiarity with 3D modelling software – if necessary we will provide training to improve your CAD capabilities. The nature of our work does necessitate travel throughout the UK, so a full driving licence is essential.

Acoustic panel roof top plant room with louvres and architectural tubes, Canary Wharf

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Committee meetings 2016

DAY	DATE	TIME	MEETING
Thursday	14 July	11.30	Meetings
Monday	1 August	10.30	Executive
Tuesday	9 August	10.30	Diploma Moderators Meeting
Thursday	11 August	10.30	Membership
Tuesday	**13 September**	**10.30**	**Council**
Monday	26 September	11.00	Research Co-ordination
Wednesday	12 October (TBC)	10.30	Engineering Division
Thursday	13 October	11.30	Meetings
Thursday	20 October	11.00	Publications
Thursday	27 October	10.30	Membership
Tuesday	1 November	10.30	Diploma Tutors and Examiners
Tuesday	1 November	1.30	Education
Wednesday	2 November	10.30	CCENM Examiners
Wednesday	2 November	1.30	CCENM Committee
Wednesday	2 November	10.30	CCBAM Examiners
Thursday	3 November	10.30	CCWPNA Examiners
Thursday	3 November	1.30	CCWPNA Committee
Tuesday	8 November	10.30	ASBA Examiners (Edinburgh)
Tuesday	8 November	1.30	ASBA Committee (Edinburgh)
Tuesday	15 November	10.30	Executive
Tuesday	**6 December**	**10.30**	**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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