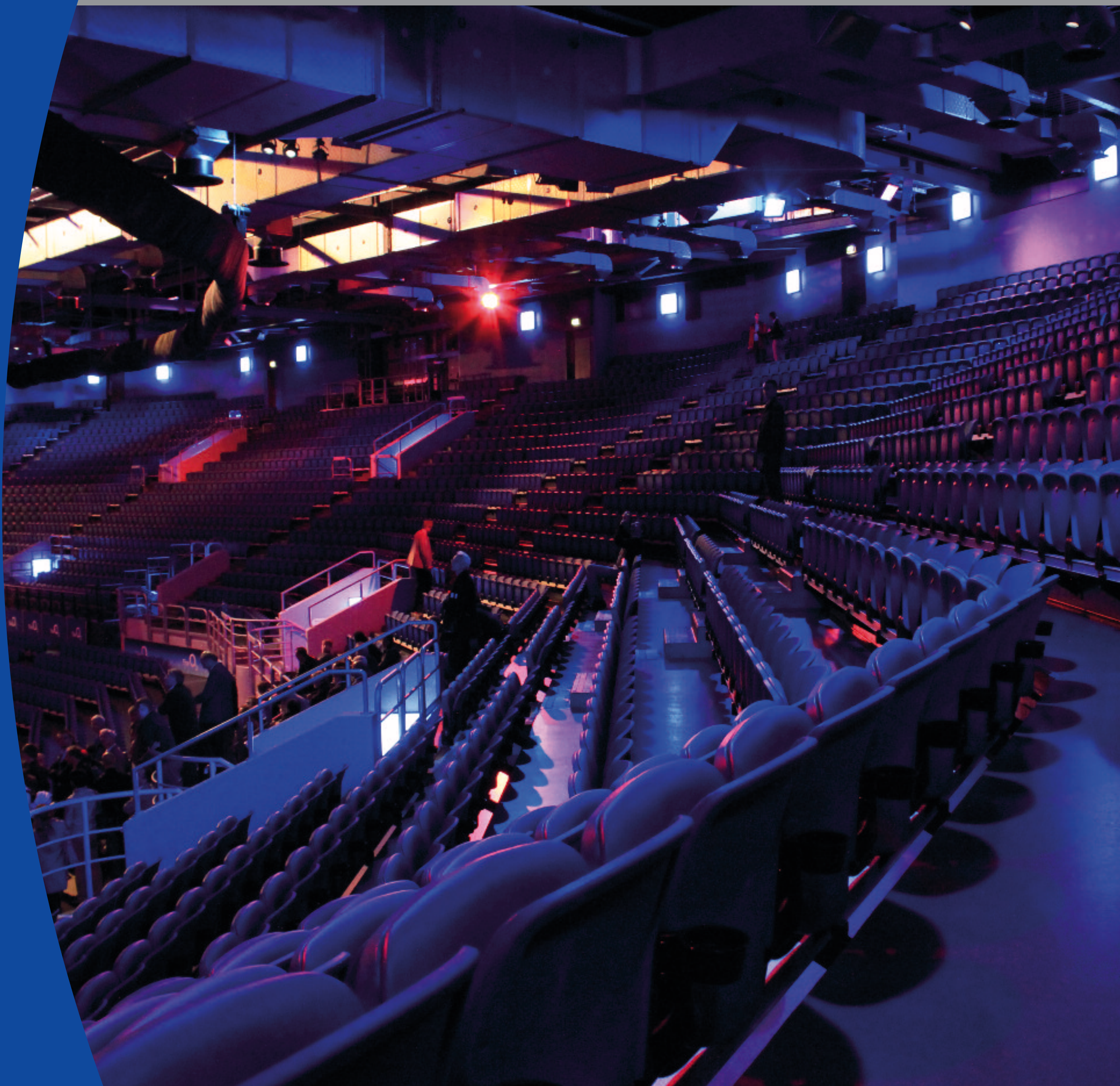
Vol 36 No 4 JULY/AUGUST 2011

ACOUSTICS BULLETIN



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Institute of **Acoustics**

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Front cover photograph: The very successful Auditorium Acoustics conference series continued in May 2011 in the Dublin Convention Centre in Ireland, hot on the heels of the State Visit by HM the Queen. There were 32 presented papers and another 15 in poster session. Tours were organised of the venue itself, the O2 Arena, the Grand Canal Theatre and (inevitably) the Guinness Storehouse. Photos from the brewery tour were not forthcoming, but the cover photo shows a dramatic interior view of the O2 Arena – the one in Dublin, of course!

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Designed and printed by:
Point One (UK) Ltd., Stonehills House, Stonehills, Welwyn Garden City, Herts, AL8 6NH
e-mail: talk2us@point-one.co.uk
web site: www.point-one.co.uk

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

Institute of Acoustics

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.

Dear Members

I am writing this letter sat in a cafe outside the Guggenheim Museum in Bilbao - who said being President was a hard job? I am being interviewed for a Channel 4 documentary about why architects need to think beyond the visual. This interview arose because the Institute was contacted to find an expert in architectural acoustics. We spent ages recording a rather crass TV experiment where the presenter was blindfolded and wandered around the large atrium taking ear defenders on and off and pretending to have an acoustical epiphany. Before that, I spent the morning taking pictures and recording sound in the galleries for my own interest: normally this would not be allowed, but I had a press pass! There are huge works by Richard Serra in a ground floor gallery, vast narrow spirals of rusting iron sheets rising high above your head, often leading you down a tortuous path into small elliptical or round enclosures. The acoustics in some of the sculptures are great, with echoes sounding like rifle shots, strange colourations of the voice, and whispering gallery effects around some of the curves.

Being a typical room acoustician, I started by clapping my hands to hear the sound effects. But this seemed too intrusive in the reverberant gallery and so I took to using a palatal click. This is where you use your tongue to make a clicking or clucking sound, like a child impersonating a horse. I was inspired to do this because of a paper at the Institute's excellent Auditorium Acoustics conference last week in Dublin. The paper was about blind people echo-locating by sensing the colouration of reflected palatal clicks. You can read more about the conference elsewhere in this issue of the Bulletin: a conference memorable for the excellent papers and the drinks reception involving pints of Guinness. But I digress: apparently palatal clicks are popular because they are less likely to be overhead than a handclap, and hence why I spent the morning clucking about in sculptures.

Another notable media success for the Institute was getting an article into the Independent on Sunday. This was at the start of Noise Action Week and it highlighted the Institute's work to try and retain some form of regulation for school acoustics. A few weeks before that I was asked to summarise the entirety of acoustics in 150 words for the Times 'Eureka' magazine. Apologies to any disciplines or organisations I didn't mention, but the word allocation was very miserly. I thought you would be interested to see what I wrote:

***A brief description of the field** - Acoustic engineering and science is about the production, transmission, manipulation and perception of sound. It includes the physical properties of sound waves, and the psychological and physiological response of humans and animals. Noise can damage the environment, cause deafness, harm pupil attainment and create annoyance. Good acoustic design can enrich music in concert halls, reduce noise in our homes, help make announcements in railway stations intelligible and create stunning sound effects from games consoles.*

***What it's used for, how and where it's studied** - Mobile phones, trains, brain scanners, washing machines, hearing aids, loudspeakers - these can all be engineered to sound better. The largest academic departments are those at universities of Salford and Southampton.*

***And where would we be without it?** - mp3 coding has revolutionised music listening; cochlear implants have restored hearing for some, and cars, lorries and planes are much quieter than they used to be.*

I am also in the middle of making a documentary for BBC Radio 4 called Green Ears, which is all about designing a garden to sound good and goes out at 11.00h on 27 June. I was lucky enough to get a trip to the Chelsea Flower Show, including taking a trip in Diarmuid Gavin's sky garden where you are hoisted 25m up into the air by a giant crane. Unfortunately, the main acoustical effect as you climb above Chelsea is to make the noise from the neighbouring road louder as you emerge above the boundary wall. I must remember to send Diarmuid a copy of Environmental Noise Barriers, a book co-authored by our esteemed former president Colin English.

Trevor Cox

PRESIDENT

Conference report

Mike Barron and Raf Orlowski. **Eighth International Conference on Auditorium Acoustics, Dublin, 20-22 May 2011**

Sandwiched between a visit to the Irish capital by the Queen and Barack Obama, just over 100 delegates attended the latest Auditorium Acoustics conference. But why Dublin? The seventh conference had been held in Oslo and was closely linked to their new opera house. This year there were no obvious major new auditoria to link with the meeting, though London was a good contender with some smaller music spaces. But three auditorium spaces have been recently completed in former dock areas in eastern Dublin, albeit each mainly used for amplified events. Dublin's fair city, 'where the girls are so pretty' (Molly Malone) proved an excellent choice, helped by the genial and relaxed style of the Irish. The meeting was certainly international, with only about a third of the delegates being from Britain.

The conference was held in the new Dublin Convention Centre, where the Queen had in fact been only the evening before. Fortunately acousticians require a rather degree of security presence. But we started on the Friday morning with a hiccup, when Daniel Commins (commins acoustics workshop) found he had not brought his Powerpoint presentation! Courageously he described to us without pictures the post-earthquake cardboard concert hall in L'Aquila, Italy; the cardboard came from the 8m long rolls at the centre of newsprint. This was followed by Jeremy Newton of Arup Acoustics talking about the new opera house for Wexford in south-east Ireland. Albert Xu, Xu-Acoustique, has been testing a 1:10 scale acoustical model of a vineyard concert hall with 2000 seats in Taiwan, battling to keep the air humidity down for accurate measurements. Finally, before a coffee break, Ingo Witew from RWTH Aachen, Germany, discussed measurement accuracy for room acoustics measurements, the results of careful measurement and statistical analysis.

We continued with an account by Francis Li of Salford University of an on-going project, now fifteen years old, into making measurements in occupied auditoria. José Nepumuceno of Acustica & Sonic, Brazil then described changes and results in the Teatro Municipal, a one-hundred-year-old opera house in Rio de Janeiro. Tapio Lokki and colleagues from Aalto University, Finland, are engaged in an ambitious programme of simulating an orchestra through loudspeakers on stage: they have been applying techniques for sensory evaluation developed in the food and wine industries to the listening situation in auditoria. A contribution from a home team completed the morning sessions: Chris Dilworth of AWN Consulting told us about work with the Irish Chamber Orchestra to find them suitable venues for performance and rehearsal.

No auditorium acoustics conference is complete without the enthusiastic participation of David Griesinger from New England (David Griesinger Acoustics). He talked about the requirements for audience engagement, a new buzz-word in the field perhaps. We then moved to jazz clubs with Anastasia Savopoulou at UCL, London, reporting on subjective studies in jazz venues in London and Athens. Combs appear to be mostly outside Tor Halmrast's personal requirements (Statsbygg, Oslo) but he has had a long term interest in comb filtering as perceived on orchestra stages: as an illustration he considered the ways blind people use this phenomenon. Evan Green, newly at Sound Space Design, reported on interesting results from measurements in a generic concert hall scale model of the effects of different placement of scattering material.

We then held a session introducing the posters, with presenters being allowed two minutes each. This was followed by an extended tea break to allow for viewing the 15 or so posters. For the final session of the day, the first two presentations were concerned with scattering and diffusion. Jin Jeon from Hanyang University, Korea, has been conducting subjective experiments based on recordings in real auditoria where significant surfaces could be changed from reflective to absorptive. Claus Lynge Christensen of Odeon, Denmark, proposed the Dynamic Diffusion Curve as a possible measure for diffusion. It is based on the difference between the integrated impulse response measured with an omni-microphone and an intensity probe. The last presentation of the day was concerned with the design of the Convention Centre we were in, which opened in September 2010. Richard Muir of Sandy Brown Associates took us through the various sound insulation and room acoustics issues that had had to be tackled.

Saturday started with a visit to the Grand Canal Theatre. Jeremy Newton of Arup Acoustics, the acoustical consultants, assembled delegates in the stalls of the spectacular new auditorium and gave an account of how the design was developed to combine the requirements of a lyric theatre with an opera house. Delegates were then guided around other parts of the building to gain a full impression of the facilities.

Peter Exton of Marshall Day (Melbourne office) gave the first paper of the technical session on the acoustical design of the Guangzhou Opera House, China, by architect Zaha Hadid. The session chairman, Jerry Hyde, announced before the paper was presented that the Guangzhou project had won an international award for architectural excellence from the RIBA. The citation stated that 'for all the auditorium's asymmetry, the acoustics are perfect'. The next paper was by Higini Arau from Arau Acustica, Spain, who described the acoustical design of an orchestral canopy to improve the stage sound at the Tonhalle St Gallen in Switzerland. The 'canopy' is a series of plates 0.9m deep arranged in a grid pattern: Higini considered it a miracle that this intervention had the effect of increasing the reverberation time.

The president of the Institute of Acoustics, Prof Trevor Cox, then took the stage and, after reading a citation, presented the Rayleigh Medal to John S Bradley from the National Research Council, Canada. John then gave his Rayleigh Medal Lecture which was entitled *Using room acoustics to understand a large room and its complex sound reinforcement system*. The room in question was none other than the Canadian Parliament and John gave an insightful account of the acoustical characteristics of the room and how they might be improved during the forthcoming refurbishment.

Following lunch, Mike Barron of Fleming & Barron discussed non-linear decays in simple spaces and how they were affected by diffusion. He indicated how non-linear decays, which increase the later reverberation time, might usefully be exploited in the acoustic design of multipurpose auditoria and school halls.

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Trevor Cox introduces John Bradley

Trevor Cox presents John Bradley with the Rayleigh Medal 2011

John Bradley gives the Rayleigh Medal lecture on the use of room acoustics to understand a large room and its complex sound reinforcement system.

Mike Barron opens the conference

Georgia Zepidou receiving the Young Person's Award for Innovation in Acoustical Engineering from Geoff Crowhurst (IAC).

Alexandra Sotiropoulou discusses the acoustic requirements for jazz

IOA Chief executive Kevin Macan-Lind with happy delegates at the dinner at Guinness

Anders Gade hamming it up while taking pictures of the Grand Canal Theatre

Night-time scene of venue and bridge

Grand Canal Theatre from the stage as Jeremy Newton talks about the design

Eighth International Conference on Auditorium Acoustics - *continued from page 6*

The next speaker, Jukka Pätynen of the Aalto University in Finland, was first congratulated on winning the Arup student award and then presented his paper on the development of frequency response with time in concert halls. He emphasised the gravity of the seat-dip effect and questioned the 'clarity' parameter following a demonstration showing that differences in concert hall sound can be clearly heard in the first 100ms after the direct sound. Paul Luizard of LIMSI-CNRS in France continued the discussions about multi-slope impulse responses and presented an automated analysis method called 'marching-line'.

Isabelle Schmich of CSTB in France gave a detailed account of the installation of the CARMEN electro-acoustic system in the Aylesbury Theatre. She confirmed that the installation was very successful but pointed out that tuning it had been troublesome, with orchestral musicians having to play in hard hats and high visibility vests! Gunter Engel from Mueller-BBM in Germany was unable to attend and his paper was presented by colleague Eckard Mommertz. Eckard continued the discussion of elecro-acoustic enhancement systems and gave three examples of installations, one of which was outdoors. He predicted that these systems would gain more currency in the coming years. Andrzej Klosak from the Krakow University of Technology in Poland described the acoustic design of the Penderecki Hall, a 500-seat shoebox-shaped concert hall. He explored several types of diffusing surfaces during the design with the help of model scale and full-scale tests which helped him to optimise the final design. Jean-Dominique Polack of the Université Pierre et Marie Curie in Paris presented an intriguing paper considering the relationship between performances at Wagner's opera house in Bayreuth and cinema performances. He postulated that audiences at the Bayreuth Opera House were not listeners but spectators - just as they were in cinemas.

The conference dinner was held in the Guinness Storehouse, the top tourist venue in Dublin. After walking through the exhibition explaining how the porter was and is now brewed, we arrived at the top in the Gravity Bar, with a fantastic view of Dublin to accompany the home product: white wine was available as an alternative. Dinner several floors lower was much enjoyed by all.

On Sunday morning we battled eastwards against gusting winds along the north bank of the River Liffey to reach the new O2 Arena. Bigger than its London counterpart in The Dome, it claims to be the largest enclosed auditorium in Europe, with a capacity of 9500 seated and 14,500 with standing audience in the stalls. It follows a wide fan shape in plan. The acousticians Sandy Brown Associates (presented by Daryl Prasad) did well to contain the sound levels with a lightweight roof. Some of us, no doubt, wished for their youth to experience the venue in real action!

The final session of papers began with John O'Keefe of Aercoustics, Toronto, talking about a 16-year project, the Queen Elizabeth Theatre, Vancouver, that has finally been completed. Its prime uses are for amplified musicals and pop music as well as opera. For the last-mentioned use, lateral reflectors have been added to assist. Serafina di Rosario at Buro Happold discussed the use of auralisation for a 'public' space The Forum at the University of Exeter: sounds included rain noise from an ETFE roof, a café and performing musicians. Non-linear auralisation from Lamberto Tronchin of Bologna University had some of the audience wondering whether sound transmission had suddenly become non-linear. In fact the non-linearity was involved in synthesising sound of musical instruments: his aural examples were impressive. Finally Eckard Mommertz of Müller-BBM, Munich, described renovation of the New York State Theater at the Lincoln Center, which is home to both the New York City Ballet and the NYC Opera. With 2700 seats it is smaller than the Met opposite, but still large. The major changes were to remove the electronic enhancement system, to enlarge the pit and install a moveable reflector above and in front of the proscenium.

In conclusion, Raf Orlowski thanked authors and the Institute staff for a conference which he rated at least equal to, if not slightly ahead of, the previous one in Oslo!

The Institute of Acoustics Rayleigh Medal

Citation for John S Bradley

John Bradley obtained his Bachelor and Master of Science degrees in physics

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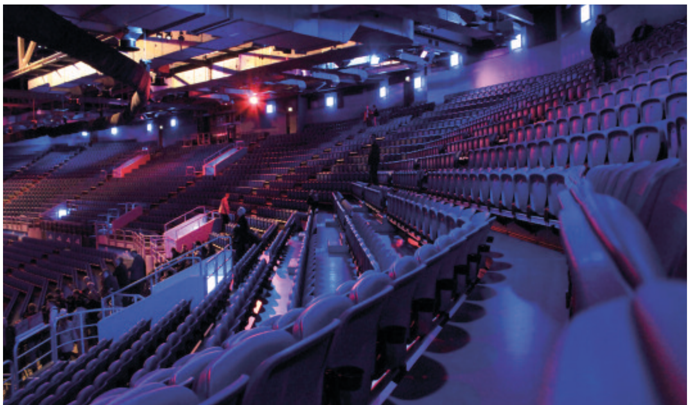
Jukka Patynen discusses the frequency response of halls



Dimly lit O2 during tour

Eckhard Mommertz bravely stands in for Gunter Engel and discusses electronic enhancement

Damon Lavelle discussing the O2 acoustics from the vast stage

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Norsonic

Eighth International Conference on Auditorium Acoustics - *continued from page 8*

and acoustics at the University of Western Ontario in Canada. He then came to Imperial College, London to carry out postgraduate work on electro-acoustic enhancement systems in rooms for which he was awarded a PhD in 1972.

John returned to Canada to take up an academic post at the University of Western Ontario where he focused mainly on the prediction of road traffic noise. In 1980 he moved to the National Research Council of Canada and in the following 30 years carried out an outstanding body of work in architectural acoustics.

In the field of auditorium acoustics he has produced seminal papers in key areas such as the perception of envelopment in concert halls and the development of detailed measurement procedures. His contributions to the understanding of the acoustics of classrooms are highly influential and have helped to formulate the acoustic design of schools for the 21st Century.

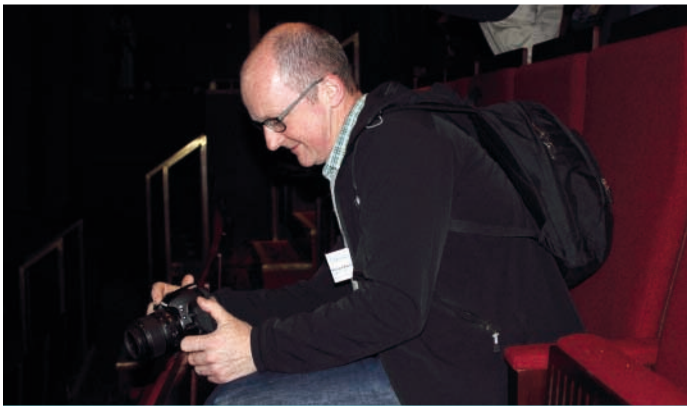
More recently, John's studies have concerned speech intelligibility in open plan offices and the related issues of speech privacy and speech security. These have led to fundamental recommendations concerning the architectural, acoustical and interior design of these spaces.

John is a Fellow of the Acoustical Society of America, and a member of the Editorial Board of the Journal of the Audio Engineering Society. He is a past President of the Canadian Acoustical Association and has served on several working groups including those of ANSI, ISO and WHO.

What is particularly notable about John Bradley's contribution to acoustics is that he has taken up difficult topics and has researched them extremely methodically. He has produced new understanding of them which is disseminated widely in the journals and at conferences in a very accessible and humble way.

For his outstanding contributions to architectural acoustics over a sustained period of time, the Institute of Acoustics is proud to present its highest accolade, the Raleigh Medal, to John S Bradley.

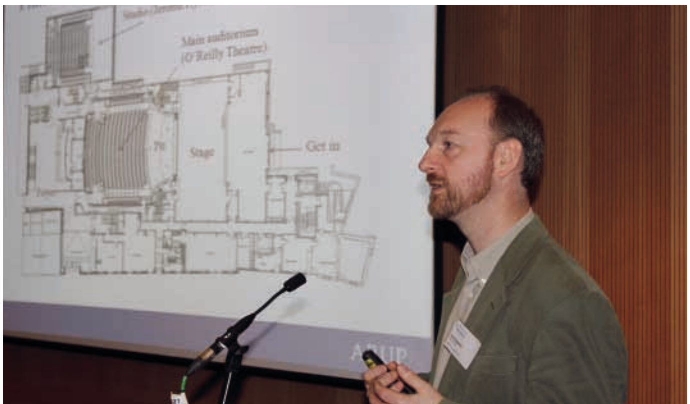
Lively discussions at the poster session



Grand Canal Theatre: a photo opportunity for Richard Ballinger!

Serafino di Rosario describes how auralisation helped the design of The Forum at the University of Exeter

Isabelle Schmich discusses the electroacoustic enhancement of Aylesbury Theatre



Jeremy Newton presents the design of the Wexford Opera House

Daryl Prasad discussing the acoustics of the O2

Meeting report: South-west branch

Mike Wright. Lance Foy, organ builder - an intuitive acoustician?

Could this have been the first ever meeting of the South West branch of the Institute of Acoustics in Cornwall? After months of planning (and some debate over the number of people who would make the long drive to Truro on a Saturday morning) seven IOA members attended on 7 May 2011. They were accompanied by members' friends and partners, plus a few local organists, who enjoyed a most informative and entertaining day.

Lance Foy is well known in the West Country as one of the finest organ builders around. Rumours abound in Dorset, Devon and Cornwall that if Lance Foy had not worked on a particular instrument, it was not worth working on! That may be something of an overstatement but his name appears on the brass plates of organs in Camborne, Falmouth, Plymouth, Great Torrington and Barnstaple to name but a few. From a listing of the National Pipe Organ Register there is evidence that he has been responsible for the sound of at least 150 different organs he has built, restored and modified. The visit featured some of the finest instruments of the south-west right in the centre of Truro.

The morning session was held at Truro Methodist Church in Union Place. Lance Foy firstly gave a brief history of the organ from its humble origins, starting with the 'hydraulis' in Greece in the 3rd Century. On these instruments, the wind supply was created by water pressure. Bellows were later introduced as a means to provide wind for the pipes and by the 17th Century, the classical organ as we know it now had been developed. However, he also pointed out the fact that there are now very few surviving early English organs made before the Reformation of the 16th Century as most were destroyed at that time.

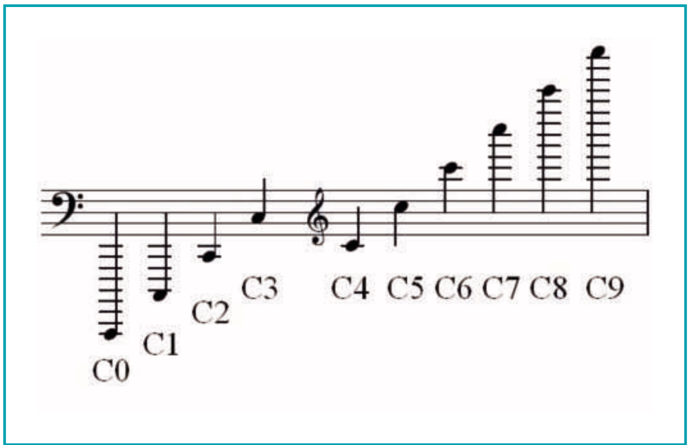
Lance Foy went on to explain how a pipe organ works by describing flue pipe as working in the same manner as a recorder or a whistle. Air under pressure (referred to as wind) is driven down a flue and against a sharp lip called a *labium*, causing the column of air in the pipe to resonate at a frequency determined by the pipe length. A reed pipe is one that is sounded by a vibrating brass strip - a reed - where the wind is directed towards the reed, which then vibrates at a specific pitch. Nowadays, the air is supplied at various pressures to ensure that as few or as many of these pipes as the player wishes can function properly at the same time.

He then moved on to the mechanics that take the actions of the organist using the keyboards ('manuals') and pedals to the place where the sound is produced at each pipe. He described the pros and cons of the various methods of achieving this objective. These range from basic mechanical systems of connecting levers and rods (known as a 'tracker action') through to the later pneumatic systems that were needed to cater for the larger instruments that became common in the 19th Century. He then moved on to describe the more modern electrical systems. However, he was keen to explain that whilst less direct systems may make for a rather less strenuous effort on behalf of the organist, there can be significant time delays after pressing a key or pedal before anything starts to happen! Such delays are in addition to the 'speaking time' of a pipe which tends to be greatest at lower frequencies. The organ at Truro Methodist Church was originally built in 1895 and had a pneumatic action. This was later replaced in the 1950s with electrical relays that were not particularly satisfactory. Lance Foy completely rebuilt the organ in 1983 with new actions and much enhancement of the tonal scheme.

The organist and choirmaster of Truro Methodist Church, Phil Davey, assisted Lance Foy by illustrating the various 'ranks' of pipes which are controlled by the 'stops', as he selected them singularly and in combination, to demonstrate the wide range of sounds that were possible.

Lance then explained about the pitch produced by an organ pipe, which is a function of its length. The wavelength of the sound produced by an open pipe is approximately twice its length. If the longest pipe, pitched at C, is 8 feet (2.4m) in length, the pipe one octave higher will be 4 feet long, and two octaves above (middle C) will be 2 feet long. A closed (stopped) pipe produces a sound one octave lower than an open pipe.

The nomenclature of a 'rank' of open pipes (diapason) was explained further. This refers to the length of the longest pipe in the rank. Thus the longest pipe (C2) two octaves below middle C (C4) is 8 feet (2.4m) long. In a rank of stopped pipes, the lowest pipe is 4 feet (1.2m) in length but sounds at unison pitch, so it is known as an '8ft stop'. Assuming the organ is tuned to 'standard concert pitch', A = 440Hz and tuned in equal temperament, then 'middle C' (C4) has a frequency of 261.626Hz. Lance Foy explained the work he undertook in a further rebuild of 2009 to change the organ to 'standard concert pitch'. Before this restoration work, A was approximately 449Hz, making it impossible to play the instrument in combination with any other fixed pitch instruments. To achieve the lower pitch meant that the lowest 16 foot pipes in the 'Double Diapason' rank were not large enough to be corrected. As a result, Lance Foy was obliged to use modern 'digital technology' to complete this rank of pipes and at the same time, introduce a new 32 foot (C0 or just over 16Hz) 'Sub Bourdon' stop to enrich the depth of sound. The pitch range is illustrated in the Figure.



Range of organ pipes


Lance Foy explains a mechanical system!


Phil Davey demonstrates the fine organ at Truro Methodist Church

An appreciative group of acousticians, organists and enthusiasts.

Around the time of the latest rebuild, significant changes were made within the building - new seating and a carpet - which significantly changed the acoustics of the building. Lance Foy's work clearly demonstrated that his work was a fine match for the new acoustic and Philip Davey concluded the morning session by playing *Carillon de Westminster* by Louis Vierne.

After lunch Lance took us on a tour of the three organs in Truro Cathedral. First we saw the 'Byfield' organ from 1750 that he had refurbished in 1985. He then showed a supreme example of 'miniaturisation' in the form of a chamber organ of 1997 by Kenneth Tickell and Co which is used for rehearsal and chamber music. We then toured the loft that comprised the magnificent Henry (Father) Willis organ of 1887. It went without saying that Lance had also undertaken work on this historic instrument!

It was not possible to have a recital at the time of our visit as the cathedral was open to visitors. However, there was an organist present who was busy rehearsing for a concert later in the evening to give us a 'flavour' of the instrument. Unlike the comparatively 'dry' acoustic at the Methodist Church, the lofty Gothic ceilings of the Cathedral gave it a reverberation time that was understood to be around five seconds.

Lance Foy has had absolutely no formal training in physics or acoustics. However, he was also an organist and had learned his skills of organ building through much trial and error over the years, starting as an employee of firm in Plymouth. However, there was no doubt in the minds of the group who attended that he had intuitively understood the acoustics of these historic buildings and many others in the south-west in order to deliver such fine sounds to audiences or congregations.

Chamber organ of 1997 by Kenneth Tickell and Co

Meeting report: London branch

Wind farm statutory nuisance

On Wednesday 18 May 2011, Dani Fiumicelli gave a presentation to the London branch of the Institute of Acoustics on 'Statutory nuisance: Wind farms and wind turbines'.

Local Authorities have a legal duty to investigate complaints of nuisance, including those that relate to noise from wind farms and wind turbines. Like many complex noise sources there can be substantial logistical and technical difficulties in undertaking such investigations, and careful planning is crucial.

Research into the impacts of noise from wind farms suggests that elements of the nature and character of some of the sounds emitted may aggravate the impact compared with those of other noise sources: decibel for decibel, wind turbine noise can apparently be more annoying than other sources. However, it is clear that in common with other noise sources, non-acoustical factors play a significant role in dictating the impact of wind farm noise, and a robust dose-response for wind turbine noise is yet to be established.

Planning controls may offer greater protection of residential amenity than can be achieved via statutory nuisance, as the latter only covers unreasonable material interference with property of person comfort (in England, Wales and Northern Ireland) and matters that are more than ordinarily tolerable (in Scotland), or that are injurious to health (in all jurisdictions). However, the nuisance limb of statutory nuisance is subject to a 'best practicable means' defence that can permit a the source of a nuisance to continue provided that reasonably practicable measures have been used to counteract it.

Notwithstanding that NPS/IPC approved schemes may have a defence against nuisance action, the investigation of complaints of statutory nuisance due to noise from wind farms is not constrained by the planning system.

Planning permission on its own does not authorise or justify statutory nuisance from noise from wind farms and turbines. However, the granting of planning permission affects decisions on statutory nuisance where it fundamentally alters the nature and character of the location so that such noise is to be expected or tolerated. Notwithstanding this, compliance with planning conditions does not provide blanket protection against statutory nuisance. However, it is considered that where a permitted wind farm scheme has been through a rigorous environmental impact assessment process the risk of statutory nuisance is very low, albeit the risk of statutory nuisance increases as the degree of rigour of the environmental impact assessment process weakens.

Where a wind farm has been through an environmental assessment process the risk of statutory nuisance is very low

Investigation of complaints of statutory nuisance due to noise from wind farms and turbines needs to be carefully planned on a case-by-case basis and no single prescriptive method is applicable in all cases. However, a set of fundamental principles common to investigation of all noise complaints applies equally to the investigation of complaints of statutory nuisance from wind farms. In addition to these fundamental principles it is strongly recommended that investigation of noise complaints involving large scale wind turbines should include detailed assessment of the weather conditions when complaints arise and during any active phase of the investigation *ie* during noise measurements or observations.

Although there is no statutory or case law based requirement to include noise measurements in an investigation of statutory nuisance, it is advisable that the use of noise measurements as well as subjective observations and evidence from complainants should be considered as part of the investigation of wind farm noise complaints for several reasons. These include:

- Providing noise level based information to a wind farm operator may help facilitate a rapid remedial and collaborative response to an initial or informal approach by a local authority, which can sometimes resolve noise problems more quickly than the formal statutory nuisance procedure;
- Noise measurements can provide information to support subjective qualitative judgements regarding the presence of an adverse noise impact, and thereby help counteract claims of inconsistency, unduly high expectations, over-zealousness, inexperience and unreasonableness, against investigating officers or consultants;
- It is common in cases involving commercial interests that the defence will introduce noise measurements or noise level standards and guidelines as means of justification. It can be difficult to counter the apparent scientific rigour of such an approach without undertaking noise measurements, and without engaging in critical review of the noise level standards and guidelines used to justify the noise;
- Noise measurements can assist in countering claims that the complainant is unduly sensitive or has unrealistic expectations;
- Noise measurements can provide objective quantified data to help justify and articulate decisions on whether to proceed with the enforcement action in response to complaints.
- Noise measurements are often important in rebutting attempted defences of best practicable means, or establishing to what degree a nuisance should be restricted if a BPM defence applies.

Whilst suggesting ways in which wind farm noise can be investigated, Dani was careful to point out that statutory nuisance is a flexible concept and that fixed standards and investigation methods cannot be justified in all circumstances. This freedom is an important benefit of the statutory nuisance system and Dani robustly made the point that 'tick-box' type checklist approaches to investigation may constrain the requirement to take account of local and non-acoustical factors that can be decisive in determining statutory nuisance.

The London branch committee would like to extend their thanks to Dani for taking time from his busy schedule and to WSP for providing the venue.

Topics and speakers for the evening meetings are generally identified and organised by the London 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 Nicola Stedman-Jones on **stedmann@rpsgroup.com**.

Meeting report: Eastern branch

Chris Gilbert.

The Eastern Branch March meeting on 12 April 2011was a well attended event held at Braintree Town Hall focusing on the subject of *Noise impact of small wind turbines*. Dani Fiumicelli works for AECOM, having formerly been a Environmental Health Officer for some 16 years, and he expertly presented his considerations of the assessment of noise from small wind turbines (later to be called 'small wind'), defined by the British Wind Energy Association as having a rotor swept area of $200m^2$ or less.

Proceedings started by Dani giving an overview of the so-called 'relevant' standards associated with wind farms and environmental noise. These included absolute noise level targets, for example World Health Organisation *Guidelines for Community Noise* and BS.8223, and as would be expected, comments related to the relevant Planning Policy Statement (in England), PPS22. This was followed by predicted noise level assessment methodologies using the principles of BS.4142 and BS.7445. As would be expected from the title, consideration was also given to ETSU-R-97: *The Assessment and rating of Noise from Wind Farms*, but it soon became apparent that this standard is not suitable for small wind turbine schemes. Other, perhaps less well-known publications - such as the Noise Policy Statement for England issued by Defra - also had an airing, with an alternative perspective considered: could the fact that small wind turbines offer lower carbon emissions counteract possible noise issues?

Using all his years of experience, Dani engrossed the audience with fact-based examples, using such criteria as the Night Noise Guidelines to determine whether there was a number that could be placed on a noise source which gave the human perception of the metric called the *Lowest Observed Adverse Effect Level*, which should not be confused with the *No Observed Effect Level*. Having briefly delved into the noise, sleep and health effects and the associated biological functions associated with night-time noise, it appeared that the general consensus was that the average night noise level over a year (yes, that is an average of 365 days) would possibly be about right at a level of 40dB(A) $L_{night, outside}$. For the definitions etc see ISBN 978 92 890 4173 7, which references Directive 2002/49/EC: June 2002 as defined in ISO 1996-2: 1987.

Moving away from the laborious documentation phase, interestingly and humorously put together by Dani, we were then led by the hand to the matter of actual noise generation within wind turbines themselves. It was stated that the maximum efficiency of a wind generation system needs laminar wind flow not turbulent conditions, which is why turbines should not be placed on cliff tops, but in the middle of a flat area - I didn't appreciate this, either! This also explains why small wind turbines on tower blocks in London will not be very efficient, as there is permanent turbulence due to the presence of the buildings: apparently the optimum separation is around 150 metres - again, difficult to achieve in a built-up area.

We briefly skirted around the vibration issues associated with the roof mounting of these small turbines, by dismissing the structure-borne vibration as levels that were likely to be undetectable: the typical vibration dose value quoted is around $0.015m/s^{1.75}$.

Proceedings were concluded with two interesting points. The first was that if a stringent night-time noise criterion were to be set, as some of the aforementioned standards would have us do, then there could be a situation where a small wind turbine would have to be located further from a residential property than a large, commercial wind turbine (or 'big wind'), if the latter were to be assessed using ETSU-R-97: this was agreed obviously to be a ridiculous situation. The second, more useful and practicable finding, which Dani promoted as a 'conservative' level of protection, is the possible noise target of $L_{Aeq,10min}$ at 35dB(A) based on a wind speed of $8ms^{-1}$ outside a residential dwelling. As always with environmental noise, this level will come across as too low for the developer and small wind turbine installer, and too high for the neighbours of said wind turbine generator.

Finally, on behalf of the Eastern branch committee, the 20 Local Authority attendees and 12 consultant (or similar) attendees, I would like to thank Dani for his excellent presentation and enjoyable style. Thanks are also long overdue for Clive Pink for his organisation of this and many other meetings.

This is about as big as 'small wind' gets: here in a rural setting

Stolen equipment

Any information gratefully received

SRL Technical Services Ltd unfortunately had one of their sound level meters stolen in April 2011. If any member has received an unorthodox approach and been offered some or all of this equipment, please would they contact Ryan Arbabi in **0161-929 5585** or email **rarbabi@soundresearch.co.uk**. SRL's northern office is at Lynnfield House, Church Street, Altrincham, Cheshire WA14 4DZ.

Description	Location	SRL no.	Make	Type	serial no.
Sound level analyser	Altrincham	532	Brüel & Kjær	2260	2370478
Preamplifier	Altrincham	537	Brüel & Kjær	ZG-0026	2770
Microphone	Altrincham	550	Brüel & Kjær	4189	2616485
Calibrator	Altrincham	536	Brüel & Kjær	4231	2327011

James Report under fire for failure

IOA regrets failure to recognise the importance of acoustics

The Institute of Acoustics has strongly criticised the Review of Education Capital led by Sebastian James for its failure to recognise the importance of good classroom acoustics. Prof Trevor Cox, the President, said that acoustics barely rated a mention in the 105-page report, which is absolutely incredible given its crucial role in the classroom. It may sound obvious to most people, but pupils has to be able to hear what their teachers were saying in order to learn, and teachers must not be obliged to put their health at risk by raising their voices to make themselves heard.

There was a wealth of scientific evidence to show that external and internal noise affected children's performance in literacy, numeracy and memory tasks, and that these effects could be reduced by good acoustical design. Children with special needs were more seriously affected by noise than others, as the impact on their performance in spelling and reading was three times that of the impact on other children.

The Institute had hoped that the James Report would recognise the importance of acoustics somewhere in its findings so its failure to do so was extremely worrying. As a result the Department for Education was now being asked to give parents and teachers a firm and unequivocal assurance that acoustics would continue to remain a priority in schools.

The Institute has been campaigning since the start of the year to ensure that the current review of Building Regulations by the Department for Communities and Local Government does not lead to a reduction of acoustical design standards in schools.

It is particularly concerned that section E4 of the regulations, which requires schools to be 'suitable" acoustically, may be scrapped or watered down without being replaced by a statutory mechanism that carried equivalent weight.

In February 2011 Prof Cox warned Communities and Local Government Minister Andrew Stunell that failure to construct schools that were not fit for purpose could result in 'disastrous consequences' for future generations of schoolchildren.

Classrooms with poor acoustics

Children suffer an adverse impact on memory, reading and numeracy skills

This is a précis of the article by Emily Dugan which was published in the Independent on Sunday on 22 May 2011.

According to a new study, children who are taught in noisy classrooms with poor acoustics suffer academically. While classroom chatter is unavoidable, many teachers and students suffer unnecessarily high levels of noise because badly designed classrooms exacerbate the problem, or because external noise sources from aircraft and road traffic are inadequately reduced by the building envelope.

Government proposals to relax the standards to which school acoustics are considered in new or refurbished buildings when new school locations are selected could adversely affect pupils.

The Institute of Acoustics and Institute of Education study took two groups of secondary-school students and exposed them to high and low levels of noise while lessons were in progress. In the tests, half of each class listened to background noise at the equivalent of 50dB(A) through headphones while they worked, and the other half-class did the same with a headphones level of 70dB(A). Their positions were reversed after a week.

The working memory, numeracy and reading skills of 14- to 16-year-olds in noisy conditions were no better than 11- to 13-year-olds' performances in quiet conditions. Previous studies had shown in primary-school-age children that poor acoustical conditions adversely affected performances, but older pupils were also affected in the new study: this first compelling evidence of the effects.

Dr Daniel Connolly of the Institute of Education, says that the study showed poor acoustics to be very bad for learning. In many tasks, higher noise levels took the older age group back to the achievement levels of the younger age group. Although there would always be a certain amount of noise in a school, leaving students in a room with poor acoustics and high background noise, or both, could only make matters considerably worse.

Education Department officials are reconsidering the requirement that schools are 'suitable' in terms of acoustics (BB93) as a part of the coalition government's headlong gallop in pursuit of large cuts in public spending.

The head teacher of Hounslow Heath Infant School, which is under the final approach path to Heathrow airport is Kathryn Harper-Quinn. She has direct experience of how important it is to protect a school from external noise. She says is it something the government should worry about, because significant problems will result from a failure to take school acoustics into account. Her school had taken several years to achieve adequate insulation against the noise of incessant aircraft over-flights to the extent that they were no longer a distraction, but she still felt there was a long way to go.

A great improvement in pupil concentration had been apparent since the school building had been properly insulated, but it would have been far better to build schools where external noise was not an issue in the first place.

Environmental Protection UK sponsors the initiative. Their Mary Stevens said that there was a big drive for deregulation at the moment, but the loss of acoustical planning requirements for schools would mean the loss of valuable protection from noise, an this would have a serious impact on pupils and teachers alike.

Acoustics presentations for primary school's Science Week

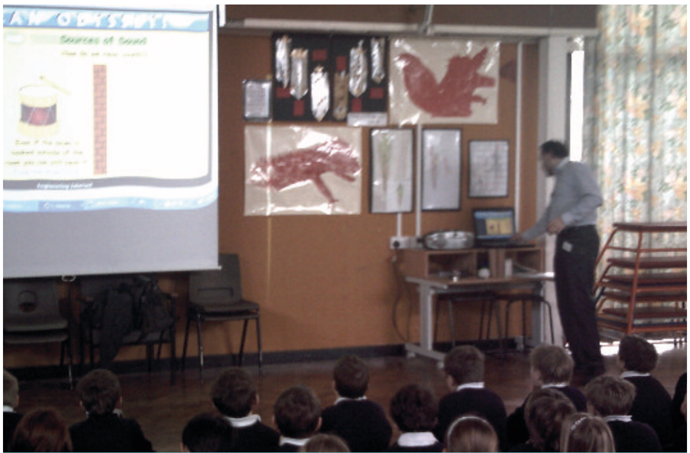
STEM Ambassadors scheme

In March 2011, Alex Krasnic of ZBP Acoustics and Richard Collman of Belair Research were invited by Grove Road Primary School, Tring to give a one-day acoustics presentation to their Year 5 pupils as part of their Science Week. Organised by Setpoint Hertfordshire through the STEM *Ambassadors Scheme*, the theme of the day was 'Communication and acoustics'. Alex took the morning session to give an interactive acoustics presentation to the pupils. He started with basic concepts aided by visual demonstrations of some acoustical principles, followed by an acoustics quiz. This presented the pupils with an opportunity to save Mel the Mermaid from the clutches of the Evil Sea Serpent by identifying the key organs of the hearing mechansism as well as learning how noise is transmitted in buildings. Ably assisted by dB Dolphin, the pupils were thoroughly entertained whilst also learning about hearing and acoustics.

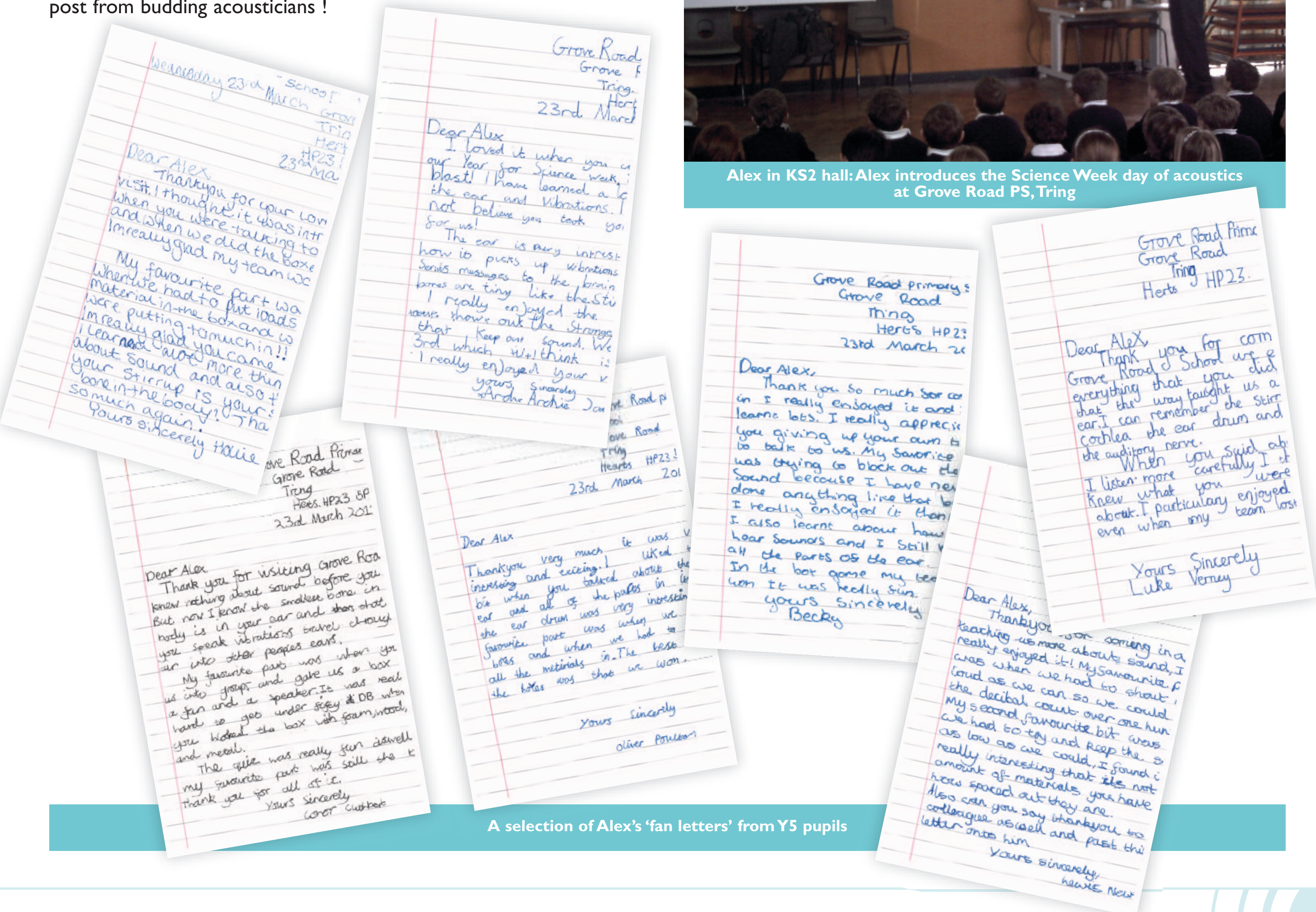
The afternoon session saw Richard return with the hugely popular 'You're banned' demonstration. As with similar events, this pitted different groups of pupils against each other to provide sound insulation for their (model) music practice rooms with a variety of acoustical materials. The winning team would be the one which registered the lowest noise level from a small fan and MP3 player, simulating a drum set and guitar. As always, this was very well received, with healthy (if sometimes noisy) competition between the ten or so participating teams.

All in all, this proved a very successful event lauded by both pupils and teachers alike, with Alex even receiving a number of fan letters in the post from budding acousticians !

Alex in class: Alex Krasnic gets involved with the Year 5 class



Alex in KS2 hall: Alex introduces the Science Week day of acoustics at Grove Road PS, Tring



Wednesday 23rd March
School
Grove
Trin
Hert
HP23
23rd Ma

Dear Alex
Thankyou for your lov visit! I thought it was intr when you were talking to and when we did the boxe I'm really glad my team wo
My favourite part wa when we had to put loads material in the box and w were putting to much in!! I'm really glad you came I learnt alot more than about sound and also your stirrup is your bone in the body!? Tha so much again!
Yours sincerely Hollie

Grove Road
Grove
Tring
Herts
23rd March

Dear Alex
I loved it when you c our Year for Science week, blast! I have learned a l the ear and vibrations. I not believe you took for us!
The ear is very intrest how it picks up vibrations sends messages to the brain bones are tiny like the sti
I really enjoyed the shows out the strange that keep out sound. We 3rd which Will think is
I really enjoyed your v
yours sincerely
Archie

Grove Road Primar
Grove Road
Tring
Herts. HP23 5P
23rd March 201

Dear Alex
Thank you for visiting Grove Roa before you knew nothing about sound. But now I know the smallest bone in body is in your ear and that when you speak vibrations travel through air into other peoples ears.
My favourite part was when you us into groups and gave us a box a fan and a speaker. It was real hard to go under DB when you lined the box with foam, wood, and metal.
The quiz was really fun aswell my favourite part was still the
Thank you for all of it.
Yours sincerely
Conor

Grove Road
Tring
Herts HP23
23rd March 201

Dear Alex
Thankyou very much it was interesting and exciting. I liked when you talked about the bit when all of the parts in the ear and drum was very interestin the ear favourite part was when we had to boxes and when we put the materials in. The best all the boxes was that we won.
Yours sincerely
Oliver

Grove Road primary
Grove Road
Tring
Herts HP23
23rd March 20

Dear Alex,
Thank you so much for co in I really enjoyed it and learnt lots. I really apprec you giving up your own to talk to us. My favorite was trying to block out the sound because I have nev done anything like that I really enjoyed it then I also learnt about how hear sounds and I still all the parts of the ear. In the box game my tea won it was really fun.
yours sincerely
Becky

Grove Road Prima
Grove Road
Tring
Herts HP23.

Dear Alex,
Thank you for com Grove Road School we e everything that you did that the way taught us a ear. I can remember the stirr cochlea the ear drum and the auditory nerve.
When you said ab I listen more carefully I were knew what you about. I particulary enjoyed even when my team lost
Yours Sincerely
Luke Verney

Dear Alex,
Thankyou for coming in a teaching us more about sound, I really enjoyed it! My favourite was when we had to shout loud as we can so we could the decibal count over one hun My second favourite bit was we had to try and keep the as low as we could, I found really interesting that the amount of materials you have how spaced out they are.
Also can you say thankyou to colleague aswell and past thi letter onto him
Yours sincerely,

A selection of Alex's 'fan letters' from Y5 pupils

Young Persons' Award for innovation in acoustical engineering 2011

Georgia Zepidou.

Over the past four years Georgia Zepidou has been successfully applying her knowledge of architecture and classical music to the field of acoustics. Working with the Royal Academy of Music (RAM) and the London Philharmonic Orchestra (LPO) she has developed new techniques and processes for the assessment and mitigation of noise exposure in classical musicians. She approached the challenge by dividing it into four areas: education, audiometry, dosimetry, and development of novel mitigation solutions (room acoustics and noise control).

Novel mitigation solutions included the development and application of sound absorbing mirrors in music teaching spaces, the development and testing of acoustic screens (stage, orchestra pit etc), the use of novel and educational monitoring devices and the use of highly absorbent bespoke decorative panels to control reverberant noise. This research formed the basis of her doctoral thesis. She showed great enthusiasm and professionalism and continuously and proactively sought ways to protect musicians from excessive sound levels without affecting the quality of their performances. A précis of her winning entry is reproduced below.

When the Control of Noise at Work Regulations came into effect in 2005, entertainment noise was given a temporary exemption until April 2008. The aim of the new Regulations was to protect those working in the entertainment sector from any risks associated with noise. Unfortunately, classical music was caught by the legislation even though it is the point of the activity rather than a side effect, in contrast with the situation in industrial noise. The issue of noise exposure and hearing protection immediately provoked a widespread debate amongst musicians, managers and venue owners on the implications of the new Regulations on music performance and teaching, their impracticality and the difficulty of complying.

Since 2006, the RAM has been working together with London South Bank University (LSBU) on developing all practical means of complying with the new Regulations. The 'noise project', which started before any specialised guidance or advice was published by HSE of the Association of British Orchestras, was split into four separate challenges: (1) educating the musicians, whether students or teachers); (2) assessing the aural history of the music students and teachers and monitoring any changes in terms of hearing loss; (3) assessment of individuals' noise exposure and identification of key instruments, ensembles and environments in the Academy that create the highest noise levels; and (4) development of mitigating solutions through architectural, teaching, and novel means. The emphasis of the project was to use or apply only culturally acceptable methods and solutions. The 2008 the LPO joined forces with the project in their attempt to protect musicians and comply with the new Regulations.

1 Education

Information, instruction and training are critical to the health and safety of musicians and one of the key solutions to the noise exposure problem. Educating musicians during the early stages of their career can promote good practices and help protect them from further hearing damage. Seminars scheduled during the first week of the students' course were tailored to each instrument group to address different exposure types.

2 Hearing assessments

Since 2006 all first-year RAM students have undergone audiometric testing during freshers' week. One-to-one interviews were used to identify any factors that may hacve influenced the health surveillance results. As a result of the testing over the past four years, a unique audiometric database has been developed, holding around 1200 RAM student and LPO players' audiograms. This large collection of detailed data has been analysed and has provided valuable information on the effects of each instrument, past exposure, etc on the musicians' hearing health. Hearing assessment at RAM will be used as case study material in a future BBC publication on musicians' noise exposure.

3 Noise exposure assessments (dosimetry)

An extensive programme of detailed noise exposure measurements was undertaken for both the RAM and the LPO. This resulted in a comprehensive collection of information on noise exposure from various instruments, ensembles, repertoires, and in various acoustical environments. The knowledge gained was used to identify those musicians most at risk and te spaces that are unsuitable for certain uses.

4 Development of mitigating solutions

Excessive noise levels recorded during the vast majority of dosimetry measurements at the Academy indicated, even at early assessment stages, the urgent need for noise mitigating solutions. Over the past four years, numerous ways of protecting the students and staff have been investigated. These began with the education of all students and the effort of raising their awareness (an ongoing process) but also included investigations on:

- Existing room acoustic conditions in all teaching and rehearsing spaces
- Feasible ways of improving existing room acoustic conditions in the above spaces (by means of room treatments)
- Feasible ways of mitigating the problem using management techniques
- The effectiveness of commercially available noise control solutions (screens, monitoring devices, *etc*)
- Development of novel and culturally acceptable noise control actions suitable for each use or space
- Existing and novel hearing protection suitable for the players of each instrument

Novel noise monitoring

The SoundEar 'traffic light' system was introduced at the Academy to educate the students as to their noise exposure levels. This is a noise indicator that presents a clear warning as soon as the noise within a room exceeds a present limit.

Apple's iPhone application 'SoundMeter' from Faber Acoustical is cost-effective, and is considered a good indicator of excessive noise exposure. It is user-friendly and can be used as an excellent educational tool.

Five Cirrus Research noise badges were used for the formal risk assessments at both the Academy and the LPO. To overcome the problem of musicians not wearing the badges during performances (as they would be visible to audiences) a special black version of the badge was requested from the manufacture to match the musicians' concert dress. Cirrus Research now offers this new black version of the noise badge commercially.

Novel noise control solutions

Beyond the traditional room acoustics noise control measures recommended in 'A sound ear II' and 'Sound advice', four novel methods were evaluated at the Royal Academy of Music.

- Twenty Amadeus Acoustic Shields were purchased by the Academy and tested under several different conditions of use. Measurements indicated reductions of between 0.2 and 6.3 dB in the A-weighted levels depending on the instrument (one-to-one conditions) but when tested within a full orchestra, maximum reductions of 1dB overall were noted. This was the result of the problematic design of the Amadeus Shields.
- A new absorbent noise screen was developed for use specifically in orchestra pits where the visual impact of the screen plays no role. The new screen was tested both in the laboratory and in the Academy's theatre pit. Results from the anechoic chamber indicated the effectiveness of the screen above 500Hz. When tested in the pit, consistent level reductions of 3dB were measured. The screen has proved itself effective, but because pit space is at a premium, a new design is currently underdevelopment. The new design aims to have a zero footprint, being mounted on the music stand itself. Tests show that the new music stand screen when used in the main hall produces reductions of 4dB overall, ith a 1dB increase at the player's position due to reflected sound.
- An entirely new type of sound absorber, the sound-absorbing mirror, was developed by the acoustics team at LSBU and patented in July 2009. It is a novel solution that acts both as an effective absorbent panel and a mirror. As the majority of musicians spend long hours practising in front of mirrors, the sound absorbing version can replace a traditional, highly sound-reflective mirror while at the same time absorbing the unwanted frequencies of musical instruments, reducing noise levels and consequently the noise exposure. The development of the sound-absorbing mirror was based on a new lightweight reflective heat-shrunk and adhesive film that was proven to be acoustically transparent. The film ins laid and fixed to a timber frame lined with 30mm thick dense mineral wool slab, with a 3mm air gap between the film and the insulation. Laboratory testing shows that the mirror is an effective absorber between 500Hz and 4kHz, with a performance of 0.8 NRC. The mirrors were installed at the Royal Academy of Music, and reductions in A-weighted noise exposure of the order of 2.5 to 4 dB have been found. The effectiveness of the mirror depends on the instrument played, the distance of the musician from the mirror and the positioning in front of it. Reverberation time measurements show a reduction of around 0.1 second with the mirror in the room. This indicates that while the mirror is not reducing the 'liveness' or reverberation in the room, so preferred by musicians, it still acts as an effectice means of reducing the noise exposure.
- The use of highly effective 3D artistic absorptive panels by Anne Kyyro Quinn's design house was investigated. Laboratory tests on various panel constructions indicated an absorptive performance of up to NRC 1.0.

Conclusions

Since 2006, the RAM and LSBU have been working closely together to address the issues raised by the Control of Work Regulations 2006 in the context of entertainment. An extensive project involving the use of audiometry, education, noise dosimetry and the investigation of all available and novel mitigation measures has put the RAM at the forefront of progress in this issue, setting the standard by which classical music organisations are assessed. Thy eover-riding concern of the project was that the quality of performance and artistic planning would be unaffected by any noise reduction measures offered. Laboratory and on-site measurements of all the novel solutions developed indicated reduction on levels of musicians' noise exposure without them affecting the musicians' perception of their own and other players' music (based on their subjective responses after measurements). The use of the new zero-footprint music stand screens can protect musicians playing in theatre pits without occupying any of the valuable space within those usually small areas. Finally, the new sound-absorbing mirror can replace the traditional, highly reflective, mirror in practice rooms while at the same time reducing noise levels and subsequently noise exposure without affecting the acoustical environment within the room.

Instrumentation Corner: How low can you go?

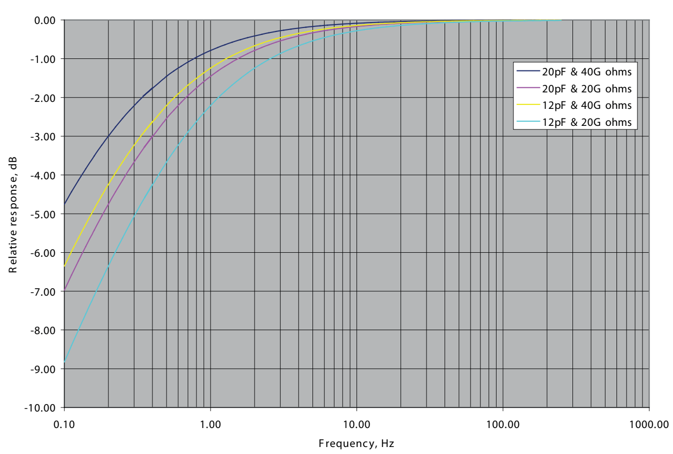
Ian Campbell HonFIOA. **Measurement of low frequency noise**

In the previous contribution to the measurement and instrumentation corner we considered the measurement of low level noise: this time we are looking at the measurement of low-frequency noise. The subject has been very topical, with discussion on the problems of low-frequency noise sufferers, and also when considering the propagation of noise from blasting and other impulsive sources.

The first point to consider is the measurement microphone itself. This is designed to respond to a pressure differential across its diaphragm so one side is exposed to the sound we want to measure whilst the other is held at its internal 'reference' pressure. If the microphone was completely airtight, any changes in barometric pressure due to weather systems or changes in altitude would result in a static deflection of its diaphragm which in turn would affect the ability of the diaphragm to respond correctly to changes in sound pressure. This is just same as the case of an aircraft taking off. As the aircraft climbs, the static air pressure in the cabin falls, but the air pressure in the inner ear of a passenger is still at ground level and hence the ear drum is pushed out. As it is stretched it cannot respond properly, that is, until the internal pressure equalisation tube to the back of the throat releases, often prompted by chewing the complimentary toffee. The ear 'pops' and the excess pressure is released, allowing normal hearing to return. A similar but opposite condition then occurs on landing. A comparable pressure equalisation in a measurement microphone is achieved by a controlled air leak to the back of the diaphragm.

As the frequency of measurement gets lower and lower the sound has more time to get round the back of the microphone and hence to the rear of the diaphragm. Once the sound appears on both sides of the diaphragm at the same time, the pressure differential across it will start to fall and hence the output will also go down. These effects can be complex with changes in both the amplitude and phase of the output signal.

So when designing a microphone the compromises that have to be balanced are making the air-bleed to the rear short enough to accommodate any sudden changes (pushing on a calibrator, changes in altitude, weather *etc*) but long enough to ensure that the low-frequency performance is preserved. Most general-purpose microphones have low frequency limits around 10Hz or so, whilst special low-frequency microphones will measure down to less than 1Hz: in these special microphones the time constant of the air leak is made as long as possible by adding extra components within the microphone. But of course, during their service lifetime microphones may suffer damage that significantly increases the air leak to the rear cavity; the most common of these is small perforations in the diaphragm itself. We have seen microphones that calibrate correctly at 250Hz and 1kHz but are in the order of 10dB down at their specified lower cut-off frequency. This means that any slight damage or mark on the diaphragm needs investigation to ensure there is no air leak.



Low frequency limits with different microphone and preamplifier combinations

All of this becomes more important when you realise that the 'traditional' method of testing microphones both in production and re-calibration is to use an actuator that uses an electrostatic force to attract the diaphragm so that it moves in manner similar manner to that when it is excited by a sound pressure wave. This is fine for higher frequencies but as there is no actual sound pressure wave generated to get round the back there can be no 'back to front' cancellation effect, and hence low-frequency performance will be overestimated. For this reason actuators are not used at frequencies below 100Hz and special test chambers must be used that excite both the back and front of the microphone for testing at less than 100Hz.

Having optimised the design of the microphone you then need to establish that the associated sound level meter can take full advantage, so you need to check the low-frequency limit of the instrument as these can vary widely. Often there is a temptation for manufacturers to limit the low-frequency response to minimise the effect of the self noise rather than produce more expensive preamplifiers and input amplifiers; they are just taking advantage of the fact that even under the most recent sound level meter standards a Class 1 meter does not have to work at all below 16Hz: the tolerance below this frequency is $-\infty$. Some manufacturers fit high-pass filters to remove troublesome wind noise etc (look for pass band settings sometimes called 'wide band mode' or something similar). These will of course impair the measurement of low-frequency noise and should be switched off.

Beyond these considerations the primary element that determines the low-frequency response of the sound level meter is the interaction between the microphone and preamplifier. The equivalent circuit of the microphone can be modelled as a pure voltage source in series with its self capacitance whilst the input to the sound level meter preamplifier is primarily resistive. There is thus a conventional RC time constant producing a high-pass filter. The cut-off frequency of this network can be determined from the reciprocal of the product of the capacitive and resistive elements. So to maximise the low-frequency performance the capacitance of the microphone and the input impedance of the preamplifier need to be as high as possible. Most microphones are around 12pF for electret types and 20pF for conventional air dielectric microphones. A typical value for input impedance of microphone preamplifiers is 20GΩ although special low-frequency preamplifiers having an input impedance of 40GΩ are now becoming available to allow best use to be obtained from the sound level meter's performance.

What this all means is that you should check the specification for your meter, and with a good bit of kit you should be able to measure down to 5Hz - and possibly even lower.

New Sponsor Member

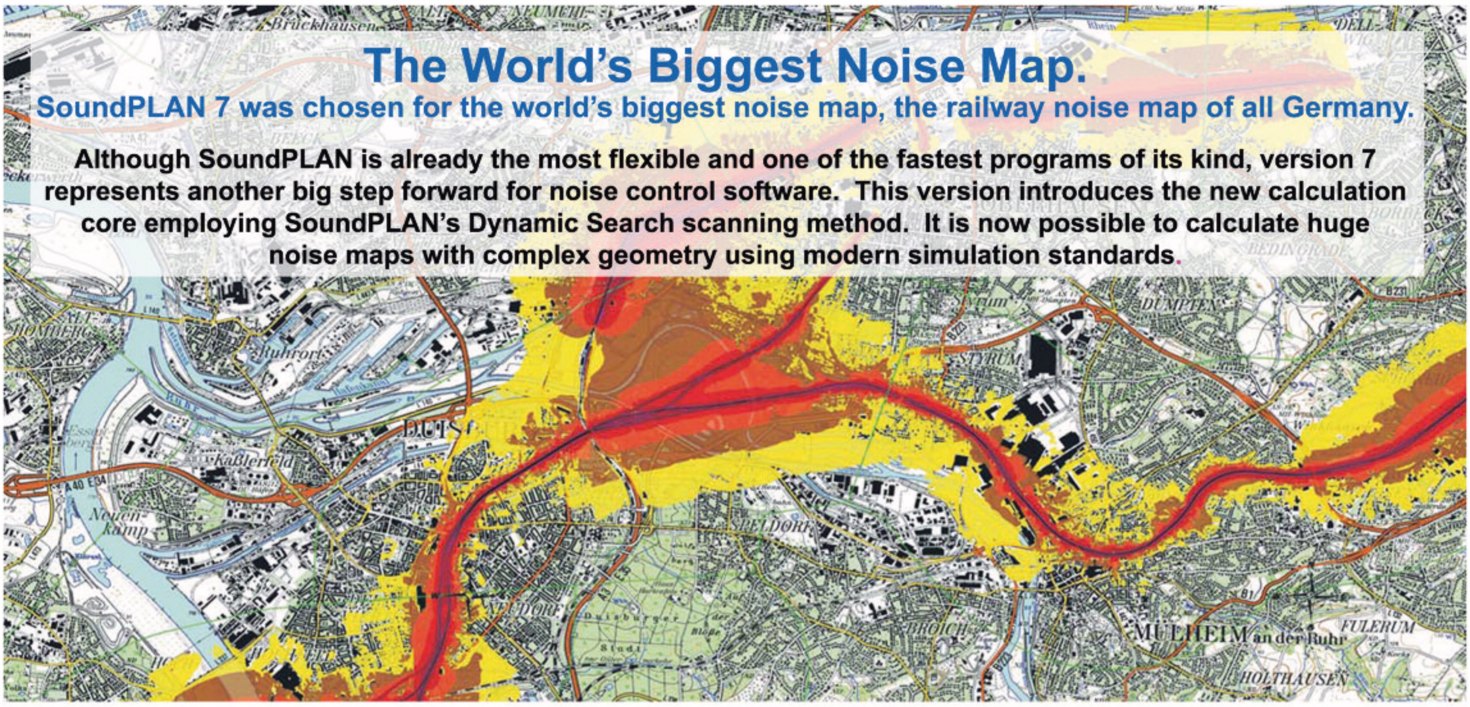
Doorset Global Solutions

The Institute of Acoustics is pleased to announce that Doorset Global Solutions, of Grove Trading Estate, Dorchester, Dorset DT1 1ST has become a Sponsor Member of the Institute.

The World's Biggest Noise Map.

SoundPLAN 7 was chosen for the world's biggest noise map, the railway noise map of all Germany.

Although SoundPLAN is already the most flexible and one of the fastest programs of its kind, version 7 represents another big step forward for noise control software. This version introduces the new calculation core employing SoundPLAN's Dynamic Search scanning method. It is now possible to calculate huge noise maps with complex geometry using modern simulation standards.



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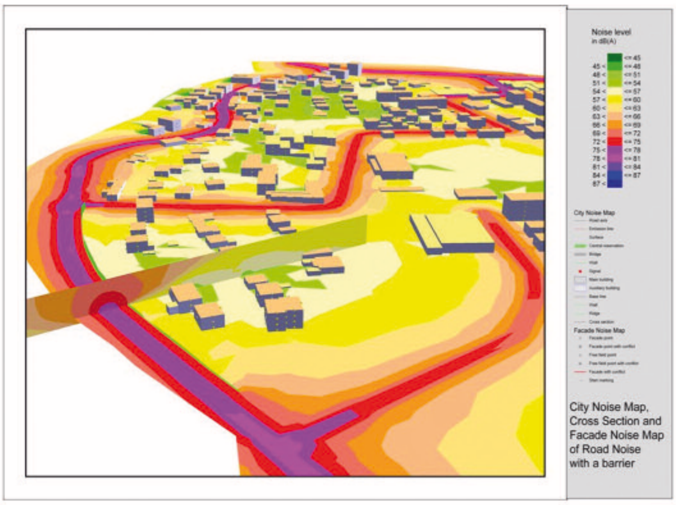
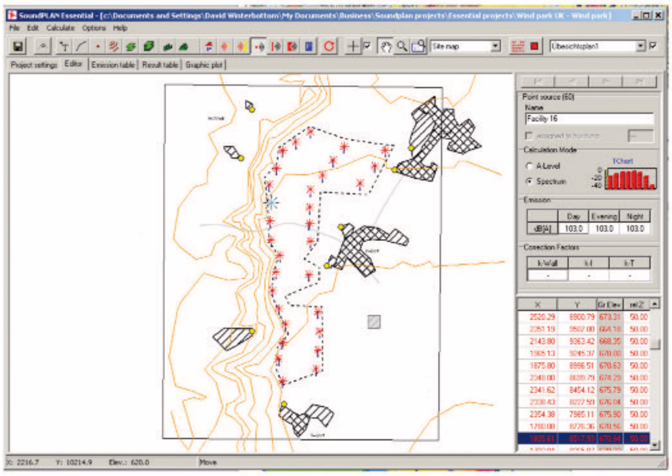


City Noise Map, Cross Section and Facade Noise Map of Road Noise with a barrier



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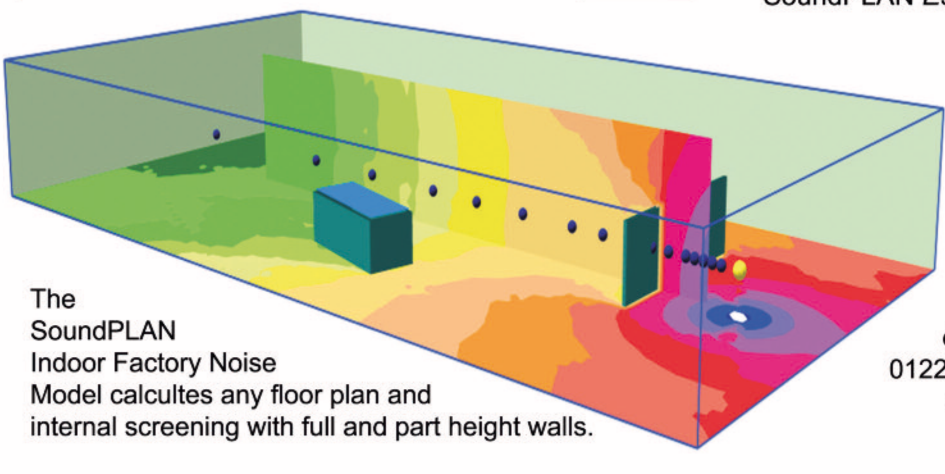

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Meeting report: London branch

Construction noise on a large infrastructure project

On Wednesday 19 January 2011, Steve Summers of RPS Planning and development gave a presentation to the London branch of the Institute of Acoustics on 'Assessing construction noise and vibration for a large-scale infrastructure project', based on the Crossrail project. It was obviously a hot topic for discussion, as the evening drew in a record crowd in excess of 75 attendees.

Crossrail is a major project that will link existing railways either side of London and complement the existing London Underground services. When complete, Crossrail will provide services through central London, linking Maidenhead and Heathrow to the west of the city with Shenfield and Abbey Wood in the east. It is currently the largest rail project in Europe.

RPS provided noise and vibration consultancy advice direct to Crossrail Ltd from 2003. The appointment started with work on route selection, continued with extensive baseline noise surveys, noise and vibration aspects of the Environmental Impact Assessment (EIA) and subsequently providing support for the Crossrail Bill through the Parliamentary process, where noise and vibration effects were key issues. The Crossrail Bill gained Royal Assent in 2008.

Steve provided an overview of the history of assessing construction noise, from the Wilson Report to the ABC method, developed for use on the Channel Tunnel Rail Link. Crossrail adopted a criterion based on a significant effect being predicted where the total noise (pre-existing ambient plus airborne construction noise) exceeds the pre-existing ambient noise by 5dB or more. This applies to day, evening and night-time periods but with a lower cut-off tailored to each period. The assessment methodology adopted has since been published as one of the example methods in Annex E of British Standard 5228-1:2009. The assessment criteria were also designed to work in tandem with the Crossrail noise and vibration mitigation scheme. The scheme enables residential properties to receive noise insulation or temporary re-housing, if certain noise levels will be exceeded for a given duration.

As part of the EIA for Crossrail, baseline noise monitoring was undertaken at over 300 locations along the proposed route. Many of the surveys were over a seven-day period, with additional 24-hour and three-hour surveys. Such extensive monitoring was necessary primarily to provide the baseline levels needed for the construction noise assessment.

Modelling was carried out using the SiteNoise module of Noisemap in to predict construction noise from every Crossrail work site. The construction sites modelled ranged from simple platform extensions at existing surface stations to the major civil engineering works for the central London sub-surface stations and tunnel portals. Many of the assessments considered several phases of work and needed to consider night-time effects of 24-hour activity at Central London worksites, or possession working on the surface railway sections. Steve highlighted the point that obtaining realistic construction planning information became a key issue, and RPS had to work closely with Crossrail engineers to obtain it.

Steve explained that standard mitigation measures were classified into tiers to provide a simple indication of the level of construction noise mitigation required for each work site. He also set out the estimated numbers of properties qualifying for noise insulation and temporary re-housing and those expected to receive significant residual construction noise impacts.

For vibration from construction activity, levels were predicted in terms of peak particle velocity (PPV). However, the Crossrail assessment methodology assessed human effects in terms of vibration dose value (VDV). There was no simple way to convert PPV to VDV, so an approximate conversion method was used at the time. Since then, the 2009 edition of BS.5228 Part 2 has been published including a scale relating human impacts to levels of vibration in terms of PPV. This makes the task of assessing construction noise effects much simpler for similar projects. Steve summarised the findings of the construction vibration assessment which indicated that significant effects were predicted at the majority of the central London worksites.

The presentation concluded that the assessment of construction noise and vibration for Crossrail had been one of the most extensive ever carried out. The assessment methodology for noise is now reproduced in the guidance published in the 2009 issue of BS.5228 and relevant developments on the assessment of vibration are also covered by the Standard's update.

For further information please contact Steve Summers on **summerss@rpsgroup.com**.

The London branch would like to extend thanks to Steve for giving his valuable time to join us for the evening to give a very interesting presentation, which proved to be one of the most popular topics on the London branch programme. The committee would also like to extend thanks to WSP for providing the venue.

Determining appropriate acoustic design criteria for sustainable office buildings

C Field. **The noise problems associated with passive cooling**

Introduction

Natural ventilation is widely accepted as a sustainable design strategy for buildings. The use of natural ventilation in buildings often conflicts, however, with the control of ingress of external noise via the façade because of the need to provide ventilation openings. In addition, national noise standards provide recommended guidelines for internal background noise limits for building use based on the assumption that the buildings can be sealed and air-conditioned, and therefore external noise ingress can be controlled by the façade construction.

In many projects, the use of natural ventilation is not considered feasible because of noise issues - either because the perceived high-noise environment cannot be controlled with practical measures to the noise level limits recommended in national standards, or because the capital cost of noise mitigation measures outweighs the benefits of natural ventilation.

The intention of this article is to challenge the use of noise level limits presented in national standards with respect to the need to provide a compromise to meet other non-acoustical sustainability goals.

Acoustical design challenges posed by sustainable building design initiatives

Sustainable design considerations listed in 'green building' rating systems can introduce the following acoustical design challenges.

Indoor Environmental Quality (IEQ) credits related to the use of natural ventilation in buildings conflict with the control of ingress of external noise through ventilation openings to meet internationally recognised background noise limits for building use.

The use of passive cooling systems such as radiant flooring and exposed thermal mass of ceilings may conflict with the use of acoustically absorptive floor and ceiling finishes to control reverberation and occupational noise levels (therefore controlling distraction and annoyance to nearby occupants). Acoustic finishes also assist in achieving adequate speech intelligibility within office buildings.

The use of daylighting is also an important sustainable design factor. Occupant productivity and wellbeing is enhanced with direct connection between indoor and outdoor spaces[1]. This is achieved with the use of lower partition heights, interior light shelves and interior glazing. The benefit is quantified by achieving a minimum percentage floor area illuminated by natural daylight.

The consequence of lower partition heights, light shelves and the use of interior glazing, however, is an increase in noise disturbance to workers seated at open plan workstations, and reduced acoustic privacy in meeting rooms using glazed walls. These effects are due

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Determining appropriate acoustic design criteria... - *continued from page 23*

to the use of lower partition and workstation heights, the acoustical barrier effect provided by these elements is lost, resulting in increased propagation of noise from occupants throughout open plan offices. Light shelves are often hard and reflective acoustically, resulting in the increase of discrete sound reflections within the building. For private offices and meeting rooms, glazed walls, used to allow daylight penetration, have lower sound insulation performance compared with conventional plasterboard and stud partitions.

To a lesser degree, the encouragement of increased recycled content in materials poses difficulties for acoustical design due to the lack of choice of recycled materials that provide the required acoustical properties. In addition, non-fibrous alternatives are now being more widely considered as a replacement for traditional fibreglass. Examples include packless silencers which do not include any fibrous sound absorbing media, and closed cell foam duct liners which are manufactured using more environmentally friendly processes. The acoustical performance of these alternative products, however, is generally lower or the cost significantly higher than for fibrous products.

Can we use the thermal comfort assessment approach used in green building rating systems for acoustic design?

Green building rating systems[2,3,4] include credits for high levels of thermal comfort in office buildings. Different assessment criteria are specified depending on whether the building is naturally or mechanically ventilated. For example, Greenstar[3] stipulates that for naturally ventilated buildings, the 80% and 90% acceptability limits set out in ASHRAE Standard 55-2004[5] must be complied with to achieve one credit and two credits respectively. The acceptability limits are calculated using an adaptive thermal comfort model derived from a global database of over 21,000 measurements taken primarily in office buildings.

For mechanically ventilated buildings, the Predicted Mean Vote (PMV) levels calculated in accordance with ISO7730-2005[6] are used as the basis for compliance (ASHRAE Standard 55-2004 also proposes this PMV method for mechanically ventilated buildings).

The reason for using separate assessment criteria for natural ventilation and mechanical ventilation is explained in ASHRAE Standard 55-2004, which states that occupants in naturally ventilated spaces have 'different thermal experiences, changes in clothing, availability of control, and shifts in occupant expectations'.

ISO7730-2005, Section 10, also says that extended acceptable environments may be applied for occupant-controlled, naturally conditioned, spaces in warm climate regions or during warm periods, where the thermal conditions of the space are regulated primarily by the occupants through the opening and closing of windows. Field experiments have shown that occupants of such buildings could accept higher temperatures than those predicted by the PMV.

The questions, therefore, taking the different assessment approaches to assessing thermal comfort in green building rating systems as an example, are:

1. Should separate acoustical design criteria be specified for naturally ventilated buildings and mechanically ventilated buildings?
2. Should acoustical criteria be further re-evaluated to take account more appropriately of the occupants' ability to control their acoustical environment?

Re-evaluating acoustical criteria does not necessarily have the underlying aim of reducing noise levels in indoor environment in office buildings so that they are not noticeable. The preferred approach is to provide a 'comfortable' acoustical environment while facilitating the other sustainable design elements of office buildings including:

- natural ventilation
- natural daylight
- reduced energy consumption
- increased use of recycled and renewable materials
- individual control of the working environment to enhance productivity.

The definition of 'comfortable' must be carefully considered while facilitating these non-acoustic sustainable design elements. The discussion presented here focuses on a suitable acoustical environment to facilitate the use of natural ventilation in office buildings. As a compromise for the non-acoustic benefits which natural ventilation provides, alternative approaches are offered to challenge noise level standards already set for sealed, air-conditioned buildings.

Acoustical criteria used in the past

Standards and guidelines for mechanically ventilated buildings

As a point of reference for establishing design criteria for naturally ventilated buildings, recommended background noise levels for unoccupied office spaces provided by three nationally recognised guidelines are given in Table 1.

In summary, for open plan offices, a typical background noise limit of 40 to 45 dB L_{Aeq} is recommended, and for private offices and meeting rooms, a typical background noise limit of 30 to 35 dB L_{Aeq} is recommended.

Acoustical criteria currently used in green building rating systems

The criteria used in green building rating systems generally reference national guidelines and standards intended for mechanically ventilated buildings. No specific acoustical criteria for naturally ventilated buildings are given.

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Occupancy type	L_{Aeq}, dB to BS.8233[7]		L_{Aeq}, dB to AS.2107[8]		NC* to ASHRAE[9]	
	satisfactory	maximum	satisfactory	maximum	satisfactory	maximum
private office	35	40	40	50	25	35
meeting room	30	40	35	40	25	35
open plan office	40	45	45	50	30	40

Table 1

Recommended background noise limits for unoccupied mechanically ventilated spaces * *For comparison purposes, the NC rating is numerically typically 5 lower than the* L_{Aeq}

Determining appropriate acoustic design criteria... - continued from page 24

The Green Building Council of Australia includes a credit in its rating system *Greenstar – Office design and office as built*[3], for meeting the recommended background noise levels given in AS2107-2000 (and reproduced in Table 1).

The US Green Building Council's rating system *LEED®-NC*[2] does not currently offer a credit for limiting background noise levels in offices.

The Building Research Establishment in the UK includes a credit in their rating system, *BREEAM Offices*[4] to 'ensure the acoustic performance of the building meets the appropriate standards for its purpose'. The acoustic criteria referred to generally follow the recommendations of BS8233-1999 and are reproduced in Table 1 here.

These green building rating systems have adopted internal acoustic criteria usually applied to mechanically ventilated buildings without consideration given to natural ventilation strategies usually employed in these buildings. The acoustic credits in the respective green building rating systems are therefore unachievable in most practical building locations due to noise ingress via the large areas of façade open areas required to achieve the natural ventilation credits.

Establishing alternative criteria using subjective assessments

As a starting point for establishing more suitable design criteria for naturally ventilated buildings, subjective assessments were carried out. Two separate subjective assessments were made in a controlled acoustical environment to determine the effect on speech intelligibility and task distraction of traffic noise ingress via naturally ventilated facades. The goal was to determine the traffic noise level at which speech intelligibility in offices was impaired and occupants were distracted from their usual tasks.

The key points and conclusions from the subjective assessments are presented below. Details of the assessment methodology and experimental set-up are omitted for brevity.

Assessment assumptions

Some assumptions were made during the assessments in the interest of achieving some meaningful conclusions. The assumptions were follows.

- The five-minute noise source recordings used were representative of typical street activities in Manhattan, New York, with no preference given to particular intermittent noise events or absence thereof.
- The assessments were carried out for a one-off configuration of open window area, distance from the window and elevation of the window above the principal noise sources.
- The window was sufficiently open that the principal transmission path for external noise was the opening itself.
- Assessments were made in the Arup SoundLabs in New York and San Francisco. These are a controlled acoustical environments with low background noise levels and reverberation times.

For the assessment of speech intelligibility:

- The objective of the assessment was restricted to assessing speech intelligibility levels in offices affected by external noise sources, and does not account for internal office activity noise sources.
- The speech level used in presenting word score lists for subjective testing was calibrated and normalised to 68dB L_{Aeq} at 1m on-axis.
- Speech intelligibility was assessed in terms of the articulation index (AI).

For the assessment of task distraction:

- Subjects were instructed to perform written and arithmetical tasks using a computer workstation situated in the middle of the SoundLab.
- Participant data were collected in order to document fluctuations in the accuracy of completed written and arithmetic tasks and the time taken to complete them. The data were analysed in such a way that trends in these fluctuations could be discovered as a function of background noise level.

Speech intelligibility assessment

Outline methodology

The aim of the assessment was to use subjective word tests to ascertain the level of impairment of speech intelligibility in the presence of external background noise entering office buildings via natural ventilation openings. Traffic noise recordings measured internally were varied in 3dB increments to determine the sound pressure level at which the level of speech intelligibility in offices would be unsatisfactory.

Testing procedure

(1) A series of five-minute recordings was made using a Soundfield microphone in downtown New York. The measurement position was 1m from the open window inside a private office.

(2) Stimulus word lists were generated by a trained female speaker, at a calibrated level in the Arup Acoustics NY SoundLab. Modified rhyme tests (MRTs) were carried out in accordance with ANSI S3.2-1989[10]. The word lists were played back to 15 test participants using a single loudspeaker (mono) located directly in front of the listener at a distance of 2m. The level of reproduced speech at the listening position was 59dB L_{Aeq}, measured during playback of the entire MRT set of 500 words.

(3) A randomised playback system for the word lists was developed with a MATLAB script, and a graphical user interface was used to facilitate the tests.

(4) The calibrated noise recordings were played back during the balanced word score tests via a twelve-loudspeaker ambisonic set-up in the Arup Acoustics NY SoundLab.

(5) A 20-word MRT was carried out for nine randomised increments of recorded background traffic noise level to investigate the impairment of speech intelligibility as the level of traffic noise changed.

(6) The level of speech intelligibility (SI) was quantified by the percentage of correct words, in accordance with ANSI 3.2-1989. The SI values were then converted to equivalent values of articulation index (AI) using the method given by AS 2822-1985[11].

(7) The percentage of correct words was correlated with a 'good' standard of speech intelligibility expected for satisfactory office communication (AI greater than 0.45).

(8) The internal break-in noise level limit (L_{Aeq}) appropriate for speech intelligibility in naturally ventilated office spaces was then determined.

Results and discussion

The results of the subjective testing are given in Figure 1. They indicate that an AI > 0.45 is achieved for an internal noise level of 59 dB L_{Aeq} or a signal-to-noise ratio of 0.6.

The results demonstrate that the allowable level of external noise break-in to naturally ventilated buildings could be set higher than for sealed and mechanically ventilated buildings, whilst still maintaining a good level of speech intelligibility within office spaces. This provides opportunities for introducing practical and less stringent noise mitigation measures, if necessary, for naturally ventilated buildings at a reasonable cost in the context of the building construction budget.

Task distraction assessment

Outline methodology

Participants were exposed to calibrated levels of pre-recorded traffic noise through a naturally-ventilated façade. Subjects were instructed to perform written and arithmetical tasks using a computer workstation situated in the middle of the SoundLab.

Data were collected in order to document fluctuations in both the accuracy of the completed task and the time taken to complete it. The data were analysed in such a way that trends in these fluctuations could be discovered as a function of background noise level.

Testing procedure

(1) Thirty-three people (all Arup employees) participated in the subjective test.

(2) The calibrated noise recordings were played back during the tests via a twelve-loudspeaker ambisonic set-up in the Arup Acoustics San Francisco SoundLab.

(3) Each written and arithmetical test was carried out for nine randomised increments of recorded traffic noise level to investigate the level of distraction from completing the task as the level of traffic noise changed.

(4) The following data were collected from each participant.
- Gender
- Approximate age
- Hearing difficulties (if any)
- Levels of background noise presented
- For the written task:
  - (a) the number of ASCII keystrokes involved in copying printed paragraphs into a text box, including backspace/delete keys and arrow/navigation keys
  - (b) Time between keystrokes, in milliseconds.
- For the arithmetic task, consisting of self-paced progress through a list of summation operations:
  - (a) Time taken between each presented sum
  - (b) Final answer at the end of each sequence
  - (c) Order of presentation of summation sequences.

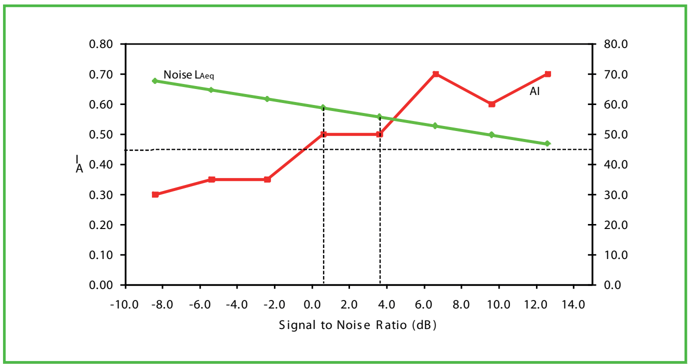

Figure 1

Articulation index for various background noise levels

Results

The results of the task distraction assessment indicated trends of participant resilience to noise ingress given office-related tasks.

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Determining appropriate acoustic design criteria... - *continued from page 27*

Owing to the complexity of the current investigation, conclusions regarding specific noise level recommendations or criteria were not possible.

While the experimental setup and methodology of the speech intelligibility assessment were dictated by an ANSI standard[9], the task distraction assessment methodology could not follow the guidance of any particular standard. In the absence of such a predetermined and codified method of quantifying performance in office-related tasks, in the presence of noise through openings in a façade, this assessment was developed based on references to previous research investigating similar subjects. Because of this, while trends do emerge in the statistical analysis of the data collected here that are possibly significant, some adjustment of the experimental setup is necessary to reach definitive conclusions. It have been determined that the research method requires this type of adjustment owing to its multi-modality, its complexity, and the multiplicity of influencing factors inherent in the topic.

Discussion

Based solely on noise level, the data suggest that people can perform tasks to a modest (though statistically erratic) degree of accuracy at higher levels of noise ingress than previously thought, but not enough data exist regarding other factors (acoustical comfort, resilience of experimental setup, non-acoustic environmental influence) to make recommendations for absolute levels.

While reliable trends begin to appear as a result of this phase of research, it is believed that there are not enough data points to make conclusions about specific noise criteria and their effects on productivity and accuracy of task completion. With some revision of the experimental setup and further research, however, such conclusions are feasible.

Revised noise criterion (nc) curves for naturally ventilated buildings

The results of the subjective assessments presented above demonstrate the complexity of assessing distraction to office tasks by ingress of traffic noise via the facade. An alternative approach would be to follow the empirical methodology adopted to develop the Noise Criterion (NC) curves, still in use today 50 years after they were first published.

Original NC curve derivation

NC curves are widely used to evaluate noise conditions in occupied spaces and are based on achieving satisfactory speech intelligibility or acoustical comfort in occupied office spaces with mechanical ventilation. The curves were derived by Beranek from personnel surveys and noise surveys in occupied office spaces of a US aircraft base in 1956[12]. The survey included 190 participants working in 17 difference spaces with various background noise environments. A follow-up study in 1957[13] provided further data from other occupied office buildings to substantiate the results from the initial study and provide a revision to the initially proposed criteria. A total of 300 participants took part in the combined study. The same questionnaire was used for both studies, and focused on interference to speech and ability to accomplish tasks without loss of performance. Analysis of the subjective assessment with the background noise measurements carried out led to the derivation of the NC curves still used as the basis for mechanical noise control specifications today.

It would therefore be a reasonable approach to undertake a similar study in existing naturally ventilated buildings to derive suitable background noise criteria in occupied office spaces. The end goal would be a modified set of NC curves ('NV-NC' curves) suitable for applying to the design of naturally ventilated office spaces.

Approach for naturally ventilated buildings

Undertaking such a study in real office environments has the advantage of removing some of the complexities encountered in a controlled and simulated laboratory assessment. The challenge, however, is that it relies on cooperation with office building owners and managers, and building occupants, to obtain meaningful results.

The intention is to partner with building owners to enable access to a range of naturally ventilated office buildings to carry out the assessment. Post-occupancy surveys are regularly carried out on new office buildings (whether they have a green rating or not), and include general questions regarding satisfaction with the acoustical environment. It would be difficult to incorporate a thorough enough assessment into these current surveys. Arup currently has acoustics offices in 14 cities around the world, which will provide a good starting point for the identification of appropriate office buildings for the study. It would be beneficial, however, to partner with other firms and academic institutions to increase the sample size of the study.

Acknowledgements

The work of Joseph Digerness and Shane Myrbeck in preparing and carrying out the subjective assessments of impairment to speech intelligibility and task distraction from external traffic noise presented in Section 5 is gratefully acknowledged. This work was supported by an internal Arup research fund.

C Field is with Arup, Sydney, Australia. This article is closely based on a presentation he gave at Reproduced Sound 2010, Brighton

References

1. Heschong Mahone Group. *Windows and offices: a study of worker performance and the indoor environment* (Technical Report) for the California Energy Commission, 2003, pp2-4
2. *Green Building rating system for new construction and major renovations (LEED®-NC)* US Green Building Council, Version 2.2, October 2005
3. *Greenstar™ – Office design and office as built* Green Building Council of Australia, version 3, 2008
4. *Building Research Establishment Environmental Assessment Method* (BREEAM) – Offices 2008 Building Research Establishment Ltd, http://www.breeam.org
5. ASHRAE Standard 55-2004 *Thermal environmental conditions for human occupancy* American Society of Heating, Refrigerating and Air-conditioning Engineers, Atlanta, USA, 2004
6. International Standard ISO.7730:2005 *Ergonomics of the thermal environment - Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria* International Organisation for Standardisation, 2005
7. *Sound insulation and noise reduction for buildings - Code of practice* BS.8233: 1999 British Standards Institution, London, UK, 1999
8. AS.2107: 2000 *Recommended design sound levels and reverberation times for building interiors* Australian Standard (Standards Australia, Sydney, Australia, 2000).
9. *ASHRAE Sound and vibration control* in ASHRAE Applications Handbook, Chapter 47, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Atlanta, USA, 2007
10. ANSI S3.2-1989 *Method for measuring the intelligibility of speech over communication systems*, Acoustical Society of America, NY, USA
11. AS.2822-1985, *Acoustics - methods of assessing and predicting speech privacy and speech intelligibility*
12. Beranek, LL *Criteria for office quieting based on questionnaire rating studies*, JASA 28, 833-852 (1956)
13. Beranek, LL *Revised criteria for noise control in buildings*, Noise Control, 3 19-27 (1957)

Simulation and application of beam-shaped subwoofer arrays

Evert Start. **Better bass definition**

Introduction

Low frequency radiation pattern control has increasingly gained interest among sound system designers and sound engineers over the last 15 years. This is because directional subwoofer systems offer some clear benefits. In a room the direct-to-reverberant ratio can be improved by aiming the LF beam to the audience, while keeping it off the walls and ceiling, resulting in better 'definition' and 'punch' of the bass. Also during outdoor events directional subwoofer arrays have proven to be useful, especially in cases where the maximum sound levels in built-up areas are restricted by environmental regulations.

Owing to the long wavelengths involved (typically 3 to 10 metres) a single subwoofer shows a near-omnidirectional radiation pattern. By stacking multiple subwoofers in an array the directivity (ie Q-factor) increases proportionally to the ratio between the size of the array and the wavelength. Consequently, large array dimensions are required to achieve significant directivity at low frequencies.

By applying delays to the loudspeaker signals, the main lobe can be steered electronically. In the steering direction the loudspeaker contributions are in phase and consequently sum coherently, while in other directions they (partially) cancel each other out. As the individual subwoofers are almost omnidirectional, the radiation pattern has mirror symmetry in the line or plane of the array, meaning that besides the desired front lobe, an almost equally strong rear lobe will arise.

On the basis of their beamforming mechanism, these arrays are often characterised as 'delay-and-sum' arrays. By nature, delay-and-sum arrays are power-efficient. By doubling the number of subwoofers in a uniformly weighted delay-and-sum array, a 6dB on-axis gain is achieved while the total electrical power only doubles (+3dB). They are also robust, *ie* relatively insensitive to loudspeaker positioning errors and acoustic deviations between loudspeakers as a result of production tolerances or ageing.

Another class of beamformers is made up of the 'differential' arrays, which consist of two or more axially spaced subwoofers. Here the pressure difference between the sound waves emitted by the front and rear loudspeakers is crucial for beamforming. Differential subwoofer arrays are 'super-directional' in the sense that a substantial spatial selectivity can be obtained with array dimensions much smaller than the wavelength. Unfortunately, they tend to be less efficient and less robust than delay-and-sum arrays.

A well known example of a differential bass array is the cardioid subwoofer, which is useful in live concert applications due to its strong backward LF sound rejection. The theoretical principle behind the cardioid subwoofer is quite simple. Basically, only two axially spaced (less than one quarter of a wave length) subwoofers are required. Assuming the two subwoofers are truly omnidirectional, only a phase reversal and an electronic delay would be required for the rear-facing loudspeaker. The practical implementation however is less straightforward, as small loudspeaker deviations or modelling errors could lead to major errors in the rearward sound cancellation. Often the power efficiency is compromised and the realised backward rejection is band-limited. Moreover, many systems require precise on-site tuning of the system.

The present work focuses on the acoustic modelling and optimisation of DDS-controlled[1] differential subwoofer arrays. These 'beam-shaped' subwoofer arrays offer some very interesting properties. For instance, with a vertical differential subwoofer array, ie a line array with loudspeakers in the front as well as at the back, it is possible to steer and shape the front lobe in the vertical plane and simultaneously reject sound to the rear or side. In this way the benefits of a delay-and-sum array and a differential array are combined.

This work is an extension of the study reported in 2005[2]. In that study a computationally efficient, hybrid PSM-BEM method was introduced for the accurate modelling of subwoofers in an array facing full-space radiation conditions. Now, the PSM-BEM method is extended with a half-space radiation condition which is expected to be more valid for ground-stacked subwoofer arrays. Using this novel modelling approach, several differential subwoofer configurations with various radiation characteristics (cardioid, hyper-cardioid and dipole.) have been simulated and, subsequently, verified by measurements.

Acoustic modelling of subwoofer arrays

The problem

Probably one of the most widely applied models in acoustic simulation software is the Point Source Model (PSM)[3]. In the PSM each loudspeaker in the array is modelled as a directional point source positioned in free space. The model assumes that the sound field (magnitude and phase of the acoustic pressure in all directions) of a loudspeaker is unaffected by the presence of other cabinets in the array.

This free-field assumption leads to accurate predictions at mid and high frequencies. However, at low frequencies the sound field of a

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Simulation and application of beam-shaped... - *continued from page 29*

subwoofer is strongly affected by the radiation impedance (the acoustic load) and the cabinet diffraction. Both the acoustic load and the diffraction are defined by the size and shape of the array and the position of the loudspeaker in the array.

In practice, subwoofer arrays are often stacked on the floor or stage. Assuming the ground plane is acoustically hard and large compared to the acoustic wavelength, it can be modelled as a infinite baffle. At first sight it might be expected that the radiation pattern of the individual array elements does not change, and that the effect of the ground plane can be simply modelled by adding a mirror-image of the source. However, owing to the contact interface between the array and the ground plane, the sound diffraction around the array is affected too, because the 'path' under the array is now blocked.

From the above it is evident that the directional response of a subwoofer is not only affected by the array geometry, but also by the radiation condition (full-space or half-space). So, in order to model accurately and optimise a (differential) subwoofer array, the actual acoustic boundary conditions (ABC) should be taken into account.

Anechoic measurement of the radiation characteristics of a subwoofer under realistic radiation conditions is practically impossible because of the large array dimensions and unlimited number of variations in array set-up. Therefore, a computationally efficient, hybrid PSM-BEM approach was developed. The principles behind the PSM-BEM approach are reviewed below.

The PSM-BEM model

Using the acoustic Boundary Element Method[4] (BEM) it is possible to model diffraction and coupling effects for low and low/mid frequencies accurately. The BEM is based on the Helmholtz integral equation (HIE). On the basis of the discrete distribution of the normal component of the particle velocity at the boundaries of a radiating object, the sound radiation can be calculated in all directions outside the object. Unfortunately, direct implementation of the BEM into the DDA modelling software would lead to dramatically increased computation times.

The idea behind the PSM-BEM approach is the following. Exactly as in the PSM, the array is modelled as a set of directional point sources. In contrast to the PSM, the spectral and directional behaviour of each point source is no longer given by the measured free field response of the loudspeaker, but is replaced by BEM-calculated directivity data of the loudspeaker facing the actual acoustic boundary conditions. A prerequisite is that the volume velocity of a moving loudspeaker cone is unaffected by the acoustic load. As the particle velocity right in front of the cone and the ports is almost completely dictated by the driver, this is a valid assumption.

In order to model ground-stacked arrays, the half-space formulation of the HIE is implemented in the propriety BEM algorithms. The PSM-BEM model now handles flown subwoofer arrays, radiating into full-space, as well as ground-stacked arrays, which are facing half-space radiation conditions.

Calculation of directivity data

Procedure

Using the BEM, a library with far field radiation data of each AXYS subwoofer model has been pre-calculated for the most common acoustic boundary conditions. Each ABC is defined by three parameters: the number of cabinets in the array, the position of the active subwoofer in the array and the radiation condition (either full-space or half-space). The BEM calculation procedure followed is explained below.

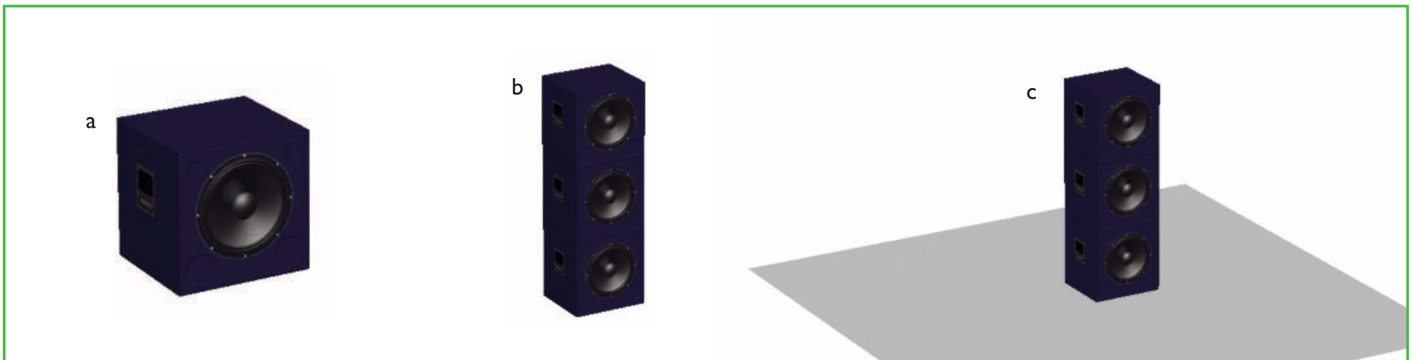

Figure 1

B-07 subwoofer facing different acoustic boundary conditions:
(a) As a single unit, 'free-field' condition (b) First unit in a 3-unit array, '3U1' full-space condition (c) As b) but ground-stacked, '3U1' half-space condition

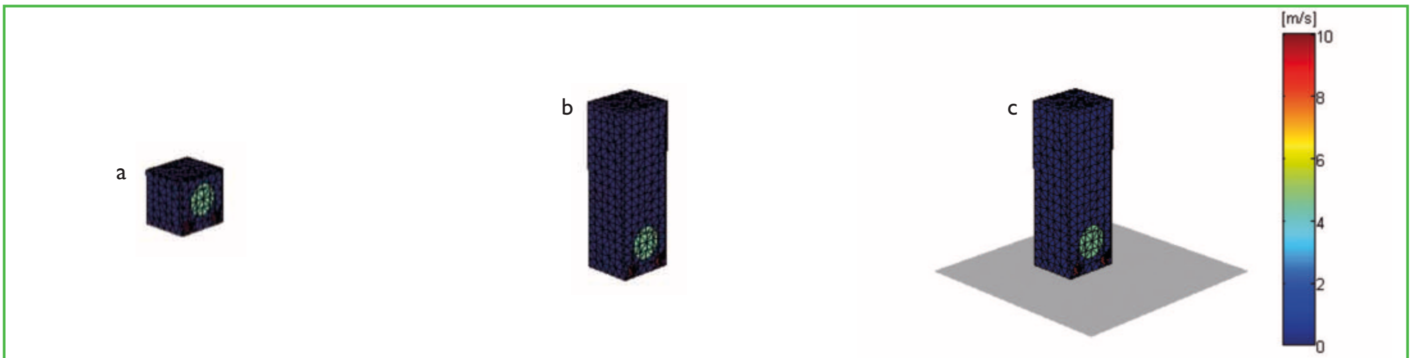

Figure 2

Measured normal particle velocity @80Hz for a B-07 subwoofer facing different acoustic boundary conditions: (a) 'free-field' condition (b) '3U1 full-space' condition (c) '3U1 half-space' condition

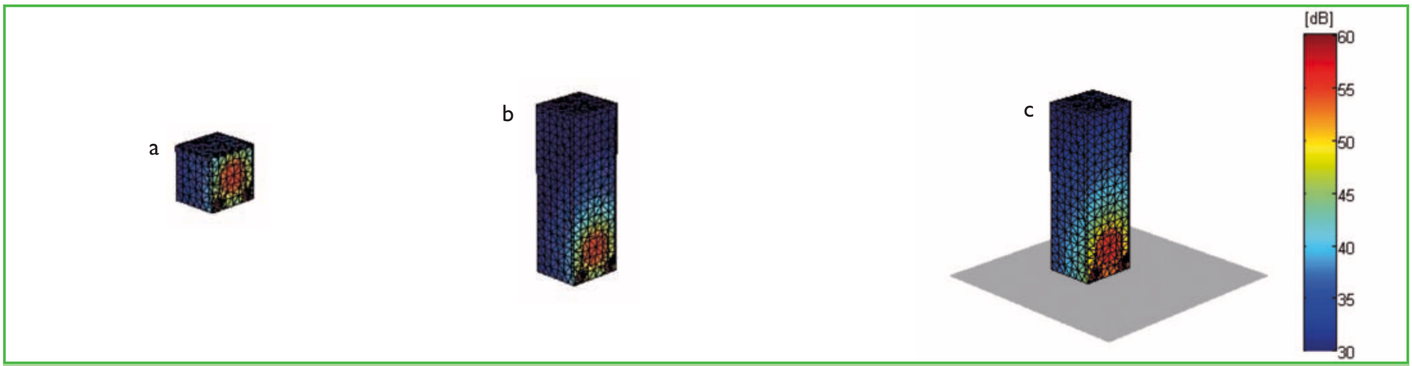

Figure 3

BEM-calculated SPL @80Hz for a B-07 subwoofer facing different acoustic boundary conditions: (a) 'free-field' condition (b) '3U1 full-space' condition (c) '3U1 half-space' condition

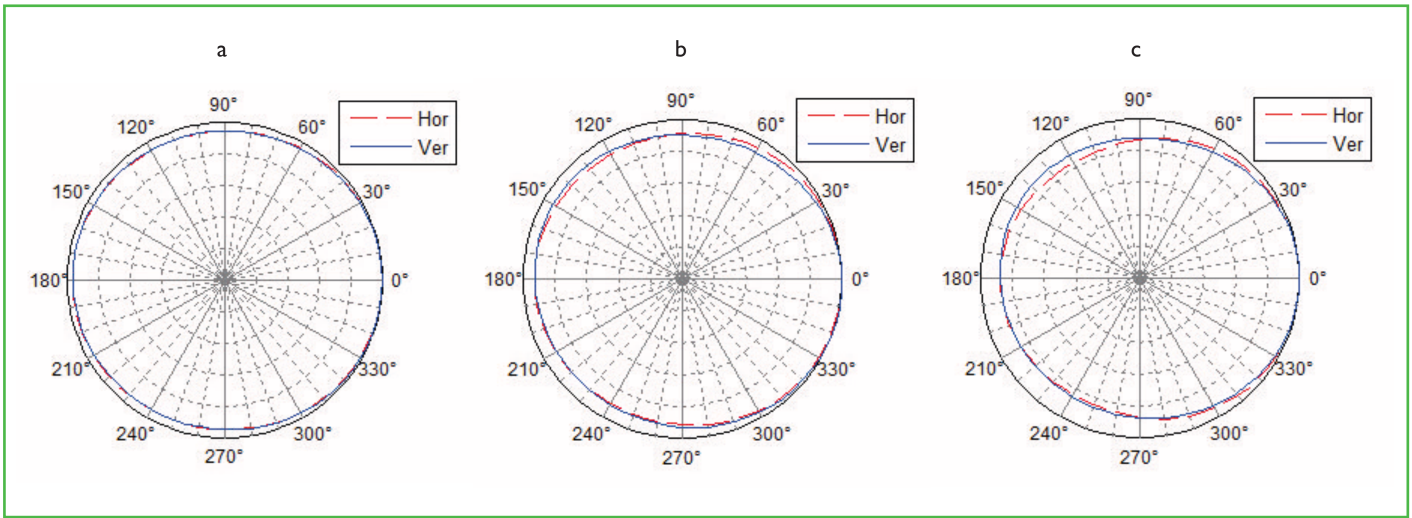

Figure 4

BEM-calculated polar diagrams @80Hz for a B-07 subwoofer facing different acoustic boundary conditions (scale: 6 dB/div): (a) 'free-field' condition (b) '3U1 full-space' condition (c) '3U1 half-space' condition

First, the normal particle velocity is measured just in front of the cone and the ports of the subwoofer using a pressure gradient microphone. As the particle velocity is assumed to be independent of the ABC, the measurements only need to be done for a single cabinet. Next, the boundaries of the array are partitioned into a large number of small boundary elements. The measured particle velocity data from the single cabinet is applied to one of the cabinets in the array. The velocities at the rigid parts of the active cabinet as well as at the boundaries of the inactive, neighbouring cabinets are set to zero.

In the next step the sound pressure at each boundary element is calculated by solving the discrete Helmholtz integral equation. Depending of the radiation condition, either the full-space or the half-space version of the HIE is used.

Knowing both the measured velocity and the calculated pressure distribution at the boundary elements, the complex far field directivity balloons can be calculated with the help of the exterior HIE. This is done by defining a spherical receiver grid (sampled every five degrees) centred around the active subwoofer. For both radiation conditions the full-space version of the external HIE is used, *ie* only the direct sound is processed into the directivity balloons. In case of half-space radiation, the reflection from the ground plane is modelled by adding a second, mirror-symmetrical point source.

The calculation procedure described above is repeated for each radiation condition.

Example

As an example, the BEM-calculation of the directivity data will be studied in more detail for an 18-inch subwoofer (AXYS B-07 model) facing three different radiation conditions.

First, the subwoofer is positioned in free-space as a single unit. This will

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Simulation and application of beam-shaped… - *continued from page 31*

be called the 'free-field' condition. Secondly, the subwoofer is supplemented by two additional cabinets, forming an array of three units ('3U1 full-space' condition). Note that only the first subwoofer (the lowest unit) is active. Only the presence of the upper two cabinets is studied here. Thirdly, the same three-element array is placed on a ground plane ('3U1 half-space' condition). The three radiation conditions are visualised in Figure 1 (a), (b) and (c).

The measured particle velocity at 80 Hz is shown in Figure 2 (a), (b) and (c) for an arbitrary input level. As already pointed out, the particle velocity in front of the cone and ports of the active subwoofer is independent of the radiation condition.

From the measured normal particle velocity data the sound pressure at the array boundaries is calculated. The results are shown in Figure 3 (a), (b) and (c) for the three radiation conditions. As expected, the sound pressure level distribution at the array boundaries is different for each of the three radiation conditions.

Using the measured normal particle velocity and the calculated pressure data, the far field complex 3D directivity balloon for each third-octave band (31.5 to 200 Hz) is calculated for the active subwoofer. The horizontal and vertical magnitude polar diagrams are shown in Figure 4 (a), (b) and (c).

Comparing Figure 4(a) and 4(b) it can be verified that vertical polar diagram of the '3U1 full-space' condition has become slightly asymmetrical, which is obviously a result of the asymmetrical position of the subwoofer in the array. In addition, the front-to-back ratio is higher compared with the 'free-field' condition. This can be explained by the larger front baffle of the array in comparison with the single unit.

Also note that the vertical directivity pattern for the '3U1 half-space' condition clearly differs from the '3U1 full-space' condition. Most striking is the higher front-to-back ratio for the half-space condition

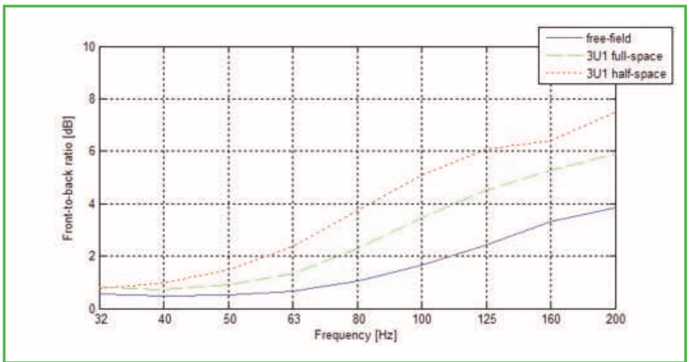

Figure 5

BEM-calculated front-to-back ratio of a single subwoofer facing different three different acoustic boundary conditions

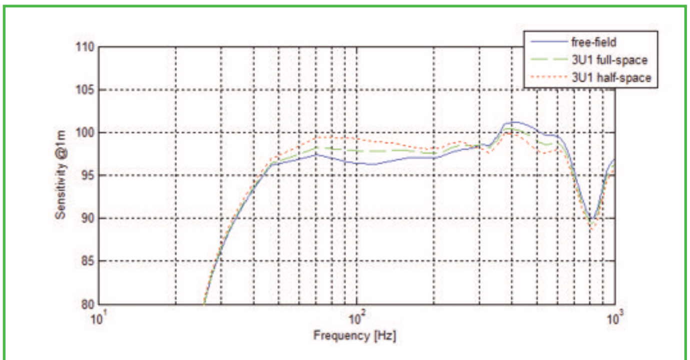

Figure 6

BEM-calculated sensitivity of a single subwoofer facing different three different acoustic boundary conditions

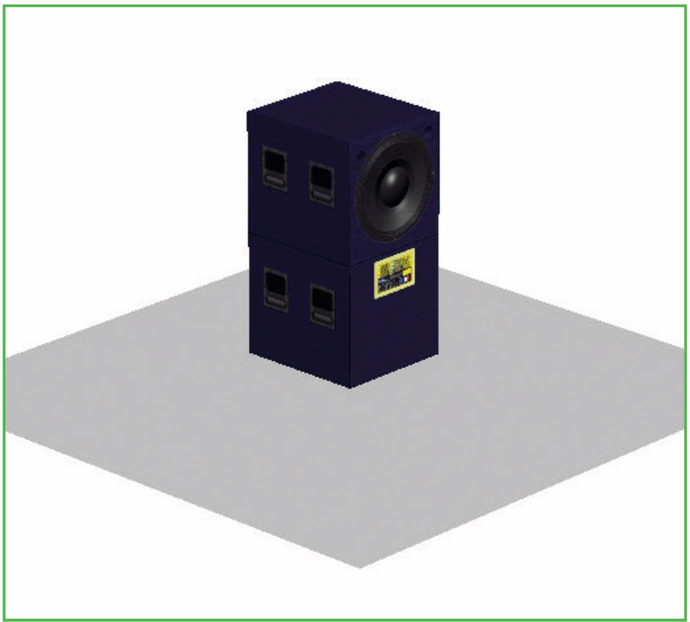

Figure 7

Differential subwoofer set-up of two B-121 units, placed on an acoustically hard ground plane

compared with the full-space condition, which will be explained in more detail below. Note that as already pointed out, the contribution of the reflected sound is not included in the balloons for the half-space condition, but will be modelled by an additional, mirror-symmetrical point source.

In order to make an easy comparison, the front-to-back ratios for the three acoustic boundary conditions are calculated as a function of frequency. The results are shown in Figure 5.

As expected, the F/B ratio increases with frequency for all conditions. Note that the F/B ratio for the '3U1 half-space' condition is higher than it is for the '3U1 full-space' condition. This can be explained by the changed diffraction of the sound waves around the array, as discussed above.

Besides the changes in directional behaviour, the BEM calculations show that the size of the array and presence of a ground plane also affect the sensitivity. To illustrate this, the unfiltered on-axis sensitivity (ie response at1m for a 2.83V input at the loudspeaker clamps) for the three conditions is shown in Figure 6.

As expected from the larger baffle size, the sensitivity for the '3U1 full-space' condition exceeds the 'free-field' sensitivity at low frequencies. The '3U1 half-space' configuration, in its turn, is slightly more sensitive than the '3U1 full-space' configuration. Note again that the contribution of the reflected energy has not been taken into account here as it will be modelled by introducing an additional point source.

Validation of the psm-bem model

In order to verify the validity and accuracy of the extended PSM-BEM model, outdoor measurements have been made on ground-stacked differential subwoofer arrays.

By means of the DDA software various radiation characteristics were DDS-optimised and modelled using half-space PSM-BEM subwoofer data. The DDS algorithm automatically balances the demands of matching the desired radiation pattern on the one side and maximising the total sensitivity of the array (*ie* the maximum output level) on the other side. In this way an accurate and robust solution can be found.

Measurement setup

The tested setup consisted of two ground-stacked, self-powered, DSP-controlled B-121 subwoofers. The upper 21-inch sub was aimed to the front while the lower sub was facing to the rear, as shown in Figure 7. The dimensions of the cabinets are 620mm high, 620mm wide and 676mm deep.

Using DDA, the radiation pattern of this array was optimised with various radiation patterns, of which the cardioid and the dipole setting are presented here. The on-board DSP can be controlled via the RS-485 network. Each setting was uploaded into a preset memory using the WinControl software.

During the measurements the subwoofer array was placed on the ground with a hard concrete surface. Impulse responses were taken at the ground plane along a horizontal semi-circle with a radius of 7m, starting in front of the array towards the back in ten-degree steps. The reflections from nearby buildings were relatively weak and sufficiently spaced in time from the direct sound, making it possible to use a time window of 75ms.

Cardioid setting

First, the differential array was optimised for cardioid radiation, as shown in Figure 8. The predicted and measured horizontal polar data for the cardioid setting are shown in Figure 9.

It can be verified that the match between the modelled and measured data is very good. At lower frequencies (40 to 80 Hz) the maximum backward rejection is found at 180 degrees. For higher frequencies the radiation dip moves slightly sideways. A backward rejection between 14 and 24 dB can be realised with this setup.

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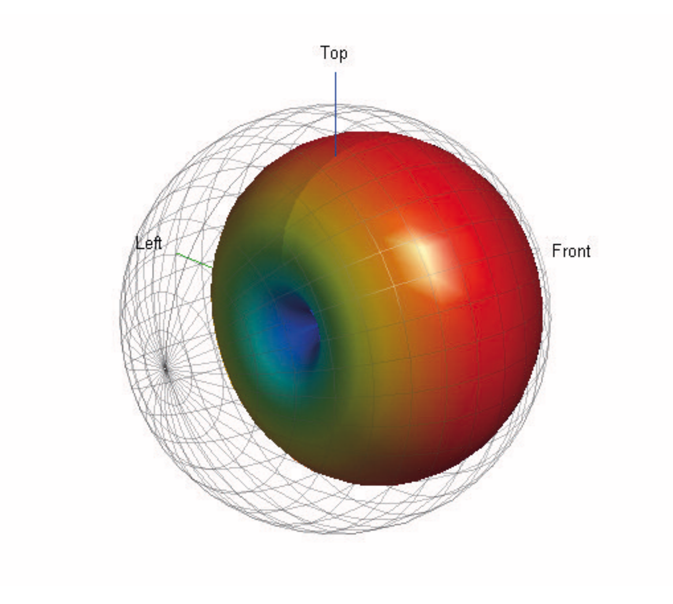

Figure 8

Desired cardioid radiation pattern

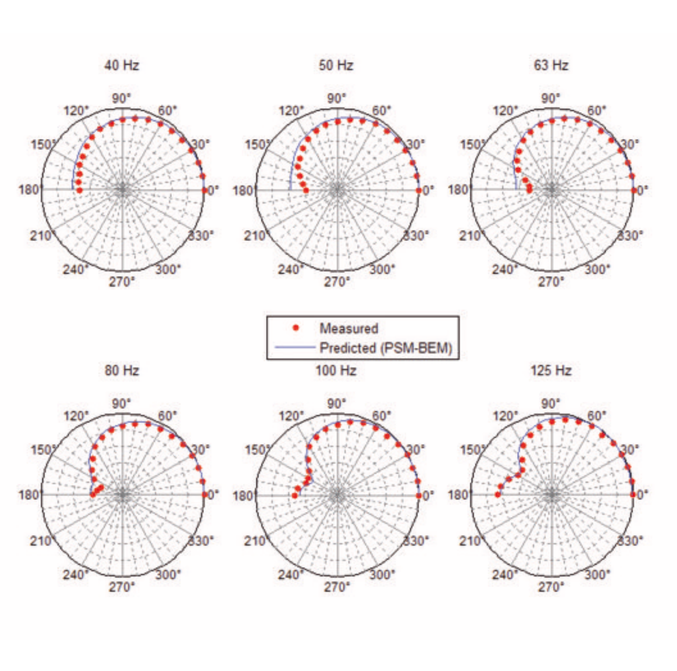

Figure 9

Measured and predicted horizontal polar data for a ground-stacked cardioid subwoofer array of two cabinets

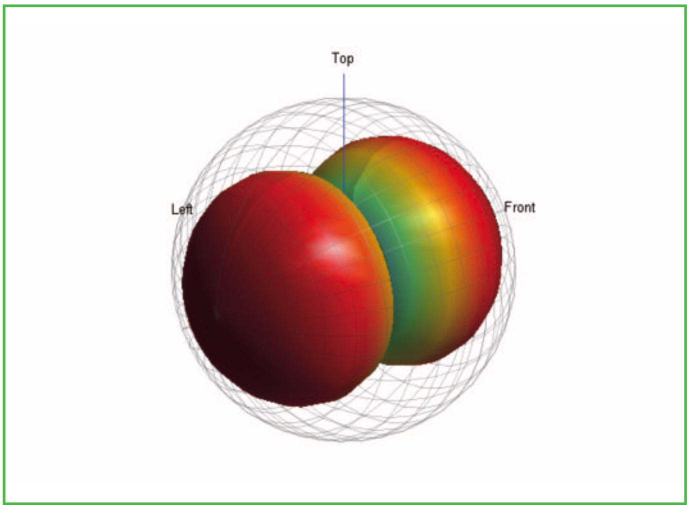

Figure 10

Desired dipole radiation pattern

Simulation and application of beam-shaped… - *continued from page 33*

By comparing the on-axis sensitivity of this cardioid differential set-up with a 'reference' summing array, consisting of two ground-stacked, front-facing subwoofers, only a 2dB reduction was found. This indicates that the efficiency and the robustness of the cardioid array are very good.

Dipole setting

The dipole directivity balloon is shown in Figure 10.

The prediction and measurement results for the dipole setting are shown in Figure 11. Again, the match between the modelled and measured data is very good. For all frequencies a strong side-ward reduction is found. The sensitivity of the dipole settings is slightly lower than for the cardioid setting: the sensitivity is now almost 4dB less than for the reference array.

Conclusions

In order to improve the acoustic modelling and optimisation of DDS-controlled, differential subwoofer arrays, the previously developed hybrid PSM-BEM model was extended. In addition to the existing full-space radiation condition, which is more valid for flown subwoofer arrays, a half-space radiation condition was introduced for ground-stacked arrays. Now, both the effect of the array geometry and the presence of a boundary plane such as a hard reflective ground plane can be modelled in the DDA software.

The validity of the extended PSM-BEM model has been tested by comparing simulations and measurements on ground-stacked, differential subwoofer arrays. Various directivity characteristics have been optimised, of which the cardioid and the dipole setting are presented in this article.

The directivity measurements confirm that the DDA predictions are very accurate. It has also been verified that these differential subwoofer arrays are very power-efficient and robust, and thus relatively insensitive to modelling errors.

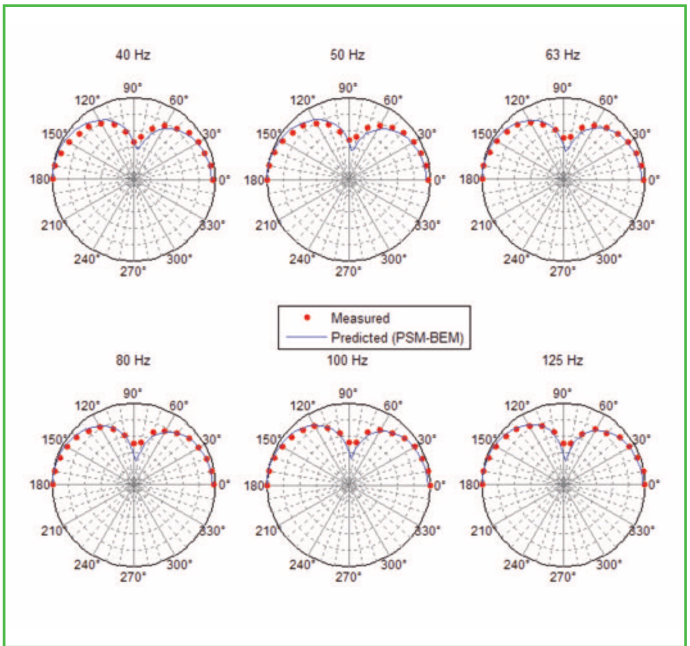

Figure 11

Measured and predicted horizontal polar data for a ground-stacked dipole subwoofer array of two cabinets

Evert Start is with Duran Audio BV, Zaltbommel, The Netherlands

This article is closely based on the paper he presented at Reproduced Sound 2010.

References

1. van Beuningen G W J and Start E W Optimising directivity properties of DSP-controlled loudspeaker arrays. Proceedings of the Institute of Acoustics (Reproduced sound) Vol 22 part 6 (2000), pp 17 - 37
2. Start E W and van Beuningen G W J Optimisation of DDS-controlled loudspeaker arrays using a hybrid PSM-BEM model. Proceedings of the Institute of Acoustics (Reproduced sound) Vol 27 part 5 (2005)
3. Borwick J Loudspeaker and Headphone Handbook. Butterworth & Co. (Publishers) Ltd. (1989)
4. Mechel F P Formulas of Acoustics (2002). Springer Verlag

A TV demonstration of sound absorption connecting the space shuttle to submarines

Timothy G Leighton, Jian Jiang and Kyungmin Baik. **Acoustics in 'Engineering Connections'**

In 2009 we were invited to provide an item for the BBC TV programme 'Engineering Connections with Richard Hammond', to be broadcast in 2011. Each episode in the series considers a single engineering masterpiece, and examines the host of previous engineering innovations which provided the necessary background for (or which nicely illustrated in hindsight) the engineering solutions employed to make the masterpiece work. The enquiry was for a programme about the space shuttle. The production team (Darlow Smithson Productions) had heard that acoustic energy generated at launch could, without mitigation, be damaging to the protective tiles on the shuttle, or to instrumentation within, or carried by, the shuttle. We were asked to provide a demonstration on this acoustical aspect of the shuttle (Figure 1).

Figure 1

Space shuttle launch

Following the filming, it was suggested that the technical aspects of the build be written up for a special 'Education in Acoustics' issue of the *Journal of the Acoustical Society of America*, and readers are advised to consult that paper for details. However the current article was suggested to explain the applications of the acoustics contained in that demonstration, those applications being the focus of the TV show. A secondary aim of this article is to describe the process of getting the demonstration to work for the TV show, outlining the constraints and solutions for those wishing to undertake such a task in the future.

The overriding factor was that, rather than coming to film us, the TV company required that we take the demonstration to them as just one item in a packed day of filming. Hence the apparatus would have to be transportable, be constructed quickly on site, and work first time. This resembles the field work that many practising acoustical consultants undertake (as opposed to the laboratory experiments of a controlled academic environment), although without the benefit of familiar commercial equipment or prior experience. Because we were a small

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A TV demonstration of sound absorption… - *continued from page 35*

component of the show, the date depended on the availability of the presenter and others, and so the actual filming date was set at short notice. The budget was small, and covered not much more than the hire of the Ford Galaxy we eventually used to transport the demonstration. The apparatus therefore had to be constructed from items we already had to hand. A series of telephone conversions with the programme's researcher, Rachel Millar, established that an appropriate narrative (with practical demonstration) was feasible.

That narrative had to link the sound suppression system at the shuttle launch with what could feasibly be built from our current apparatus, maintaining the priority that the story, facts and explanations had to be scientifically rigorous and factually correct. Furthermore, the narrative had to be compelling and understandable to an audience of young viewers, whilst of course remaining entirely honest in the extent of the link between the technologies and the explanations of how the science works.

The sound suppression system used at shuttle launch makes use of the effect of the rocket exhaust on a large mass of water. There is a hole in the surface of the launch pad, and below that hole is a 'flame trench' which channels the rocket exhaust away in a controlled manner. Following loss of 16 tiles and damage to orbiter components through sound generation during the launch of the first shuttle (STS-1), a sound suppression system was introduced. Just before launch, the flame trench is filled with over 1000m3 of water (1000 tonnes) in around 40 seconds (Figure 2). When the exhaust interacts with this water, there are several potential mechanisms by which the acoustic energy reaching the shuttle itself is reduced. Only one of these mechanisms (sound absorption by water droplets) satisfied the practical criteria, that it could be

(i) safely illustrated to an audience of children;
(ii) built within the budget, without purchasing specialised equipment;
(iii) incorporated in a demonstration which could be linked to another engineering innovation in an exciting, comprehensible and truthful narrative;
(iv) packed away and transported in a family car; and
(v) reconstructed and operational in around 30 minutes (the timescale required for meeting our filming slot).

Illustration of this one mechanism was deemed sufficient, as the other important mechanisms could not satisfy the above criteria. Such mechanisms include the entrainment of the liquid into the flow and its evaporation[1-3]. This represented the major compromise, since the reduction of the sound source level of the jet (by decreasing jet transfer through momentum transfer between liquid and gaseous phases, and reduction in jet temperature through partial vaporisation of the water)[4,5] was probably more important to mitigating acoustic damage to the shuttle and its component, than was the acoustic absorption that occurs during transmission as a result of the water droplets.

If the space shuttle launch was to be the end point of the narrative, the historical engineering innovation which would explain sound absorption by liquid droplets had to be found. In discussion with Rachel Millar, it was agreed to demonstrate the underlying physics of the mechanism we could illustrate (see above) through analogy with the anechoic linings of submarines. The lining was first designed in response to the effectiveness of the Allied anti-submarine activities, which the Germans attributed to advances in Allied sonar, but which is likely to have been due to other factors (including the cracking of the Enigma code). The tile shown in Figure 3 is from a World War II U-boat. The far side of the tile is smooth, but the side visible in the picture was glued to the hull, trapping air in its circular pores to form bubbles. The technique is acoustically effective, though in early versions the tiles debonded from the hull under pressure cycling.

Figure 2

The photograph shows the testing of the system to fill the flame trench with over 1000m^3 (1000 tonnes) of water in around 40 seconds, shown here covering the mobile launcher platform on Launch Pad 39A (photo courtesy of NASA/KSC).

Figure 3

One of the authors (TGL) and TV presenter Richard Hammond with a piece of anechoic tiling from a WWII German U-boat (detail inset).

Figure 4

(a) The apparatus is reassembled, having been taken to a barn for the filming of a TV show. The build has sufficiently simple components that supervised children can learn through assisting to set it up (the photograph shows JJ and TGL's children). (b) Detail of the mounting of the loudspeaker in the air-filled tube, when sponge is rolled about the loudspeaker cables and squeezed into the pipe base to seal it. (c) Fog made by pouring hot water into dry ice. The plastic jugs shown here are not safe for repeated usage as the thermal cycling shatters them.

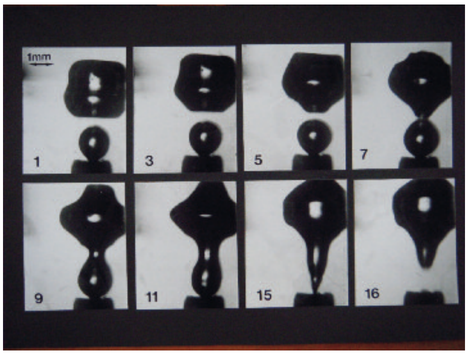

Figure 5

Selected frames filmed as air bubbles are injected into water, at a flow rate of 0.2ml/s, through a metal nozzle of external diameter 1.6mm with a bore of 0.5mm. Frames with consecutive numbers would have inter-frame times of 0.22ms. Frame 1 shows a newly-released bubble above its successor which is growing at the nozzle tip. The growth rate is sufficiently great, and the rise speed of the newly-released bubble sufficiently slow, for the two to merge in frame 7, such that the resulting bubble is released in frame 16: if it is not large enough to rise sufficiently fast, it too may merge with the next successor bubble (from reference [9]).

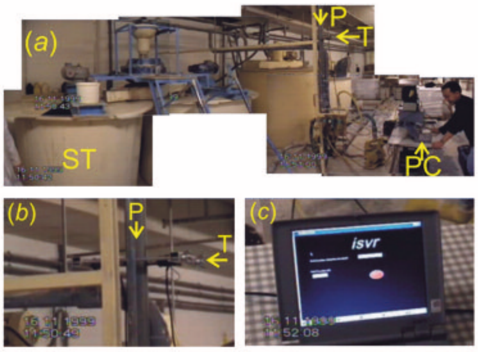

Figure 6

Frames from a video sequence filmed at the Bridgewater Pottery (Stoke-on-Trent, UK) during testing of the prototype on 16 November 1999. (a) Slip flows from the settling tank (ST) through the pipelines. The transducers (T) are attached outside one particular downpipe (P). The output of the receiver transducer is monitored by student Geun Tae Yim on a PC. (b) Detail of the pipe and transducers. (c) The 'light' on the PC has switched from green to red following the addition to bubbles to the flow. The Bridgewater tests were the first in the development of the prototype (the device was subsequently tested at six other potteries around Europe). In later trials the PC was replaced by a stand-alone unit (from reference [11]).

Bubbles are well-known to absorb sound extremely effectively, and so the demonstration was designed to show absorption of bubbles in water (linking to the submarine lining), and absorption of water droplets in fog (linking to the shuttle launch). Two vertical PMMA (Perspex™) tubes were to be placed side by side, one filled with water and the other with air (seen on location in the background of Figure 3). Each tube had a sound source at the bottom and a sound sensor (a microphone in the air column, and a hydrophone in the water column) at the top. The same signal was to be used to drive each source (the actual acoustic signal emitted by each source being slightly different because of the response of the source and amplifier), and travel up the tube to be monitored by the microphone/hydrophone (coupling between the fluid and the walls, and reflections in the pipe, changing its form[6,7]). The introduction of bubbles into the water column would then attenuate the sound more than would the introduction of fog into the air column (because the bubbles provide at least one extra potent

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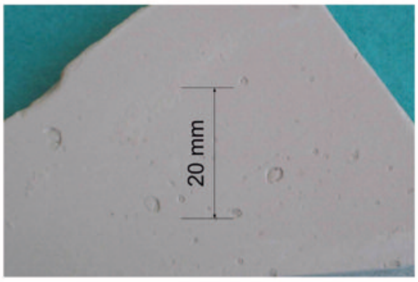

Figure 7

Photograph of a sample of defective ceramic, showing 'pinholes'.

Figure 8

Schematic of the Spallation Neutron Source at Oak Ridge National Laboratory, Tennessee. The hydrogen ions for the linear accelerator are generated in the 'front end' building at the top left of the picture, and are accelerated down the linear accelerator (shown in red) to the ring, where protons are accumulated. During repeated circulation of the ring, more protons are added to 'pain out' the complete 9-inch diameter proton beam. When this is complete (which occurs 60 times per second), the proton pulse is released into the 'target' building, the centre of which houses the sarcophagus in which the actual mercury target is housed. A possible future target building is shown in ghost outline.

A TV demonstration of sound absorption... - *continued from page 37*

mechanism for sound absorption). This effect would be detected by the microphone/hydrophone, and then explained to the audience to link the space shuttle to the submarine in a way which makes the underlying physics clear. The apparatus is shown under construction on location in Figure 4.

Details on how the apparatus is constructed, and the signals designed, can be found in reference [1]. Practical details range from the mundane to the subtle. For example, the air-filled tube needed to be sealed at the base (Figure 4(b)), and fitted with an exhaust pipe to allow displaced clean air to vent from the base of the pipe, so allowing the fog to fall to the base of the pipe and completely fill it. At the other extreme, the choice of signal had to be selected such that it would be audible to the audience when no bubbles or fog were added, but be dramatically attenuated when fog and bubbles were added. This proved challenging, since there was not great flexibility in the bubble and droplet populations that could be generated with the simple apparatus to hand. A relatively high frequency audio signal was required, which was sufficiently characteristic for the audience to latch onto it above the background noise. An upwards linear chirp sweep from 10 kHz to 20 kHz was chosen since it was sufficiently high to produce attenuation that could be heard by the listeners, but not so high as to be difficult for a wide age range of listeners to hear. The chirp is repeated every second to facilitate the audience in hearing the changes due to addition of bubbles/droplets. Rather than try to enable the audience/viewer to hear the sound emitted directly by each tube, it was most convenient to let them listen to the output of the microphone/hydrophone (which for the TV show was fed directly to the sound channel, but for live audiences can be transmitted by loudspeaker or, if feedback is a problem, by headphones).

Having found a signal which can be heard by the audience in fog-free and bubble-free conditions but which is dramatically attenuated by the fogs we could easily make (Figure 4(c)), the objective was to ensure that we could make a bubble population which would also dramatically attenuate the signal. This bubble population would need to one that could easily be injected into the water pipe using a standard portable compressor and hypodermic needle. The difficulty here was that this required bubbles which are smaller than those produced by simple injection[1]. Simply reducing the bore of the hypodermic needle does not produce smaller bubbles: although a small bubble might initially be released from the needle, it does not rise sufficiently rapidly under buoyancy to prevent it coalescing with the next bubble that is growing at the needle tip (Figure 5). The result is that the only bubble that can rise away from the needle swiftly enough to avoid any more coalescence is one that has already grown large through such coalescence. The solution was to place the vibrator from a mobile phone on the needle outside the pipe at such a position as to produce maximum displacement at the needle tip. This removed the successor bubble growing at the tip away from the location of the newly released bubble, and enabled sufficiently small bubbles to be generated (for details, see the reference list[1,9] and the video at the associated web page).

As stated above, the low budget required that the demonstration be adapted from existing equipment. The two-tube apparatus for this experiment was readily available as it had been built for previous projects on developing sensors to measure bubble populations in pipes. These two projects (for potteries and the neutron generation industry) nicely illustrate further applications linked to the acoustic absorption of bubbles demonstrated for the TV show. The first of these previous projects been to build sensors that could be clamped onto the outside of pipes in potteries to measure the bubble population within the pipe (Figure 6)[10]: when liquid ceramic 'slip' is pumped from settling tanks into moulds, any bubbles in the slip will expand when the product is fired in the kiln, producing defects and holes in the resulting pottery product (Figure 7). This is extremely wasteful as the problem is currently not discovered until after firing, meaning that many hours of production can have been wasted. Moreover the undetected bubbles generate defective product which cannot be recycled into new slip. Ultrasonic sensors were developed for the industry to detect such bubbles in the pipeline before they reached the mould[11]. This system was then adapted for a second project (using the two vertical tubes re-enlisted for this TV demo) to provide bubble detectors for the $1.4 billion Spallation Neutron Source (SNS) at the Oak Ridge National Laboratory, Tennessee, the most powerful pulsed spallation neutron source in the world (Figure 8). In this facility, a 331m long linear accelerator (linac) accelerates beam pulses of H- ions to almost 90% of the speed of light. These ions are stripped of their electrons upon entering a pulse accumulator ring that combines 1000 linac pulses into much larger pulses of protons. These proton pulses – shorter than a micro-second – are ejected from the ring at 60Hz towards the neutron generating spallation target. The produced neutrons emanate out of the target into a reflector/moderator assembly than serves to collect as many neutrons as possible and cool them to energy levels of greatest utility to the suite two dozen research instruments. Neutron instrument capabilities are largely constrained by the neutron flux that can be sent to samples to be studied. In a spallation source, higher flux can be achieved by increasing proton beam power on the target.

In traditional spallation neutron sources, a typical target material would be a high density solid (e.g., lead or tungsten) cooled by water. Cooling is necessary as the proton beam volumetrically deposits thermal energy with each pulse. While higher proton power will increase total neutrons produced in a solid target, the commensurate need for greater cooling water volume fraction limits the desired payoff in neutron flux. Liquid metal targets side step this limitation since circulation of the metal through a heat exchanger removes the beam energy without dilution of neutron flux.

Mercury (atomic number *Z* 80; melting point -38.83°C) was selected for the SNS because of its attractive spallation neutron production and room temperature liquid state. It is circulated through a stainless steel

Figure 9

TGL and Mark Wendel of ORNL fit bubble detectors to the mercury-filled steel pipelines of the ORNL SNS test loop. The large khaki pump in the foreground is a candidate bubble generator for the neutron source.

target vessel where the proton beam is directed and the spallation reaction occurs. A process system circulates some 20 tonnes of mercury that can accommodate 2 MW of proton beam power on target. The target vessel is designed as a replaceable component because radiation damage eventually embrittles the steel. Another problem - recognised at a late time in facility construction - is cavitation damage of the steel vessel that is due to intense pressure pulses caused by the micro-second beam pulses. On this timescale the heated mercury is inertially confined such that tremendous pressure (up to 40MPa) results. During the time subsequent to the pulse, this pressure interacts with the vessel whereupon rarefaction waves cause significant tensile pressure - *tensile* pressure that leads to mercury cavitation.

Cavitation bubble collapse near the vessel wall has been observed to erode an interior SNS target vessel wall. Failure of a mercury vessel *outer* wall - while not a credited containment boundary - would require immediate change of the target which has consequences for the neutron science user program and cost (procurement and waste disposition). The erosion rate is apparently strongly dependent on beam power. As SNS operations mature there is a risk that this cavitation phenomenon will limit a target's useful life more severely than radiation damage thus prohibiting the facility from achieving ultimate performance goals. One solution under development at SNS is to introduce non-condensable gas bubbles into the bulk of the mercury that can absorb the pressure pulse and attenuate cavitation formation. In this way, it is envisaged that cavitation bubble activity on the vessel walls is low energy, and erosion there is reduced. Using the two-tube rig, such sensors were developed and fitted to an SNS test facility to assess small gas bubble populations generated in the mercury flow (Figure 9).

In summary, a real-world contract to exploit the absorption of acoustic waves by bubbles (at SNS) therefore produced the two-pipe apparatus which was readily adapted for the TV demonstration. The equipment was dismantled and driven to the Herefordshire on 19 February 2010. It was a snowy evening, and the equipment was unloaded from the car into the hotel room for the night. This was an important precaution for field work with such experimental equipment required to perform first time: had not been taken, the demonstration might have failed the next morning because of condensation on electrical terminals kept overnight in the car. The location for filming was a barn, and we requested in advance that electrical power, a table to support the rig, dry ice and hot water be provided (it would not have been safe for us to transport dry ice in the car for such a prolonged drive). With these in place, it took only 30 minutes to assemble the rig, and the filming was done in one

continued on page 40

A TV demonstration of sound absorption… - *continued from page 39*

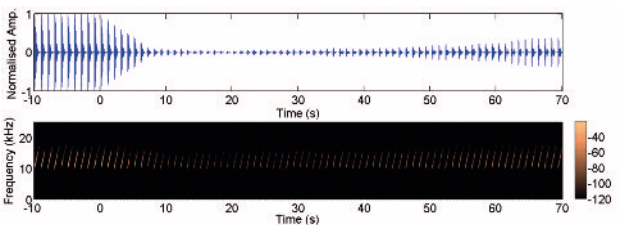

Figure 10

The upper plot shows the time history of the signal from the microphone which is at the top of the air-filled tube. The lower plot shows the corresponding time-frequency representation of the same data (shown on a common time base), in which the chirp can be seen as a line rising to the right, repeated every second. The fog is added to a previously clear tube at time t = 0. It fills the tube in under 10s, attenuating the chirp. After 90s the fog has substantially dissipated, and the received amplitude of the chirp has partially recovered. For clarity of presentation, the time series data have been normalised to zero mean and a maximum positive voltage equal to 1, which carries through to the time-frequency plot of this time series. The colour scale shows dB sound pressure level relative to 20 μPa rms recording of these data can be found at the web site [10].

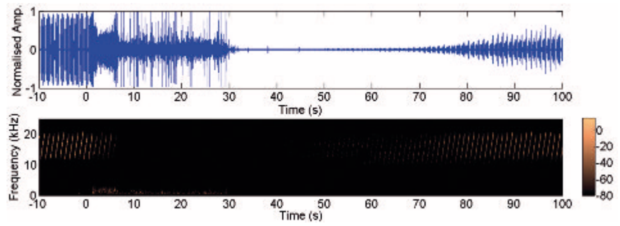

Figure 11

The upper plot shows the time history of the signal from the hydrophone which is at the top of the water-filled tube. The lower plot shows the corresponding time-frequency representation of the same data (shown on a common time base), in which the chirp can be seen as a line rising to the right, repeated every second. The bubbles are added to the previously bubble-free water at time t = 0. The addition of bubbles generates audio frequency injection noise, which is clearly visible in the time-frequency plot. More detailed analysis of these data shows that modes of the tube are excited, which rise in frequency as the rising cloud of bubbles effectively shortens the acoustically-active length of the pipe in which the hydrophone sits (see reference [1] for details). The chirp is significantly attenuated in under 10s as bubbles fill the tube, although injection noise continues for the 30s during which gas injection is maintained. The chirp slowly returns as bubbles rise out of the tube, although the small bubbles which remain after two minutes still generate significant attenuation. For clarity of presentation, the time series data have been normalised to zero mean and a maximum positive voltage equal to 1, which carries through to the time-frequency plot of this time series. The colour scale shows dB sound pressure level relative to 1 μPa rms. A recording of these data can be found at the web site [10].

continuous shoot. Such preparations and precautions are vital: there is a perception in parts of the media that academics are unreliable in generating demonstrations outside their laboratories, because such 'field' demonstrations do not work when filming begins. With such perceptions it is small wonder if TV companies risk little funding on academics, which can create a vicious circle of low-cost field demonstrations which then fail, supporting the perception. Planning can offset the limited ability to purchase bespoke solutions for field demonstrations.

Data are shown in Figures 10 and 11, and sound files of the effect of adding bubbles and fog are available at the web site[10]. Compared with the case when fog is added to air (Figure 10), the addition of bubbles to water (Figure 11) both attenuates the chirp more (because of additional absorption mechanisms) and contributes lower frequency sounds of bubble injection (addition of the fog generates no equivalent signal). A secondary acoustical effect demonstrated by this bubble injection is that, as the first bolus of bubbles rise up the tube, they effectively create an 'underwater organ pipe' which produces a note of rising pitch[1], clearly audible in the sound files[10]. Construction details for the rig, results, and explanations suitable for a young audience, can be found in reference [1].

Acknowledgement

The authors are grateful to Peter Birkin for comment and advice, to DSTL for providing the sample of anechoic tile, and to all those involved in the making of the BBC programme 'Engineering Connections with Richard Hammond'. We are especially grateful to Rachel Millar for useful discussions and suggestions regarding applications, and to the staff of Darlow Smithson Productions Ltd., to Richard Hammond, and to the technical, creative and administrative staff who worked on the production, and to the BBC. The authors are grateful for financial support and advice on applications from Bernie Riemer and Mark Wendel of the Oak Ridge National Laboratory, Tennessee (ORNL is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy), and Chris Densham, Ottone Caretta, Tristan Davenne and Tim Broome of the UK Science and Technology Research Council Rutherford Appleton Laboratory.

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References

1. T G Leighton, J Jiang and K Baik, 'Demonstration comparing sound wave attenuation inside pipes containing bubbly water and water droplet fog' *Journal of the Acoustical Society of America (JASA)*, 2011 (in press).
2. M Kandula, 'Spectral attenuation of sound in dilute suspensions with nonlinear particle relaxation', *JASA*, **124**(5), EL284-EL290 (2008) (doi: 10.1121/1.2987463)
3. M Kandula, 'Prediction of turbulent jet mixing noise reduction by water injection,' *AIAA Journal*, **46**(11), 2714- 2722 (2008)
4. M Kandula, 'Broadband shock noise reduction in turbulent jets by water injection,' *Applied Acoustics* **70**, 1009–1014 (2009)
5. V Moriniere , Y Gervais and J-L Peube, 'Numerical calculation of spectrum emission and jet noise reduction by injection of mass,' *Inter-Noise 95, Inst. of Noise Control Engineering, Newport Beach, California, July 1995*, pp. 273–276
6. E Zoppellari and D Juve, 'Reduction of jet noise by water injection,' *AIAA Paper* 97-1622 (1997).
7. K Baik, J Jiang and T G Leighton, 'Acoustic attenuation, phase and group velocities in liquid-filled pipes: Theory, experiment, and examples of water and mercury', *JASA*, **128**(5), 2610-2624 (2010).
8. J Jiang, K Baik and T G Leighton, 'Acoustic attenuation, phase and group velocities in liquid-filled pipes II: Simulation for spallation neutron sources and planetary exploration', *JASA*, 2011 (in press).
9. T G Leighton, K J Fagan and J E Field, 'Acoustic and photographic studies of injected bubbles, *European Journal of Physics*,' **12**, 77-85 (1991).
10. Institute of Sound and Vibration Research, *Educational demonstration of sound attenuation in a water-filled pipe*, www.isvr.soton.ac.uk/fdag/PIPE_DEMO/index.htm (last viewed 12 August 2010).
11. G-T Yim and T G Leighton 'The use of acoustics for real-time on-line monitoring of ceramic slip in pottery pipelines', *Proceedings of the Institute of Acoustics*, **28**(1), 862-875 (2006).
12. G-T Yim and T G Leighton 'Real-time on-line monitoring of ceramic slip in pottery pipe-lines using ultrasound', *Ultrasonics*, **50**(1), 60-67 (2010).

Vanguardia five years old

Consultancy continues to grow

Vanguardia Consulting reached its fifth birthday in May 2011 and staff were celebrating in style.

During these difficult times when many companies are struggling, Vanguardia has bucked the trend and is going from strength to strength, winning many major projects. The company first started trading on 2 May 2006 with only two members of staff: five years on and it has grown beyond recognition with twenty-one full-time consultants. Unsurprisingly the team quickly outgrew its head office in Oxted, so two years ago a second office was opened at London's South Bank University Technopark.

Vanguardia Consulting has won the noise management and control contract for all concerts in Hyde Park for the next two years. In competition, with eighteen other consultancies, the company has been awarded this prestigious contract. Royal Parks, the client, put the consultancy contract out to tender earlier this year. The winning proposal drew on the extensive experience gained by all staff members in recent years.

Hyde Park is on of the many events at which Vanguardia will be providing its consultancy advise this summer, and major tours such as Take That and Bon Jovi will be included.

Vanguardia Consulting are on
0207 922 8861

Urgent need for more women in science, engineering and technology

Smith Institute report published

There is enormous potential for the UK to meet the skills shortage in the science, engineering and technology sectors by increasing the number of women in the sector, says a new report by the Smith Institute. The report, edited by Meg Munn MP, is supported by three of the main SET professional organisations: Institution of Engineering and Technology, the Institution of Mechanical Engineers and the Institute of Physics.

Contributors to *'Unlocking Potential: Perspectives on Women in Science, Engineering and Technology'* argue that to meet the skills challenge requires much greater effort by the professions, business and government to attract more young women into the SET industries, and in particular more family friendly polices to tackle the very poor retention record.

Meg Munn MP says that women have moved into many of the professions previously dominated by men. It is now time for science, engineering and technology to act to ensure they are not losing out on the skills and talents of half the workforce.

The contributors to the report show:

- In 2008, of the 620,000 female science, technology, engineering and mathematics (STEM) graduates of working age only 185,000 were employed in SET occupations: 100,000 were either unemployed or economically inactive.
- A poll by the Institute of Physics found that seven out of ten female physicists who took a career break did so to have children. While 34% of all physicists left jobs to start families only 14% returned to the same post.
- Evidence shows that one of the main reasons why women are leaving the sector by their 40s is the poor work-life balance and the industry's culture.
- Technological change is one of the main reasons for productivity gains in developed countries and yet participation by women in the UK technology workforce has been falling (27% in 1997 to 21% in 2004).
- The decision by government to reduce the overall funding of support for this important area, following the cuts to the UK Resource Centre for Women in Science, Engineering and Technology, whilst showing a determination to protect the overall science budget shows a failure to understand the importance of investing in both women and science.

Much more can be done to improve this situation, including:

- Industry could do more to link up with schools;
- Careers for girls in SET must be shown to be interesting, exciting and rewarding;
- Flexible working practices have worked for businesses in attracting and retaining female staff (especially those who have taken time out when having children) and should be extended;
- Careers advice for those of all abilities must be improved to attract more females into the sector; and
- Better workplace culture is needed to end negative stereotypes.

Paul Hackett, Director, Smith Institute, said that the report was a wake-up call to government, business and the SET professions. For too long politicians had paid lip service to the case for stronger incentives to attract more women into these key industries. Meg Munn MP has written to Rt Hon David Willetts MP (Minister of State for Universities and Science) calling on government to establish a high-level commission on women in science, engineering and technology (a copy of the letter is attached).

Clare Thomson, Curriculum Support Manager, Institute of Physics said that it was a major cause for concern that the proportion of girls studying physics post-16 had remained around 22% for the past 20 years, as A-level physics, or its equivalent, was a gateway subject to a whole range of careers in the physical sciences, engineering and technology, as well as in many other areas of finance and business.

Research by the Institution of Engineering and Technology due to be published in the next few weeks is expected to show there has been no change in the number of women engineers in the UK.

The report *'Unlocking Potential: Perspectives on Women in Science, Engineering and Technology'* was edited by Meg Munn MP. The authors include Sandi Rhys Jones OBE, Prof Athene Donald, Sue Ferns, Dr Katie Perry and Deidre Hughes. The report was launched at the British Academy on 8 June 2011. The speakers included Arlene McConnell (IET Young Woman Engineer of the Year), Stephen Tetlow (Chief Executive, Institution of Mechanical Engineers), and Prof Christine Davies (Chair of the Diversity and Inclusion Committee, Institute of Physics). A PDF version of the report is available from **www.smith-institute.org.uk**.

The Smith Institute is a leading independent think tank which promotes progressive policies for a fairer society. It provides a high-level forum for new thinking and debate on public policy and politics. The Institution of Engineering and Technology is one of the world's leading professional societies for the engineering and technology community, which provides a global knowledge network to facilitate the exchange of ideas and promote the positive role of science, engineering and technology in the world.

The Institution of Mechanical Engineers is the fastest growing professional engineering institution in the UK. Its 80,000 members work at the heart of the country's most important and dynamic industries. The Institute of Physics is a leading scientific society promoting physics. It works to advance physics research, application and education; and engages with policy makers and the public to develop awareness and understanding of physics.

Armstrong offers a master class in ceilings

Acoustical control products in demanding environments

A new guide to ceiling and wall systems appropriate for the particularly demanding environments of educational buildings has been launched by Armstrong Ceilings.

Schools and universities have to meet a plethora of acoustical, health and safety, indoor quality and maintenance criteria, but at the same time, the student experience in contemporary education must be made as productive as possible.

To meet these requirements, Armstrong (a member of the British Council for School Environments, and sponsor of the *Big school makeover* programme) has produced a three-pronged education kit that reassures architects and specifiers of its continuing commitment to this sector.

The kit consists of an Education segment brochure, education interactive flash (see **http://www.armstrong-ceilings.co.uk/commclgeu/eu1/uk/gb/**) and updated education CPDs.

These three tools advise how the staff experience, as well as the student one, can be designed into education spaces using mineral, metal and wood ceiling and wall systems and canopies to optimise factors such as acoustics, natural daylight, health, safety and longevity.

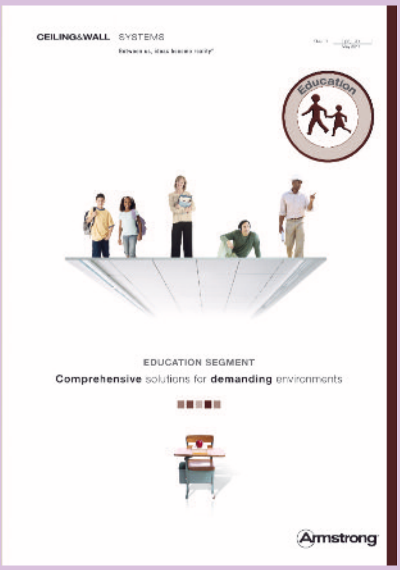
The 20-page brochure has been designed to simplify the specification process and advises specifically on acoustical solutions for education spaces ranging from classrooms and quiet areas such as libraries, through offices and corridors to humid areas such as canteens, toilets and cloakrooms. As architects are increasingly interested in environmentally-friendly solutions, it also details the recycled content of appropriate solutions, with Armstrong's Optima canopies coming out best with an 82% recycled content.

Case studies detailing how Armstrong helped specifiers to meet education performance criteria such as sound absorption and attenuation, scratch resistance, humidity, fire resistance and washability at sites such as Bolsover and Brooksbank Schools, Harton Technology College, and Southampton Solent and Oxford Universities are included in the brochure.

The interactive education flash presentation **http://www.armstrong-ceilings.co.uk/commclgeu/eu1/uk/gb/** gives viewers the option to find appropriate solutions for individual education spaces. They are then advised on the performance criteria of these rooms, with PDFs available to download, and examples through case studies of how these have been put into practice. The case studies are also accessible directly from the home page if required.

A total of four CPDs detail Armstrong's education philosophy dubbed 'ABLE' (*ie* a better learning environment), the role played by suspended ceilings in acoustics, suspended ceilings and the environment, and a guide to building acoustics.

Wall-E goes through its virtual paces



Brochure for the education market segment

Armstrong introduces an animated robot

Watch out Wall-E! Armstrong Ceilings has produced an animated robot to advise architects and interior designers on acoustical ceilings and walls. The engaging little chap, Alph-E, wings his way around Armstrong's new acoustics mini-site **www.acousticalceilings.co.uk** helping to explain why Armstrong's key concept of acoustic comfort relies on the three letters ICC (intelligibility, confidentiality and concentration).

The site shows how the correct use of ceiling and wall treatments to optimise acoustics means that building users can be understood, but not overheard or disturbed, and explains how the manufacturer's portfolio of three dedicated ranges of ceiling tiles meets these individual requirements.

For instance, the standard range of medium-density ceilings strikes a balance between blocking unwanted noise from outside while enhancing sound quality inside building interiors such as classrooms and conference rooms. The 'dB' range of higher-density ceilings minimises noise transfer between rooms, helping to keep conversations private in building interiors, especially private rooms and cellular offices.

The 'OP' range of lower-density ceilings controls excessive sound reflections, offering customers optimal levels of sound absorption in building interiors such as open plan spaces and libraries.

To complement these passive acoustical treatments, Armstrong's mini-site recommends active acoustics or i-ceilings that incorporate services such as public address systems. Other Armstrong products featured include mineral, wood and metal tiles and canopies. Sections on education, healthcare, retail and leisure, transport and offices each provide information including data documentation, case studies and tools such as a calculator that recommends the number of canopies required to achieve a desired reverberation time.

Sound tests are to the fore in all these sections, comparing the reverberation times in, for example, classrooms, school canteens, banks and restaurants.

A glossary and list of FAQs complete the expert advice available on Armstrong's acoustical mini-site.

Soundproof Studios

Get the most from your audio!

Soundproof Studios is very proud to announce the launch of a new web site at www.soundproofstudios.co.uk

Soundproof Studios is a division of the long-established architectural and domestic acoustic insulation company Sound Reduction Systems Ltd. It is dedicated to sound insulation and absorption in a variety of specialist areas, including commercial recording studios, home recording studios, professional cinemas, home cinemas, bars, restaurants, nightclubs and music venues. Soundproof Studios has identified these areas as places of particular acoustical sensitivity, where the best soundproofing and acoustic absorption products are required to ensure the venue can operate to its greatest potential.

What sets Soundproof Studios apart from most of the other companies in this specialist field is that the company develops and manufactures soundproofing and sound absorption products. The staff understand acoustics and the industry-leading technical team has academic qualifications and practical experience in the field. All the advice clients receive is free of charge, and team members are happy to talk through any project, past, present or future.

Email **info@soundproofstudios.co.uk** or phone **01204 380074**.

Soundproof Studios has exclusive access to the best performing acoustical products on the market, such as the acoustic building board Maxiboard, for walls and ceilings, high performance acoustical underlay Acoustilay, and state-of-the-art Sonata acoustic absorbers, including Sonata Vario. The comprehensive product range includes acoustic treatments for floors, walls and ceilings and a range of accessories including bass traps, isolating plinths, acoustic lighting hoods and acoustic socket and switch boxes.

For fast, free and friendly professional advice on any acoustic insulation or sound absorption issue, get in touch or visit **www.soundproofstudios.co.uk**. Soundproof Studios is passionate about audio.

Brüel & Kjær goes green(er)

Sound and vibration expert gains environmental ISO certification

Brüel & Kjær Royston, commonly associated with the colour green owing to the colour of its instruments, is now officially greener, as the company has become ISO.14001 certified.

ISO.14001 is a series of international standards on environmental management, and the ISO.4001 part specifies a system of Environmental Management controls against which an organisation can be certified by a third party. Brüel & Kjær's Royston site, which includes LDS Test & Measurement Ltd, was successfully certified against this system by the BSI. As a result of implementing ISO 14001, Brüel & Kjær's UK operations are committed to being environmentally responsible in order to meet legal requirements and those from its customers.

The company will meet its environmental objectives using specified strategies, which includes managing its resources to minimise raw material usage, correctly disposing of waste, reducing harmful emissions and promoting energy conservation and recycling. Where possible, Brüel & Kjær Royston will use components, materials or substances that are less harmful to the environment and raise this awareness amongst its employees, to enable them to carry out their work with the same consideration.

Brüel & Kjaer's Head of Operations (UK) Andrew Turner said that the organization was delighted to achieve this accreditation and join the Naerum facility, which had been ISO.14001 compliant since 2009. These changes, implemented at ther UK site in Royston, meant that the facility for manufacturing and servicing shakers - and the calibration laboratory - were now fully 14001-compliant.

Brüel & Kjaer recognised the principle of sustainable development and had consequently established a system with the purpose of managing all significant environmental aspects of activities, products and services, thereby controlling environmental impact from its activities, preventing pollution, continually improving the overall environmental performance and encouraging its suppliers to do the same.

In order to retain the ISO 14001 certification, a yearly review will be carried out by top management of the company's environmental performance and improvements.

Advance your acoustics knowledge

Brüel & Kjær supports ISVR advanced acoustic training

Brüel & Kjær is pleased to announce its support of the Institute of Sound & Vibration Research (ISVR) 2011 Advanced Course. This consists of a three-day core element which is preceded by an optional two-day refresher in the principles of vibration and acoustics. Following completion of the refresher segment, attendees then select their training schedule from a choice of three, specialist areas including noise control, structural dynamics and aeroacoustics.

The noise control course outlines the underlying principles of noise control, examines the character of noise in some key applications - and discusses how noise may be reduced by design or through palliative treatment. It is divided into three sections entitled basic principles, techniques and applications, and case histories.

Structural dynamics helps delegates to appreciate more fully the nature of structural dynamics and provides an overview of the potential and applicability of some measurement and analysis techniques. It includes a series of presentations and a half-day, hands-on laboratory session.

The advanced course for aeroacoustics provides a sound practical basis for acousticians and engineers working at an advanced level within areas such as turbomachinery noise, aerodynamically generated noise in ducts and air moving systems, noise generated by unsteady flow over airframes and motor vehicles, and noise generated by unsteady turbulent mixing in jets and wakes.

All the training sessions will be held between 12 and 16 September at the University of Southampton's Highfield campus.

Further information and registration details can be found at the ISVR web site: **http://www.isvr.co.uk/courses/index.htm**

For other information, please contact **01763 255 780** or **ukinfo@bksv.com**

Gilcrest launches into acoustic panels market

Puracoustic insulated panels now available

Bristol-based Gilcrest Group has launched Puracoustic, a new business specialising in the manufacture and installation of insulated acoustic panels. The Gilcrest Group includes three other businesses: Stancold, Panel Projects and ProjectLink.

Puracoustic offers a complete package for all acoustic requirements from acoustic surveys, design and planning through to manufacture and installation.

Gilcrest brings together its long-standing installation business, Stancold plc, and technical expertise from its bespoke composite panel manufacturer Panel Projects. The new Puracoustic team builds on this experience to offer cost effective, flexible acoustical panel systems for all aspects of noise control.

As part of Gilcrest, which has been trading successfully for over 60 years, customers can be assured that Puracoustic will deliver a high quality product and service on time and on budget, according to Chief Executive Officer of Gilcrest, Kevin Gillham.

The organisation understands that different projects have different requirements, with Stancold having supplied temperature-controlled hygienic environments to Sainsbury's, Asda and the Cooperative. It now offers a wide range of standard acoustical panels as well as bespoke solutions which all achieve acoustical and fire-prevention specifications."

Panel Projects is a specialist producer of composite panels for the construction of clean rooms and other areas such as airport terminals, passenger lifts and shops. Project Link is the latest addition to the group's portfolio and provides turnkey construction services to the food industry. Puracoustic works with an extensive range of core materials and faces and its flexible manufacturing process allows it to offer fast turnaround and bespoke panel sizes.

For more information visit **www.gilcrestgroup.com**.

Specialist composite panels

Bespoke solutions to achieve acoustical specifications

Obituary

Alison Longstaff

It is with sadness that I record the passing of Alison at the young age of 41 on 20 May 2011, following a long battle with leukaemia. Alison Gray spent her early years in Scotland before moving south to the Institute of Sound and Vibration Research (ISVR) at the University of Southampton. In1991, she obtained her Honours degree in Engineering Acoustics and Vibration.

Her early consultancy career was with Acoustic Design Ltd in Hadleigh, where she soon became conversant with the many aspects of architectural acoustics and planning. In 1996, Alison and I carried out a survey of railway noise and vibration in Russia. Under fairly challenging conditions, she performed countless measurements, and also impressed me by ordering food when we could neither speak the language nor read the menu.

In 1997, Alison joined Sharps Redmore Partnership where she worked on environmental noise assessments for commercial, retail, residential and airport developments. She quickly embraced the new methods of computer modeling and was able to use these techniques to good effect. Alison was also very knowledgeable on the IT systems within the company, and was always the first port of call when something was not working correctly.

Her husband Bob had predeceased her by four years, and she became a keen fundraiser, completing the Half Moon and Full Moon walks in London, and coastal walks, supporting both cancer and local charities.

Alison Longstaff

We shall all greatly miss Alison.

John F Bridges

Ramboll Acoustics

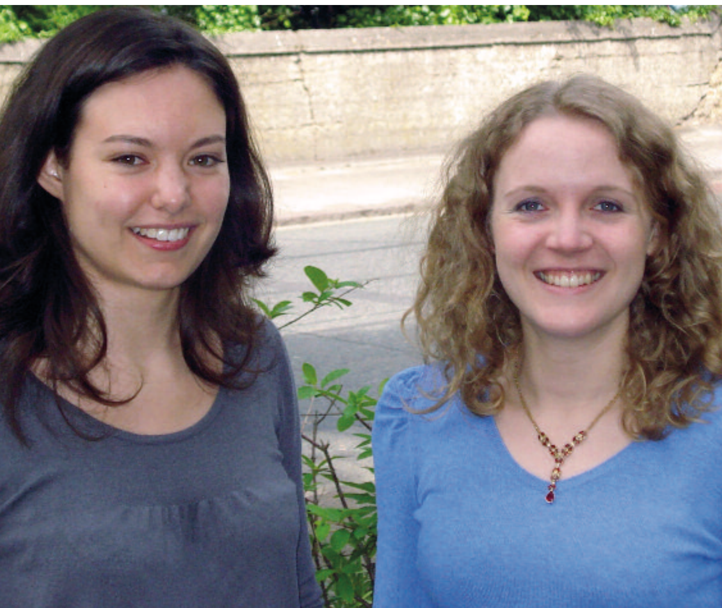
Expansion of UK team

The Ramboll Acoustics team in the UK has expanded this year with the addition of Audrey Soule and Rachel Bennett. Rachel joined as a Masters graduate in Environmental Acoustics from the University of Salford and Audrey joins the team on a six-month internship from the University Pierre et Marie Curie in Paris.

Audrey and Rachel are currently working with Ramboll Norway on the design of a new national museum in Oslo. They have also linked up with Petteri Laine from Ramboll Finland in an investigation to combine auralisations with 'fly-through' models.

Through Ramboll's recent acquisition of Gifford the team now also includes Raymond Browne. Ray specialises in noise measurement and prediction methods. He has a strong technical background in all aspects of noise assessment having worked in both the research and environmental sectors on a range of challenging projects for the MoD and commercial clients.

Ramboll Acoustics UK with its Nordic counterparts now forms a 50-strong international group dealing with all aspects of acoustics in the built environment.



Audrey Soule & Rachel Bennett

Raymond Browne

RBA Acoustics Prize for Best Dissertation

Daniel Flood, a student at London South Bank University, has been awarded the 2011 RBA Acoustics prize for the best dissertation. The prize, which is awarded for, 'Excellence in the study of acoustics and its application to real world problems' was presented to Daniel on 6 April 2011. His Masters dissertation was entitled 'Analysis and acoustic improvement to a live venue'. Russell Richardson of RBA Acoustics commented that it had been a difficult decision as the short list was particularly strong this year. He added that it had been a pleasure to read the dissertations: Daniel's was a most deserving winner.

[L-R] Steve Dance (London South Bank University), Daniel Flood, Russell Richardson (RBA Acoustics)

Rion launches the next generation of sound level meters

NL-52 (Class 1) and NL-42 (Class 2)

In the decade or so since their launch, the Rion NL-32 and NL-31 have become one of the industry standards for long-term noise measurements and as the basis of nuisance recorders. The qualities that secured this position are reliability, ease of use and speed of data handling. Rion's commonsense approach of storing the data as comma-delimited text files onto memory cards so that the raw data can be opened directly into a spreadsheet won over many users who had struggled with other meters' download software. Coupled with the Rion WS-03 outdoor microphone protection, their proven reliability made the Rion NL-31 and NL-32 pretty much the industry standard for baseline noise assessments for wind farms.

Rion has now unveiled the successor to the NL-32 and NL-31 (and their Class 2 derivatives the NL-20, 21 and 22) although these instruments will still be manufactured for some time to come.

The NL-52 retains many of the NL-32/31's best features but some exciting new functionality has been added to reflect the way in which the industry's requirements have evolved over the last decade or so. Simultaneous storage of processed values (L_{Aeq} and percentiles for instance) and unprocessed short samples (100ms, 200ms or 1s) is a particularly valuable step forward from the NL-31/32. Some features of NL-32 and NL-52 are compared in table 1.

Rion's designers have made the NL-52 intuitively easy to use but they have moved away slightly from the principle of main functions on dedicated keys. However, the menu and command system is intuitive and consistent and the NL-52 features on-board help files. Pressing the 'display' button when a menu item is selected launches a 'help' window which succinctly explains the relevant functionality. Some functions are available via the instrument's capacitative touch screen buttons (*ie* no stylus is required)

The WS-15 is the new Rion outdoor microphone protection kit for the standard pre-polarised microphone supplied with the NL-52. In addition to enabling the meter to achieve Class 1 for long-term measurements, the new system is smaller (and hence easier to hide) than the WS-03 and incorporates bird spikes. The meter itself is now IP54 rate (not the microphone) so it is resistant to spraying water.

The NL-52 is available now for hand-held measurements, long-term measurements (with

continued on page 48

Instrument	Rion NL-32	Rion NL-52 (with NX-42EX)
parameters measured	L_{Eq}, L_{max}, L_{min}, SEL and up to five percentiles (1% step)	L_{eq}, L_{max}, L_{min}, SEL and up to five percentiles (4 @ 1% and 1 @ 0.1% steps)
sub channel with independent time and frequency weighting	yes	yes
data storage	comma-delimited text to compact flash card	comma-delimited text to secure digital card
manual measurements automatically stored	no	yes
pause with back erase	yes: 0 or 5 seconds	yes: 0, 1, 3 or 5 seconds.
auto store	unprocessed instantaneous time and frequency weighted level 100msec, 200msec or 1 second intervals OR L_{eq}, L_{max}, L_{min}, SEL and up to five percentiles	unprocessed instantaneous time and frequency weighted level 100msec, 200msec or 1 second intervals AND L_{eq}, L_{max}, L_{min}, SEL and up to five percentiles.
auto store storage capacity (with sufficiently sized memory card)	99,999 results	1000 hours
minimum measurement period for processed values	10 seconds	1 second
linearity range	100dB	113dB
display	backlit 128 x 64 LCD (monochrome)	backlit 400 x 240 semi-transparent TFT LCD WQVGA (colour)
standard achieved with normal ws-10 windshield	BS EN 61672 Class 1	BS EN 61672 Class 1
standard achieved with specified outdoor microphone protection	IEC 60651 IEC 60804 Type 1	BS EN 61672 Class 1
audio recording option	yes: NX-22J	yes: NX-42WR
audio format	compressed Rion rwv file sample frequency 12.5 kHz	uncompressed wav file with user-selectable sample rate and bit length
recording trigger by level	yes	yes
periodic recording	yes	yes
periodic and level triggered recording simultaneously	yes	yes
periodic recording	15s snapshot every 15, 30 or 60 minutes	15s or 1m every 10 minutes or 1 hour
pre-trigger for audio recording	fixed 1 second	selectable 0, 5 seconds or 1 minute
real time octaves/third octaves	yes NX-22RT	yes: NX-42RT available early 2012
simultaneous measurement of multiple parameters	no: only instantaneous, L_{eq} or L_{max} measured in isolation.	yes: L_{eq}, L_{max}, L_{min} and five percentiles measured in octave or third octave bands.
percentiles measured in octave bands	no	yes
data logging in octave or third octave bands	no	yes

Table 1

Comparison of the new NL-52 with its NL-32 predecessor

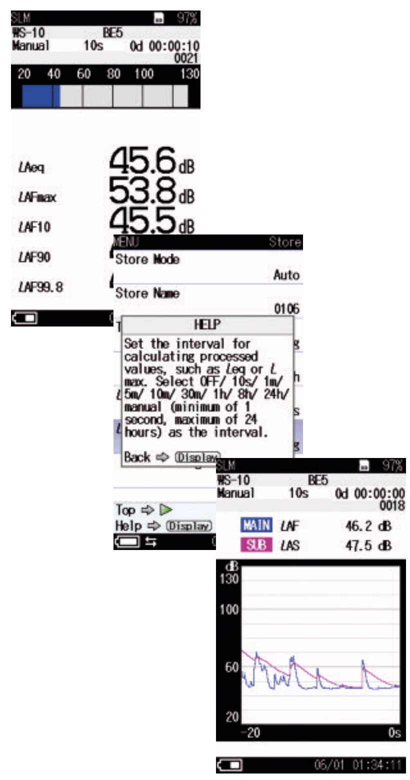
Rion launches... - *continued from page 47*

the WS-15 and outdoor kit) and as part of a nuisance recorder with the NX-42WR audio recording option. New Rion AS-60 data management software is also available now. This is a real step forward for Rion, AS-60 is very intuitive and quick. Just drag and drop the data and audio files from the NL-52 (or the NL-31/32) and the results are shown graphically (with audio file icons where audio is present) in seconds.

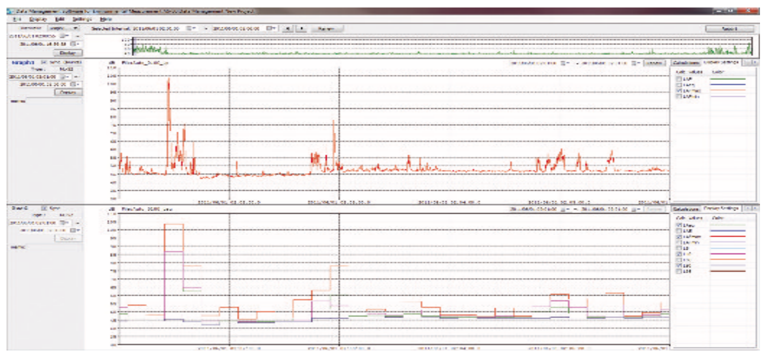
Users will have to wait for early 2012 for octaves and third-octaves. However, the NX-42RT will offer full data logging functionality and percentiles in octaves or third-octaves and an additional broadband sub-channel to enable even more parameters to be measured simultaneously. Remote control and download will be available for the NL-52 (but not for some time) and users who require this are encouraged to continue using the Rion NL-32 and ANV Measurement Systems remote control and download software (RCDS).

It may be surprising that although the NL-52 represents a significant step forward technologically, pricing is very similar to the current NL series line-up. Contact ANV Measurement Systems on **01908 642846, e-mail: info@noise-and-vibration.co.uk**) for further details.

NL-52 is IP-54 rated



Measurement display, help screen and level versus time trace



AS-60 screenshot

WS-15 microphone protection system

Svantek UK

Launches a cost effective vibration monitoring instrument

Svantek UK is the new joint venture between Svantek S.p.o.o of Poland and AcSoft Ltd. Svantek is the designer of innovative noise and vibration monitoring instrumentation. The SV106 is the latest human vibration analyser from Svantek that can measure both hand-arm and whole body vibration. The analyser can simultaneously measure vibration on both hands using two triaxial accelerometers.

The SV106 is a six-channel instrument for vibration and a two-channel instrument for static force. It can also be used to measure whole body vibration when used with a seat accelerometer. This pocket-sized instrument therefore provides a completely new approach to vibration monitoring.

It provides both octave and third-octave band analysis and fully complies with ISO 8041:2005, ISO 2631-1,2&5 (including VDV and MTVV) and ISO 5349.

Data from the instrument can easily be downloaded to any PC using a USB interface and the dedicated SvanPC+ software. The instrument contains advanced data logging including spectral analysis and the memory can be expanded using a micro SD card.

The SV106 is a cost-effective tool for hand-arm and whole body vibration measurement: a complete solution for HAV monitoring is available in the UK for under £2,500.

Contact Paul Rubens,
Director of Sales and Marketing,
Svantek UK Ltd
Email: **paulrubens@svantek.co.uk**

Cirrus Research

Calibration is key!

Cirrus Research, noise measurement specialist, is advising owners of noise measurement equipment to ensure that their instruments are calibrated regularly by an approved laboratory. This will help verify that the instruments are healthy and providing accurate measurements throughout the year.

It is of course vital that noise measurement instruments measure accurately not only to meet standards, regulations and guidelines but to clarify on an ongoing basis whether noise damage is occurring in the workplace or the environment. Each time a piece of equipment is used it should automatically be calibrated using an acoustic calibrator, both before and after each measurement. This helps verify that the equipment is working correctly and is known as field calibration. However, due to the precise nature of a measurement instrument it should be subject to routine factory verification to ensure that it continues to perform accurately and operate to its original specifications.

James Tingay, Group Marketing Manager at Cirrus Research comments that by the very nature of the job a noise measurement instrument carries out it was imperative that it was designed and manufactured to perfect standards. However, whilst individuals were willing to invest heavily in the necessary equipment, the ongoing maintenance was sometimes overlooked. Having a noise measurement instrument calibrated every year was as vital as a human being visiting the dentist on a regular basis. By opting to use a calibration service it allowed every function that was available on the instrument to be checked to ensure that it met the same specifications it had when the instrument was new.

Cirrus Research provides calibration and repair services for the entire Cirrus noise measurement product range with fully trained engineers with many years' experience in the industry making sure the products are 'as good as new'. A number of areas are checked during a calibration service and these of course vary depending on the make and model of the equipment tested.

Another feature of the service is that an instrument can have its warranty extended by a further 12 months when it is calibrated. With up to 12 years warranty available, customers can be certain that their investment will be supported for years to come.

For further information on the calibration services available please call **0845 243 2434** or visit the web page **http://www.cirrusresearch.co.uk/service_and_calibration/**.

Cirrus Research is a leading expert in the creation and production of noise measurement instruments in the UK. Formed in 1970, Cirrus uses the latest scientific and technological developments to produce noise measurement equipment to accurately measure noise and its impact. Cirrus products are manufactured in the UK and can be used in a wide range of applications and across a variety of industries.

Calibration of the Optimus

Sinus releases Apollo

New 4-channel acquisition unit from AcSoft

Sinus Messtechnik of Leipzig has augmented its range of acquisition hardware with Apollo, a new four channel unit with USB interface. Building on the success of their popular Harmonie and Symphonie hardware, both of which use the declining PC Card (PCMCIA) connection, Apollo features a completely new low power signal processor allowing direct powering from the host PC via USB 2.0.

Apollo is available in two versions – one with BNC connections for IEPE powering of transducers, and one with seven-pin Lemo connections for direct conditioning of 200V microphones. Eight 'slow' channels are also provided for other parameters such as temperature, pressure, position etc, as well as two digital tacho channels for rpm-related analyses, making the unit ideal for automotive applications.

Two output channels are available for generator functions, eg noise burst or swept-sine for building acoustics applications, or for monitoring the input signal.

The analogue to digital conversion is 24-bit, offering huge dynamic range, with a real-time bandwidth of 20kHz in all channels. Several Apollo boxes can be used to increase the channel count, and they can be sample-synchronised.

Apollo is supported by the established Samurai multi-analyser software, which is now released in version 2, to offer sound level meter, real time third-octaves, reverberation time, FFT and signal recording functions, all in the base package. Many options are available targeted at specific applications such as environmental noise, building acoustics, ground vibration, order tracking, and sound intensity. Samurai is compatible with Windows XP, Vista and also Windows 7.

The new hardware has also been integrated into SoundBook 2, built-in to a ToughBook touch-screen laptop, making a rugged field analyser for sound and vibration applications. SoundBook is currently the only PTB approved PC-based analyser system on the world market.

Sinus products are exclusively distributed in the UK by AcSoft, which also provides a wide range of sound and vibration analysis systems and transducers. AcSoft is a sponsor member of the IOA.

Contact : John Shelton,
telephone **01296 682686**,
email **jshelton@acsoft.co.uk**,
web site **www.acsoft.co.uk**

Apollo Samurai and screen capture

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Committee meetings 2011

DAY	DATE	TIME	MEETING
Thursday	**30 June**	**11.00**	**Council**
Tuesday	5 July	10.30	ASBA Examiners
Tuesday	5 July	1.30	ASBA Committee
Thursday	7 July	10.00	Meetings
Tuesday	2 August	10.30	Diploma Moderators Meeting
Thursday	8 September	11.00	Executive
Wednesday	14 September	10.30	Membership
Thursday	**22 September**	**11.00**	**Council**
Thursday	29 September	10.30	Diploma Tutors and Examiners
Thursday	29 September	1.30	Education
Thursday	6 October	11.00	Research Co-ordination
Thursday	13 October	10.30	Engineering Division
Thursday	3 November	10.30	Membership
Tuesday	8 November	10.30	ASBA Examiners
Tuesday	8 November	1.30	ASBA Committee
Thursday	10 November	10.00	Meetings
Thursday	17 November	11.00	Executive
Wednesday	23 November	10.30	CCENM Examiners
Wednesday	23 November	1.30	CCENM Committee
Thursday	24 November	11.00	Publications
Thursday	**1 December**	**11.00**	**Council**
Tuesday	6 December	10.30	CCWPNA Examiners
Tuesday	6 December	1.30	CCWPNA Committee

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.

Meetings Programme 2011

21-22 July 2011
The 5th International Symposium on Temporal Design
Joint event with University of Sheffield

24-28 July 2011
ICBEN 2011
Imperial College, London

14-15 September 2011
Organised by Building Acoustics Group, Environmental Noise Group, Measurement & Instrumentation and Noise and Vibration Engineering Group
ACOUSTICS 2011
A new decade - A new reality
Rethinking acoustic practices for the austerity decade
Crowne Plaza Glasgow

3-5 October 2011
Underwater Acoustics Group and the Underwater Sound Forum of the Marine Science Co-ordination Committee
Ambient noise in Noise-European seas: monitoring, impact and management
National Oceanography Centre, Southampton

17-18 November 2011
Organised by the Electroacoustic Group
REPRODUCED SOUND 2011 - Sound Systems: Engineering or Art
Thistle Hotel, Brighton

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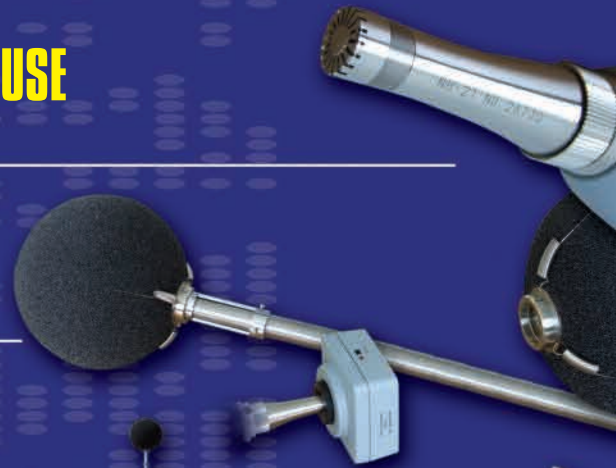

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