ACOUSTICS

BULLETIN



in this issue... Banging the acoustics drum: IOA sponsors major schools initiative



plus... **43rd Annual Report of the Council**The acoustic performance of flanking paths
for curtain walling systems
Development of a two-way
loudspeaker system – a case study





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Front cover photograph:

A youngster takes part in an IOA-sponsored schools initiative in Scotland. Credit: Allan MacDonald

The Institute of Acoustics is the UK's professional body for those working in acoustics, noise and vibration. It was formed in 1974 from the amalgamation of the Acoustics Group of the Institute of Physics and the British Acoustical Society. The Institute of Acoustics is



a nominated body of the Engineering Council, offering registration at Chartered and Incorporated Engineer levels.

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

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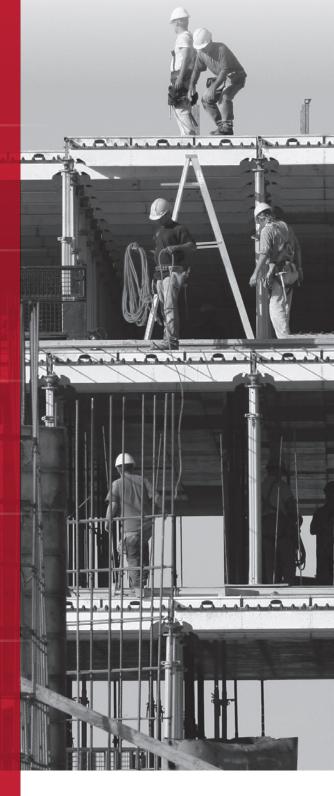


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23-27 July

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International Institute of
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24th International Congress
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Nottingham

21-23 November

Organised by the Electroacoustics Group Reproduced Sound 2017 Nottingham

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

Dear Members

The countdown to ICSV24 is running – there's only 12 weeks to go before the UK welcomes the world's researchers and practitioners in noise and vibration to the conference. Linda Canty is hard at work with organisation, and has been seeking volunteers to help out at the venue. This will be a fantastic opportunity for students (or others who are able to get the time out) to experience a major international conference.

Within this Bulletin you'll find the Institute's annual report. Our financial position currently looks secure, and we will be re-investing the surplus over the coming months in our education and learning project. This aims to put in place a system for providing continuing professional development material, to complement our existing education offering and that of our excellent UK universities.

The report gives a great view of the breadth of the Institute's work, and the variety of meetings organised. I'd like to thank on members' behalf all our volunteers who organise and present at our meetings. Also to our members' employers who make their facilities available free (or at substantial discount) to enable us to hold our meetings. Without them we would not be able to provide the branch programme that we do.

I am hopeful that, over the coming year, we'll be able to gradually trial more electronic branch meetings. This will be a cautious roll out, to ensure that we understand how to fix the most common difficulties. I look forward to a time when those who can attend in person do - and enjoy the networking and those unable to be there can benefit equally from the knowledge-sharing. Those of us who have endured poor electronic meetings in our day jobs, and suffered the frustration of missing out on dialogue or the question time after a talk will understand why we are working steadily on the project rather than rushing in. The Institute is investing in equipment which will be provided to those branches that request it, with the intention of providing transducers that can be used to improve conditions for electronic meetings. Our Meetings Committee is working on guidance to assist those running electronic meetings. Hopefully with the right technology and folk with the knowledge of managing meetings, we can make this happen. I would be very interested to know whether there would be a demand for lunchtime webinars, along the lines of those run so successfully by the Institute of Environmental Management and Assessment. If you



work in environmental acoustics, or are interested in continuing professional learning that's a bit out of your normal day-to-day focus, I would encourage you to tune in to one of their webinars.

April saw the Edinburgh International Science Festival in full swing. The Institute has sponsored Careers Hive and Generation Science (the latter being activities delivered in schools). See the report on page 17 to find out what was involved. Thank you to our members who got involved with inspiring the next generation of acousticians, and to Alistair Somerville from the Scottish Branch for bringing the idea to the Institute Council. The festival organisers are keen for material developed to be promulgated beyond the festival itself.

If you're interested in getting involved in STEM activities through the Institute, please contact head office and they'll put you in touch with those running our Acoustic Ambassadors scheme. Or, if you already have activities which you've found work in practice, and could share, we'd love to hear from you. The future of our profession is out there, but, as Sheridan Ash said (actually with reference to women in science) "You can't be what you can't see" (or perhaps in our case, hear).

As sponsors, we were kindly invited by the festival organisers to the "adults only" Science Festival Late – the opening event at the City Art Centre. For one night only, adults got to play in the flagship children's venue – six floors of science based workshops and interactive event. This was great fun, although in one activity I had an unforgettable experience with green slime made by one of our volunteers, Emma Shanks. I feat photos may appear...



Jo Webb, President

Plans move forward for the development of online learning platform in 2017

43rd Annual Report of the Council

he Institute has continued to serve the interests of its members through its established programmes in the areas of education, professional development, meetings and publications, and by providing representation in areas such as the Engineering Council, Standardisation and International affairs.

The Trustees confirm that in the exercise of their powers as charity trustees, they have had due regard to the published guidance from the Charities Commission on the operation of the public benefit requirements and the aims of the charity are carried out for the public benefit.

The strategic aims confirmed by Council remained as:

- To advise public policy with regard to the impact and nature of acoustics
- 2. Increase public awareness of good acoustic design
- 3. Increase understanding of acoustics by other professionals
- 4. Developing tomorrow's professionals
- 5. Providing better support for members
- 6. Increasing members' professional understanding.

To achieve these aims Council agreed the following objectives against which progress in 2016 is listed.

Objective	Progress in 2016
Advise policy makers on acoustics	The Institute has regularly sent a representative to the Parliamentary and Scientific Committee meetings and has supported the Campaign for Science and Engineering (CaSE) and the Royal Academy of Engineering in their reports to the Government on the implications post the vote to leave the European Union (EU).
Increase public awareness of good acoustic design	The Institute sponsored the <i>In Pursuit of Silence</i> film which had its UK premiere in London in October.
Create opportunities for other professionals to gain a better understanding of acoustics and its interaction with their specialist field	Joint activities have taken place with young members of other professional institutes. The Institute has contributed to debates on Engineering for the Future and the Nature of 21st Century Engineering Professional Institutions and the role of engineering post the decision to leave the EU. Professional practice and guidance document on noise sensitive development jointly commissioned with the ANC was consulted upon and is due for publication in 2017.
To develop links with undergraduate students	The student e-zine was produced twice and student membership increased from 377 at the end of 2015 to 397.
To support school children's understanding of acoustics	The Institute has agreed to sponsor Generation Science teaching in primary schools and secondary schools Careers Hive in Scotland in partnership with the Edinburgh International Science Festival in 2017.
To improve the operational efficiency of the Institute	Further improvements have been made to the website with the development of a learning platform planned for 2017.
To develop mechanisms for supporting members' professional development	10% monitoring of members' CPD continued. Series of conferences and events were held during the year, including online events attended by groups across the UK. A learning platform capable of delivering online CPD courses is planned for 2017.

Standing Committees

Education Committee

The Diploma and Certificate courses have continued to provide

education and training for both members and non-members of the IOA. The education programmes and courses introduce many working in acoustics and associated professions to the Institute and support the recruitment of new members.

The Diploma in Acoustics and Noise Control is now in its ninth year since revision in 2008. As a result of grades obtained in 2015/16, the Diploma was awarded to 94 students from four universities (Derby, Leeds Beckett, London South Bank and Southampton Solent) and four distance learning (DL) centres (Bristol, Dublin, Edinburgh and St Albans). Beth Paxton (DL Edinburgh) won the prize for best overall performance and Sinead McAleer for the best performance by an Irish student. Twelve students received special commendation letters for achieving five merits. The committee continued to monitor the effects of the changes in higher education funding on students and centres, and is developing options for electronic delivery of learning materials. Video tutorial facilities at St Albans continue to be used for overseas candidates and DL candidates at St Albans.

In 2016, the numbers taking and passing the Certificate courses were as follows: Hand-Arm Vibration, 15 students, 11 passes; Environmental Noise, 156 students, 140 passes; Building Acoustics Measurement, 31 students, 30 passes (including presentations made in Ireland); Workplace Noise Risk Assessment, 66 students, 49 passes. The Certificate of Proficiency in Anti-Social Behaviour (Noise) continues to be run in Scotland by Bel Noise Courses and by Strathclyde University, 26 students, 17 passes.

Since 2011, Diploma members have been able, for CPD or other reasons, to register for additional specialist modules. Nobody has taken advantage of this opportunity in 2016. However, in view of recent changes in Planning and Assessment regulations and guidance, there is the possibility of increasing numbers on the Regulation and Assessment of Noise Module by promoting it as "stand-alone" updating. The committee is also keen to work with groups and branches to support "formal" CPD, where there is a defined syllabus and assessment of learning outcomes. This may include on-line learning and topics for consideration include "sustainable acoustics", new acoustic guidance (e.g. BS 4142:2014, BB93:2014, BS 8233:2014) and devolved guidance (e.g. Scottish and Northern Ireland Building Regulations).

"You've Been Banned" presentations in schools continue using demonstration equipment purchased in 2012. Also, through Acoustics Ambassadors on the committee, opportunities for promotion of acoustics to school children continue to be monitored and pursued including local Big Bang fairs. The committee is also supporting Council's decision to participate in the Edinburgh International Science Festival in 2017 and is considering exhibiting in the national Big Bang Fair 2018. Education committee is also supporting applications for a Commonwealth Professional Fellowship to knowledge and skills in Commonwealth countries and enhance acoustics learning opportunities abroad.

The committee continues to be indebted to the support of its members, course tutors and examiners, the work of the Education Manager Keith Attenborough, supported by Education Administrator Hansa Parmar and other members of office staff.

Engineering Division Committee

Richard Perkins stood down as Chairman, following six years in this position, after the first meeting of the year. The new Chairman is Iim Glasgow.

The committee met three times during the year. As is usual the meetings were held following Engineering Council Registration professional review interviews, where there is a full complement of reviewers with the necessary skills available.

In 2016 we interviewed eight applicants. Of these, five were

processed through the individual route and three through the standard route. Seven applicants were successful and one unsuccessful.

The Engineering Division mentoring policy is continuing to produce improved numbers of better prepared candidates.

This year the IOA has appointed Blane Judd as its new Engineering Manager. Blane is a Chartered Engineer with extensive experience gained in many other engineering institutes/institutions. He has particular experience in supporting EngTech applications with his involvement in the EngTechNow campaign. He has participated in registration interviews with IET and other institutions. He has excellent contacts within the Engineering Council and is familiar with its regulations.

Blane held a joint IOA/IET meeting at BAE Systems Barrow-in-Furness and used the opportunity to promote membership of IOA with developing engineers.

Kelvin Griffiths of Engineering Division Committee has been appointed IOA Liaison Officer at the Engineering Council and is already attending meetings.

The committee has started examining the processing of various categories of TR (Technical Report) candidates for registration.

Medals and Awards Committee

The majority of the 2016 awards were made at Acoustics 2016 in September.

The Raleigh Medal was awarded to Rupert Thornely-Taylor and the Tyndall Medal to Jonathan Hargreaves. The A B Wood Medal 2016 was awarded to Dr Yan Pailhas and the Engineering Medal to Dr Carl Hopkins.

An Honorary Fellowship was awarded to Alistair Somerville for his exceptional service to acoustics and the Institute. Geoff Kerry became the first recipient of the Geoff Kerry Distinguished Service Medal

Mark Dodd was awarded the Peter Barnett Memorial Award and Vicky Stewart the Award for Promoting Acoustics to the Public.

Sarah Wakeley was presented with an award for the best performance in the IOA's 2015 Diploma and Lina Adlouni and Shang Qi Guo Wang shared the Professor D W Robinson Prize awarded at their graduation ceremony at ISVR in July.





Meetings Committee

The membership of the committee has changed slightly, but significantly, since last year's report. The Chairman remains Hilary Notley and Chis Turner Secretary and young member. Chris Skinner, Robin Woodward and Martin Lester continue to be valued members of the team, whilst Peter Rogers' input ensures the meetings programme is designed with the aims of the Sustainable Development Task Force in mind at all times. However, it was with sadness that we said goodbye to Jeremy Newton who has decided to step down from the committee after more than 20 years' service, including around 10 years as Chairman. We wish him all the best and are extremely grateful for his dedication over the years.

The committee presided over the organisation of 14 events covering a wide variety of topics. There were 12 single-day meetings/workshops and a two-day event; the annual Reproduced Sound conference, this year held in Southampton. Last, but by no means least, there was also the annual flagship event – Acoustics 2016. The feedback from the events' questionnaires in general continues to be very favourable and many of the proposals for future meeting topics are passed to the relevant specialist group.

Acoustics 2015 was a one-day event, however feedback suggested more members favoured the two-day format. Accordingly, Acoustics 2016 was held in Kenilworth over two days and this time the feedback consistently reinforced this as the preferred format. The event was judged to have been a success with 203 different attendees in total and more than 170 on each day. One hundred and fifty delegates attended the conference dinner at which awards were presented. In response to feedback, the number of parallel sessions was also reduced from five to two, allowing delegates to attend a greater number of presentations of interest to them, as well as the poster display and exhibition.

The financial performance of meetings has continued to be closely monitored and we continue to review performances and learn from our experiences so that deficits may be minimised in the future and events continue to generate a moderate surplus. This year the committee saw a surplus of around £20,000, which is a little above the target. Additionally, the committee made progress on its aims to develop the digital meetings strategy and increase communication between the centre, the specialist groups and the regional branches.





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Membership Committee

The committee met four times during 2016 under the chairmanship of Paul Freeborn. Geoff Kerry, having been a representative of Council, left the committee as his term of office on Council ended. The committee expressed its extreme gratitude to Geoff for his many years of service on the committee. Council was asked if it wished to appoint a replacement. In addition the committee was seeking an additional member to restore it to its full complement.

A revision to the Institute's Code of Conduct was submitted to and approved by Council. The revised code now fully complies with guidance from the Engineering Council.

The CPD sub-committee continued its work through the year working towards assessing some five per cent of the members' CPD records (approximately 5% check by the Membership Committee as part of membership upgrades and another 5% checked by the CPD sub-committee). The main aim of the sub-committee was to provide constructive advice where needed. The sub-committee expanded to include an additional representative from the Senior Members' Group and also a representative from the Young Members' Group. A short presentation was prepared covering the main principles of CPD, for use by Groups and Branches. In addition maintenance CPD guidance was being prepared for members whose career position required them to maintain their current level of knowledge. The CPD sub-committee was delighted that one of its members, Sue Bird, was awarded an MBE for her achievements in the fields of acoustics and women in engineering.

At the request of Council the committee has taken the first steps in setting up a Professional Standards Committee with a remit to raise standards of work by identifying areas in need of improvement and then assisting to provide resources such as informative articles, presentations or conferences to help raise standards.

A comparison of member benefits was made with other institutes and the Institute provision compared favourably. Work is being undertaken to review the benefits provided for our Sponsor Members.

The committee assessed five Code of Conduct cases over the year, of which three were not proved. One was withdrawn and one is currently being assessed by an appeal panel.

During the year 311 membership applications were assessed by the committee; slightly less than the previous year. Of these 302 were elected to membership of various grades, representing a small decrease on the previous year's figures.

2016	FIOA	MIOA	AMIOA	Tech	Affil	Sponsor	Total
Applicants	4	106	154	32	9	6	311
Elected	3	100	152	32	9	6	302
New Members	0	57	140	29	9	6	241
Resigned	3	34	12	1	2	3	55
Deceased	0	4	0	0	0	0	4



Publications Committee

Acoustics Bulletin and Acoustics Update continue to provide a high standard of technical content, reporting news and details of the Institute's meetings and affairs.

During 2016 the committee started encouraging conferences to record videos of keynote papers for inclusion on the Institute's YouTube channel, and has been working to get live tweets from IOA meetings. You can now watch the Rayleigh Medal lecture from Acoustics 2016. Many of the other ideas of the committee are on hold as they require interaction with the Institute website, including further work on abstracts and proceedings, standards lists, and having content more searchable and downloadable.

Proposed developments to be submitted to Council for approval in 2017 include finalising a style guide to enable members to ensure that documents they produce for the Institute are in line with others, and having details of future IOA meetings available in an electronic calendar.

During the year the committee has been joined by Scott Castle with Allen Mornington-West leaving. Thanks are due to all committee members for volunteering their time and enthusiasm throughout the year: Matthew Cassidy, Daniel Goodhand, James Hill, Mike Lotinga, Jordan Mayes, Chris Middleton, Seth Roberts and Bob Walker. Thanks are also due to IOA office, Charles Ellis, Allan Chesney and Dennis Baylis. Lastly, thanks are due to everyone who contributes to the Bulletin and website with meeting reports, technical contributions, letters, book reviews, blog posts and everything else.

Research Co-ordination Committee

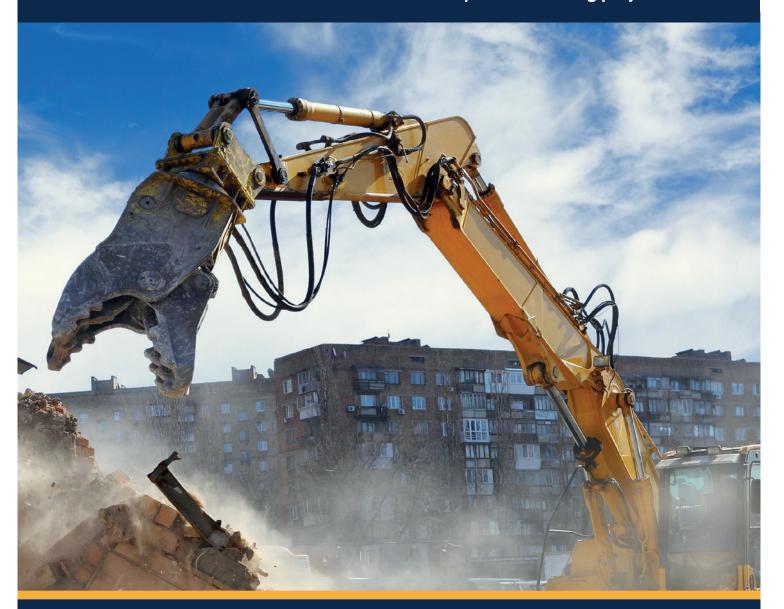
In 2016 meetings of the committee (RCC) were held in May and November at the Defra offices in London. Professor Kirill Horoshenkov stepped down as Chairman after five years in the role, during which time the committee was re-balanced to increase industry representation. In 2016 the RCC welcomed Mike Swanwick of Rolls Royce and Alan Curtis of Thales as Tier 1 members. Professor Abigail Bristow took over the role of Chairman.

In order to promote acoustics as a research discipline Professor Horoshenkov and Dr Andrew Bullmore led the organisation of the successful Acoustics research challenges in the 21st century workshop held at the Royal Society in London in April. This workshop brought together academic and industry researchers working in acoustics. The attendees discussed the challenges faced by acoustics research in the UK and, most importantly, agreed on actions that could help mitigate the impact of the funding cuts on this important science discipline. Speakers at the workshop included Dr Neil Viner (EPSRC), Mark Jeffries (Rolls Royce) and Aaron Hankinson (Jaguar Land Rover) and Dame Professor Ann Dowling. Stephen Turner produced a report of the event published in Acoustics Bulletin in August 2016. A key outcome of this event has been the development of a Network Grant proposal to EPSRC led by Professor Horoshenkov and Professor Richard Craster, UK Acoustics Network (UKAN). This activity has already brought together a diverse range of stakeholders from Universities and industry. The formal proposal was submitted in early February 2017. P10 ▶



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The RCC submitted evidence to the EPSRC balancing capabilities call for evidence in June 2016. The RCC submitted a note on UK acoustics research and the proportion of funding for UK researchers from the EU to the House of Commons Select Committee on Leaving the EU: implications and opportunities for science and research inquiry call for evidence (http://data.parliament.uk/writtenevidence/committeeevidence.svc/evidencedocument/science-and-technology-committee/leaving-the-eu-implications-and-opportunities-for-science-and-research/written/35111.html).

In 2016 the value of RCUK funding to research in the discipline of acoustics was £110 million supporting 155 live grants (Source: RCUK, http://gtr.rcuk.ac.uk/, 13/05/2016). At the same time, £98 million (£118 million) in grants from the EU for collaborative research in acoustics in the UK supported 29 live grants (Source: Cordis, EU, http://cordis.europa.eu/search/simple_en, 13/7/2016). Effectively, the EU provides 47% of the funding for acoustics-related research in the UK, and so any reduction in EU funding that follows Brexit will see a significant drop in the level of financial support for acoustics. A reduction of this level will have potentially serious consequences for the UK research community in acoustics, and cause significant harm to our position internationally. RCC members have attended meetings on Brexit and the Higher Education Bill.

These and other actions are detailed in meeting notes submitted to the Institute in a timely fashion following meetings.

Specialist Groups

Building Acoustics Group

I have been part of the BAG committee for nearly 20 years now and I still marvel at the commitment, sacrifice and fortitude of the many volunteers that allow the Institute of Acoustics to be what it is. I thank all of my committee members for their hard work in helping to deliver conferences and meetings, and with their writing and commenting on Standards and guidance documents. This is all without any thought of their own personal gain. They should be very proud.

2016 was focused around helping to organise Acoustics 2016. The return of the conference dinner allowed us to not only enjoy the vast array of presentations but also to strengthen current friendships and to meet new people. I think we are all agreed that this model works well and should be repeated.

Much work has also been done on helping Standards and guidance documents throughout the year. These include:

- Pro PG, BS EN ISO 12354 parts 1, 2, 3 and 4
- BS EN ISO 16283 parts 1 and 2
- EN 15657
- Good practice guide on the control of noise from places of entertainment
- CIBSE Guide B4.

With the start of 2017 we look forward to the opportunity of hosting ICSV24 in London – our "Olympics". It is a great opportunity to show the rest of the world that the United Kingdom is at the forefront of acoustics in research, consultancy and manufacture. We encourage all members of the Institute to embrace this opportunity and secure the future of our profession in this great country.



Electroacoustics Group

The main activity of the group during 2016 was the organisation of the annual Reproduced Sound conference. This year it was held at the Holiday Inn in Southampton, which was chosen partly because of the close proximity to two universities, both with significant acoustics teaching, consultancy and research activities. The organisational tasks were once again spread amongst the committee members which made this very much a team effort. The conference was well attended with 97 registered delegates, and the committee agreed that it was a success overall. The Peter Barnett Memorial Award was presented at the conference to Mark Dodd who kicked off the conference with a highly enlightening talk on transducer development. The conference is moving venue again for 2017 to the Nottingham Conference Centre.

There have been a few changes to the EAG committee this year: Stan Boivin-Champeaux has joined as Robin Dibble has retired and Helen Goddard has stepped down from the role as Secretary, which has now been taken up by James Allen alongside his existing role as Young Persons' Representative. The committee is grateful to Helen for many years of service as Secretary but it is noted that she will continue as an active member of the committee. The committee met on three other occasions during 2016. In January, the committee carried out a review of RS2015, decided on a short list of possible venues in Southampton for RS2016 and drafted the call for papers. The abstracts were reviewed and the programme mapped out in June and the details of the conference were finalised in September.

Environmental Noise Group

Through 2016 the Professional Practice Guidance on Planning & Noise (ProPG Planning and Noise) committee met regularly drafting national guidance to fill the gap left by the repealing of Planning Policy Guidance 24. The committee has eight IOA members, working with representatives from the Chartered Institute of Environmental Health and the Association of Noise Consultants, and has been sponsored by all three organisations. In January 2016 the committee published the consultation draft; *Professional Practice Guidance on Planning and Noise: New Residential Development.* Consultation events held in London and Manchester in March were attended by more than 100 IOA members and the online consultation questionnaire generated 249 responses. The committee continues to work on finalising the guidance for publication in 2017.

The group held a workshop in January entitled *Next steps for UK aviation industry following the Airports Commission's Final Report.* The meeting was held at London South Bank University to discuss the lessons learnt from the Airports Commission's process and how the acoustics industry could apply these when approaching future projects. Around 50 delegates attended comprising acousticians, local authorities, the CAA and community representatives.

Committee: Chairman: Steve Mitchell; Secretary: Nicole Porter; Young Persons' Representative: Robert Miller; members: Tony Clayton, Dani Fiumicelli, Colin Grimwood, Bernadette McKell, Robert Miller, Claire Parsons and David Waddington.

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Measurement and Instrumentation Group

During 2016, the group organised two one-day meetings.

The previously successful *BS 4142 workshop revisited* was re-run on 10 March at Austin Court, Birmingham, again organised by Mark Dowie and Tony Higgins, and we are also grateful to the original contributors for making themselves available.

On 6 October, another one-day meeting was organised, *Where shall we three measure again, in lightning, thunder and rain...* concerning accurate measurements in the face of inclement weather. The meeting took the format of a workshop, which involved "real' measurements outdoors, at the Fire Service College in Moreton-in-Marsh. Ably organised by Mark Dowie, the format was deemed a success, generating a useful surplus, and future meetings will certainly benefit from lessons learned.

The group also contributed a half-day session at the Acoustics 2016 conference on 5-6 September.

During 2016, the group identified a need to cover numerical methods as part of its remit, and co-opted Giles Parker on to the committee. Giles is organising the next meeting in 2017, on 14 March in Manchester entitled *Sound transport modelling*.

The group committee will also provide several session co-chairmen at ICSV24 in July.

2016 also saw two events potentially affecting the acoustics instrumentation community – Brexit, and the closure of the airborne acoustics facilities at NPL. Tony Higgins provided a detailed summary on the Brexit issues for the IOA, and we are also pleased to retain the services of both Susan Dowson and Ben Piper, despite the latter moving on from NPL to pastures new. The group will continue to provide input to the IOA efforts at mitigating the effects of the NPL changes on the acoustics community.

Over the past year, group committee members have continued to contribute to the regular Instrumentation Corner article in *Acoustics Bulletin*, 44 to date, which has produced some interesting discussions and articles, and this is scheduled to continue for the forthcoming year.

All available articles have now been edited and made available on the members' page of the group on the IOA website.

My thanks go to all members of the committee for the active roles they take in all aspects of the group's activities.

Musical Acoustics Group

The group had a successful year in its efforts to convince the wider acoustics community that musical acoustics is much more than a "hobbyist" subject. This was well demonstrated by two events during 2016.

The main meeting of the year was *Current developments in musical acoustics* which was our fourth consecutive July event, this time held at London South Bank University. There were technical papers covering the understanding of the acoustics of various instruments and possible ways to enhance the sounds they produce. For those interested in improving outdoor music events, an innovative and sustainable design of acoustic shell was illustrated. An interesting discussion and demonstration of organ design included a reminder of Sabine's work in a recreation of surprisingly accurate Victorian acoustic apparatus! Meanwhile, there was a health and safety warning via a presentation focussing



on the factors that can lead to singers experiencing vocal strain during the course of their careers. Finally, there was food for thought, with a total reappraisal and new developments based on 19th century piano design, the subject of a collaboration involving Daniel Barenboim. The AGM was held during the lunch break. The committee remained the same apart from Owen Woods who retired due to his workload.

Acoustics 2016 squeezed in six presentations on musical acoustics with diverse content. These included a study of emotional responses to emulated violins using electroencephalography, an insight into virtual emulation and listener evaluations of Stradivarius violins, a presentation on representing acquired light signals as sound: signal modality translation, and a study of intelligent loudspeaker design, all contributed by the University of Manchester. The session also presented interesting findings on pitch drift when singing in a *cappella* choirs and some ideas for measuring and rating the noise impact of church bells.

The management committee of the group has been active with six committee meetings held during the year.

Noise and Vibration Engineering Group

Only one full committee meeting was held during the year, but there were a number of sub-group meetings to focus on planning for particular events, especially Acoustics 2016. The NVEG contribution to the conference was very successful, with a well-attended full day session on numerical modelling in acoustics covering a good range of topics.

Unfortunately, work commitments of individuals on the committee prevented any stand-alone meetings from being organised in 2016, and so it is important for the group to move forward with an event in 2017, in addition to individual contributions to ICSV24. Possibilities include meetings on automotive NVH (noise, vibration and harshness), underwater noise from ships, and awareness of noise at work issues.

Physical Acoustics Group

Now better established, the group (PAG) has contributed to the Institute programme of events in 2016 in two ways: firstly, by holding a well-received session at Acoustics 2016, comprising nine academic papers. The various technical subjects discussed reinforce the supposition that there is still much to learn. For instance, the way that a sound wave propagates through and past various media, and how systems respond and react to an applied force, is clearly not yet fully understood. Our second contribution was providing two evening meetings (held by the Midlands and the Yorkshire and North-East Branches) where the presentations related to the misconceptions of what physical acoustics is, and its underlying knowledge providing the ability for "problem-solving".

Providing a representation for physical acoustics within the IOA has been recognised as being fundamental to the requirements of what is the foremost learned society for acoustics in the UK. Albeit we remain to communicate with our sister PAG within the Institute of Physics to avoid duplication of effort, we no longer coordinate our separate activities. However, we do continue to advertise each other's events.

In 2017, we will continue to support ICSV24, through







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the active encouragement of academics, environmentalists and industrialists to submit technical papers with a physical acoustics theme. Furthermore, now the IOA PAG has re-established itself as an autonomous group, we strive to maintain this level of momentum.

In addition to the above, we still need people who can help with finding conference papers or speakers who would like to present their work during PAG sessions as part of future conferences. We will also consider supporting ideas and requests for regional evening meetings, and collaboration with other specialist groups and institutes. Please contact the chair via the link on the PAG page of the IOA website.

Senior Members' Group

All communications have been by email, particularly with the committee, and this seems to have worked well. We also use the IOA *Acoustics Update* from time to time, which is circulated electronically once a month.

We have only had one meeting this year and that was at the time of our AGM when we had a presentation by Dr Rodger Munt on *Modelling the blast from guns*. This was well received.

Plans were laid for a second meeting for Dr Gurmail S Paddan, Head of Acoustics and Vibration, Institute of Naval Medicine, to talk about the role of the Institute and also at a later date to talk about his work. Unfortunately, no suitable venue or date was available and it was decided to invite him to give his first talk at our next AGM on 6 April 2017.

The group has continued to support the work of the CPD Committee throughout the year. The history project, to which many members contributed, was finally published during the year, with every member receiving a copy. Members were reminded that archive material is always welcome and that history marches on, so that it is helpful to keep full records including photos of work in progress.

Our future programme was discussed at the AGM and it concluded that it would be helpful if meetings included a place of interest. Meetings are always open to all IOA members. Travel is a constant problem (especially for members living abroad), not only in terms of time but cost of rail fares.

The members' page on the IOA website has been updated to give a description of group information, so do watch out for it.

With the history project completed, it is time to reconsider our role. While any gathering of senior members is always likely to have a social element, it might also be appropriate to consider a more substantial role within the IOA and within the study and practice of acoustics generally. It should be noted that some members are still helping with CPD; however the mentoring issue seems a bit moribund but has not quite died, it is just awaiting clarification.

The Chairman (Ralph Weston) is standing down at the AGM in April. He wishes to thank the committee for its support and contributions to the group, especially the Secretary, Mike Forrest.

Speech and Hearing Group

The group hosted one event, a talk by Professor Mark Huckvale entitled Avatar therapy for the relief of auditory hallucinations in schizophrenia, held in central London in May. This was well attended, prompting a large number of very varied questions, and accompanied the group's AGM, which was attended by approximately 25 group members. At the AGM, Derek Nash stood down as Secretary, replaced by Graham Frost, and Emma Greenland and Bradford Backus were confirmed as having resigned from the committee. Phil Harrison and David Canning were re-elected as ordinary members of the committee, and Dan Doherty and Cleopatra Pike (previously co-opted members) were elected as ordinary committee members, with Cleo taking over from Rob Conetta as the Young Members' Representative. Pippa Wilson was also confirmed as a co-opted member of the committee. There is still one further vacancy for an ordinary member of the committee, and nominations are currently being sought.

The group committee met three times (in February, May and October) during 2016. The group continues to liaise with other professional bodies (such as the British Standards Institute, the

Royal College of Speech and Language Therapists and the British Society of Audiology) and also other specialist groups (including the Building Acoustics and Musical Acoustics Groups) and local branches of the Institute regarding topics of mutual interest. Joint meetings in collaboration with some of these are being planned for the future.

The group was very disappointed to hear of the planned closure of the Airborne Acoustics group at the National Physical Laboratory, and noted its concerns about the impact of both this and the impending Brexit on the UK acoustics community in general, and on speech and hearing science and technology in particular.

Committee: Chairman (Acting): Gordon Hunter; Secretary: Graham Frost; Bulletin editorial contact: To be appointed; Young Members' Representative: Cleopatra Pike. Other members: Dr Evelyn Abberton (co-opted), David Canning, Rob Conetta, Dan Doherty, Phil Harrison and Pippa Wilson (co-opted). Pippa Wilson is due to stand down in 2017 due to other commitments. Possible appropriate replacements for her are being sought.

Young Members' Group

The committee meets quarterly with three meetings by telecom and one meeting in person. In 2016 our face-to-face meeting was held in December in London, which was followed by a social gathering of the committee.

In 2016 we held a mock planning inquiry with the Southern Branch. We also organised a number of social events, including a get together for young members attending Reproduced Sound.

The second Inter-Professional Networking Event in London was a success with more than 80 engineers and architects from six professional bodies attending. The event used the same format as previously with participants playing "networking bingo", i.e. seek out as many individuals as possible that fit the descriptions on the bingo card. Drinks and nibbles were provided.

To promote the IOA to students we gave presentations at the University of Southampton about the benefits of membership and chartership. An Acoustics Exchange Day was held at the University of Sheffield with the aim of building a community of interest that spans all areas of sound.

For the year ahead we aim to fulfil the previous ambition of presenting to students at more universities (e.g. Anglia Ruskin University, Southampton Solent University, University of Derby, University of Liverpool, Edinburgh Napier University and University of Edinburgh). Young members are also being encouraged to volunteer for the IOA stall at Edinburgh International Science Festival. We are also hoping to host an event at the Science Museum and organise the third Inter-Professional Networking Event in London as well as putting on a quiz in London.

The big event for 2017 is ICSV24. The group has secured space within the programme to provide an early careers workshop for young acousticians and we will also be hosting an international social as part of the social programme for the conference.

Underwater Acoustics Group

The group's activities continued to concentrate on the dissemination of knowledge related to underwater acoustics through its conferences and related activities. The main event in 2016 was the conference on *Acoustic and environmental variability, fluctuations and coherence* held at Cambridge University's Møller Centre on 12-13 December. This included a keynote lecture by Chris Harrison on relevant work he carried out at the NATO Centre for Maritime Research and Experimentation (CMRE) at La Spezia, Italy, and an A B Wood Medal Lecture on the overlooked information that often lies in the phase of acoustic signals by Yan Pailhas of Heriot-Watt University. The medal was presented to Yan by Peter Dobbins, Chairman of the Underwater Acoustics Group.

The group has been active in promoting the idea of making past IOA conference papers freely available on the IOA website. Several members of the committee are currently on ISO working groups developing new International Standards for underwater acoustics and the group is represented on the joint MOD/DEFRA Underwater Sound Forum, where a group representative presents

P16 ▶



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a regular update on group activities. The group is now dedicating its efforts to future meetings, including a conference on bioacoustics, to be held at Loughborough University and one on *Synthetic Aperture Sonar and Radar* in Lerici, Italy, as well as sessions at the *Underwater Acoustics Conference and Exhibition* in September 2017 at Skiathos in Greece.

A full copy of the report, which includes regional branch reports, can be found in the publications sections of the website. lacktriangle

Grade	2015	2016
Hon Fellow	38	36
Fellow	175	172
Member	1789	1794
Associate Member	772	799
Affiliate	57	53
Technician Member	125	127
Student	377	397
Totals	3333	3378
Founding Key Sponsor	2	2
Key Sponsor	1	1
Sponsor	46	46

Table 1. Membership

Group	2015	2016
Building Acoustics	1475	1563
Electroacoustics	434	464
Environmental Noise	1804	1863
Measurement & Instrumentation	711	767
Musical Acoustics	433	468
Noise and Vibration Engineering	1215	1280
Physical Acoustics	285	321
Senior Members	122	126
Speech & Hearing	243	274
Underwater Acoustics	264	277
Young Members	324	370

Table 2. Group membership

Branch	2015	2016
Central	244	247
Eastern	291	293
Irish	134	134
London	881	937
Midlands	446	455
North West	404	427
Overseas	341	326
Scottish	193	206
South West	297	312
Southern	517	545
Welsh	80	84
Yorks and North East	243	257

Employment Category	2015	2016
Architectural Practice	324	376
Consultancy	1914	2000
Education	602	648
Industry/Commerce	634	658
Public Authority	437	433
Research & Development	623	689
Retired	141	124
Other	185	201

Table 4. Details of employment

Topics, Date & Venue	Attendance
Aviation Noise 26 January - London	50
The Art of Being a Consultant 3 February - Salford	55
BS4142:2014 Revisited 10 March - <i>Birmingham</i>	73
Acoustic Research Challenges 15 April - London	55
Acoustics of Unconventional Onshore Oil and Gas 21 April - <i>Glasgow</i>	33
Acoustics of Large Infrastructure Projects 10 May - London	52
Current Developments in Musical Acoustics 5 July - London	25
Acoustics 2016 5-6 September - Kenilworth	203
Effect of Weather on Outdoor Measurements 6 October - Moreton-in-Marsh	63
The Impact of Brexit on Noise Management 19 October - London	50
Reproduced Sound 2016 15-17 November - Southampton	97
Defra Research – A Synopsis of Recent Publications 23 November - London	47
ETSU-R-97 Time to Move On? 7 December - Birmingham	55
Acoustics and Environmental Variability, Fluctuations and Coherence 12-13 December - Cambridge	59
Table 5. Meetings and attendance in 201	6

IOA spreads acoustics message among Scots schoolchildren

13-strong team of IOA volunteers has been spreading "the acoustics message" to thousands of secondary pupils in Scotland.

They took part in an education project entitled Careers Hive which aimed to open the eyes of 11 to 14-year-olds as to the wealth of opportunities available to those who opt for STEM subjects when choosing what to study.

The project was one of two that the Institute supported as part of a partnership agreement with this year's Edinburgh International Science Festival.

The other saw it support the delivery of Generation Science shows and workshops known as Ella's Wobble and Good Vibrations at 600 primary schools across the country, reaching 58,000 children.

During a special schools week, Careers Hive attracted more than 2,400 pupils and around 200 teachers from 38 high schools in 12 local authorities across Scotland.

Institute Council member Emma Shanks, one of the volunteers who took part in the Careers Hive, held at the Museum of Scotland in Edinburgh, said: "What we did was talk about ourselves, what we do and how we got into our jobs.

"I think our involvement was generally successful. The students I spoke to were interested and surprised to learn about acoustics as a career. And once they'd made the link with school subjects they

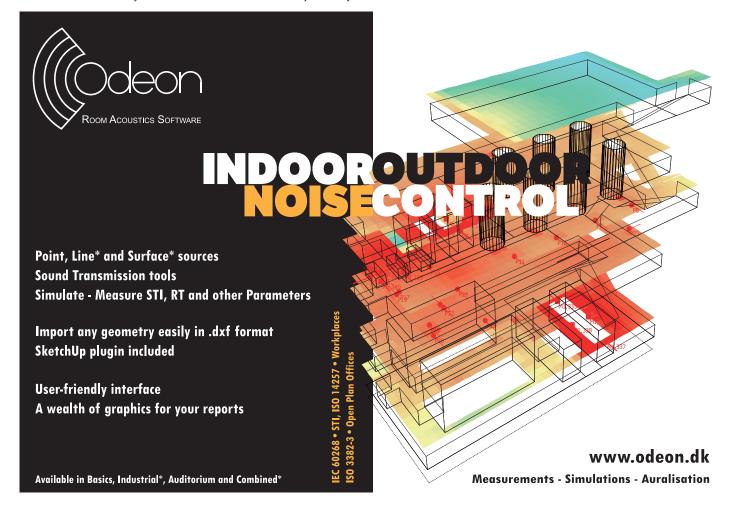


Sounds good: Institute volunteer Anne Budd with young visitors to the Careers Hive Credit: Allan MacDonald

were quick to think about aspects of their own lives affected by acoustics every day."

Joan Davidson, Festival Education Manager, warmly welcomed the IOA's involvement in Careers Hive. "The addition by the keen STEM professionals and engaging activity run with groups like the Institute of Acoustics really unearthed the diversity of opportunities that are out there for students, "she said.

"As a result we've already had requests from some schools to book in their classes for 2018."



Sound transport modelling

By Giles Parker

omputer noise modelling is now a fundamental component in the management of transportation noise. Commercial calculation packages help to standardise methods and approaches. Giles Parker of Sound Barrier Solutions welcomed members on behalf of the Measurement and Instrumentation Group to a one-day conference specifically focussed on noise modelling approaches and techniques for transport applications.

Transport noise models

Adam Lawrence (Atkins) kicked the day off with an overview of the history of transport noise modelling and the benefits and reasons for modelling with regard to funding and future planning. He outlined a correct approach for data input (source, receiver and propagation) to aid accurate calculation and the need to comprehensively review and verify the final noise model to ensure all assumptions were appropriate and correct.

Ian Holmes (Highways England) brought members up to speed with the approach to noise issues on Highways England's Strategic Road Network. Their key performance indicator is to address noise at 1,150 acoustically defined "Important Areas" by 2020. There is also a longer term aspiration that by 2040 there will be 90% fewer people impacted by noise from the Strategic Noise Network. As part of this strategy, Highways England is assessing the benefit of having a network-wide computer noise model for efficiency, consistency, to help provide a meaningful response to local public concerns and for ongoing strategic planning, prediction of noise levels and mitigation requirements.

Matthew Muirhead (AECOM) considered the proposed revisions to the Calculation of Road Traffic Noise, putting it first in its historical context, taking into account the fact that when the method was first developed, large scale computer noise modelling was not being considered. Proposed revisions covered the inclusion of road surface corrections, accounting for age, traffic and multiple lanes as well as conversion to LAeq. The revision remains unpublished. As to whether it would form a future British Standard or a Europewide method (CNOSSO-EU) might ultimately be adopted only time would tell.

Limitations and uncertainties

Giles Parker looked at the limitations of current calculations and modelling techniques with regard to noise barrier design. Standard international methods such as ISO 9613-2 do not take into account noise transmission through barriers nor degradation of performance. Giles encouraged members to specify the acoustic performance of barriers for their anticipated design life. The tendency to only specify barriers for their performance on day one means that built barriers typically under-perform because of degradation. It is also vital that modellers understand how barriers perform at low frequency and that high levels of diffraction will ultimately require the design of much higher barriers.

Matthew Naylor (Hoare Lea Acoustics) examined the problems relating to the calculation of double barrier attenuation in ISO 9613-2. These include the interpretation of the double barrier paragraph in the standard, when and how to estimate a double barrier as a single barrier. Looking at simple model examples Matthew identified possible solutions and approaches for cases with multiple barriers.

Simon Shilton (Acustica) sent members to lunch with a comprehensive appreciation of the four key sources of uncertainty in a modelling system: Input uncertainty, model uncertainty, error propagation or sensitivity and uncertainty of evaluation data. No engineering method has yet been designed to simulate every real world situation. With regard to managing uncertainty, ISO 17534 was discussed as a tool for software developers with the main objective that the same calculation method with the same data will produce the same results in different computer noise modelling software.

Implementation and innovation

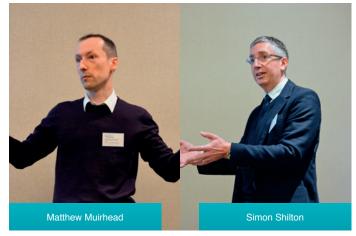
Antonio Notario (DataKustik GmbH) discussed the implementation of the Directive 2015/99 EC into Noise Mapping Software Platforms, with regard to how CNOSSOS-EU is used to construct the noise emission and propagation model and how the software is implemented with regard to traffic flow, source geometry, speed correction, road surfaces and gradients. There was also a need for the development of input databases of traffic and road surface data adapted for the needs of each country.

Stephen Byrne (Transport Infrastructure Ireland) outlined the need to adopt a centralised strategic noise mapping approach in Ireland. This was because of the number of noise mapping bodies nationwide for major roads, the different levels of GIS and acoustic experience and software and to avoid double counting population exposure assessments. Carrying out large scale noise modelling requires optimum efficiency settings to reduce processing time with an understanding of any resultant uncertainty and the development of a variable receiver grid.

Dan Pope (Atkins) completed the day by considering an innovative approach to noise impact assessment in early stage road and railway planning. The goal is to estimate the noise impact of a scheme at an early stage with the goal of minimising the number of noise exposed dwellings by evaluation of alignments while at the planning stage. This would help in determining the optimum route for a transport scheme by considering its noise impact at an early stage.

The conference was well received, being considered by members to be relevant and hitting the mark. This also left the potential for future events to consider further advances in noise modelling for transport and other applications. \square





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The art of being a consultant

By Chris Turner

his year's edition of *The art of being a consultant* was held at London South Bank University in February and featured the usual all-star cast of speakers and included references to Bruce Springsteen and Star Trek.

For the first time the meeting was chaired by Chris Turner, the Young Members Representative on the Meetings Committee, who welcomed a full house of delegates and introduced the first speaker.

David Watts of AIRO gave a brief and concise view on what acoustics consultancy involved. David handed over to Mark Murphy of Vanguadia who spoke about "negotiating the contract" and described the "Springsteen scale of acoustics consultancy".

Following a coffee break, Russell Richardson of RBA focussed on "doing the job". Russell highlighted the need for asking the right questions and that your knowledge of relevant standards and guidance should be as good as it can be.

Mike Hewitt of AECOM provided a clear overview of the types of main contract that an acoustics consultant may come across including "traditional" and "design and build". Mike provided a number of useful tips and warnings to delegates on the risks involved with each type of contract.

After lunch Stephen Turner of ST Acoustics spoke about report writing and outlined that the report is likely to be the lasting legacy of the work involved. The report is, more often than not, available within the public domain. Stephen highlighted that while templates



are useful, "cut and paste" is best avoided and that the report should be tailored for the reader.

Stephen was followed by Ed Clarke of Clarke Saunders Associates who highlighted the importance of quality assurance and that it is not only the final output that needs to be reviewed. Ed explained the importance of keeping accurate records and that formalised accreditation can provide a new client with a "comfort blanket".

The final two speakers were Stuart Dryden of Rupert Taylor and Paul Shields of AECOM. Stuart's talk focussed on the ethics of consultancy. He highlighted the need to be fully briefed by the client and to advise the client of what they can and cannot expect.

Paul's talk focussed on the Institute's CPD scheme and the need to maintain CPD records. The chairman confessed that his records had been assessed within the last 12 months and that no-one was immune to being reviewed.

The day ended with a healthy discussion and Q&A session followed by the traditional visit to a local hostelry. The next event, in early 2018, will follow the triennial cycle and return to Southampton.

Midlands Branch reports

By Fiona Rogerson

An alternative psycho-acoustic approach to addressing open plan office acoustics

The branch got its 2017 programme off to great start in January with a lively and enthusiastic presentation from Dr Nigel Oseland of Workplace Unlimited to an audience of 44 people at Atkins' Birmingham office. His presentation covered an alternative psychoacoustic approach to addressing open plan office acoustics and looked at acoustic and non-acoustic factors that influence the design of the ideal office space. The best office acoustic solution is ultimately about worker health, well-being and productivity. It requires consideration of the people, the activities taking place and the physical space itself. Nigel reviewed more than 100 research papers and found that along with speech interference, factors such



as personality, attitude, age, task and noise sensitivity have more impact on individual performance than sound levels alone. From his literature review, Nigel proposed several hypotheses linking personality and acoustic preferences to performance. He tested the hypotheses using an on-line survey and then developed a set of tools, on behalf of Ecophon, to help resolve problems with noise in the office. The solutions include acoustic treatment, zoning (by personality, role and task) and behaviour change. Many thanks to Nigel for the talk and to Atkins for hosting the event.

BS 4142:2014: How do the results of the Objective and Reference Methods for Tonal and Impulsive Noise compare with your professional opinion?

Our February meeting was an engaging insight into the workings of BS 4142:2014. Mike Breslin of ANV Measurement Systems gave a presentation which focussed on audience participation.

Mike started with an introduction to section 9 of BS 4142:2014 which advises that certain acoustic features can increase the significance of the impact of a sound and that where such features are present a character correction should be added to the Specific Sound to obtain the Rating Level. The Standard suggests that this can be approached in three ways a) Subjective Method b) Objective Method (1/3 Octave Band) and c) Reference Method, and Mike explained each of these.

He then posed the question "How do the Results of the Objective

and Reference Methods for Tonal & Impulsive Noise compare with your Professional Opinion?"

Recorded samples of 11 commercial sounds of varying complexity were played to the audience who submitted their subjective assessments of the tonality and impulsiveness rating penalty they would apply in a professional situation in accordance with Section 9.2.

The results of the audience's subjective assessments for each sound were compared with the results of the 1/3 Octave Band and Reference Methods. The analysis showed a wide range of subjective responses for some of the sounds and overall the Reference Method was more likely to result in a penalty than the 1/3 Octave Band

P22▶



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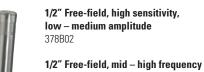


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method for this set of samples.

Mike will be giving similar presentations to other branches and it will be interesting to see whether the subjective assessments are as diverse for these other meetings.

Many thanks go to Mike for the talk, his colleague Matthew

Robinson who collated and analysed the responses and to AECOM, Nottingham for hosting the event.

Thirty people attended the event, apologies to those who were not able to attend due to the high demand for spaces.

Noise, ventilation and overheating in residential design

North West Branch report

By Paul Francis

any acoustic consultants have long been aware that while they play a part in defining the requirements of a residential façade – to provide sound insulation – they play little part in considering other aspects, such as the provision of ventilation or considering overheating. Thus the talk at our meeting in January entitled *Noise, ventilation and overheating in new dwellings: the forthcoming ANC Guide* drew a capacity audience to learn more from one of the authors, Jack Harvie-Clark of Apex Acoustics.

Jack explained how there is often no consistent approach to integrating the façade sound insulation with the ventilation strategy, and overheating is seldom currently considered. The problem begins with the sound insulation scheme needing to satisfy the planning department, with ventilation monitored by Building Control. Overheating assessments are currently required in some situations, such as under planning for major developments in London, but may otherwise only be undertaken as part of a comprehensive design exercise.

The typical result of the non-joined up assessment of internal conditions was illustrated by a recent residential development where the external noise levels were 73 dB $\rm L_{Aeq,16hr}$, 67 dB $\rm L_{Aeq,8hr}$ with a night-time 90 dB $\rm L_{AFmax}$. Leaving the windows open as the only means to control overheating would result in internal night-time noise levels of 52 dB $\rm L_{Aeq,8hr}$ and 75 dB $\rm L_{AFmax}$. The occupant must therefore choose

between intolerable acoustic or thermal conditions, rather than being able to enjoy reasonable conditions of both.

The current design situation can result in health risks for occupants, design risks for consultants and legal risks for developers. The ANC Guide hopes to reduce these risks by encouraging holistic design for the façade sound insulation, with assistance for the acoustic consultant so that they can suitably identify ventilation and overheating risks and raise these concerns with the other members of the design team who are responsible for them.

Jack also described the frequently woeful state of ventilation provisions, ascribed in part to the reluctance of Building Control to take much interest in enforcing the requirements of Part F. The ANC Guide will describe ventilation for acousticians, so that they can be confident when assessing the sound insulation requirements that they are properly considering the ventilation strategy options that are feasible for a particular site. The potential problems with noise from mechanical ventilation systems was also described. Although around 70% of new dwellings currently use some form of continuous mechanical ventilation (driven by the thermal performance considerations, rather than noise), noise from mechanical systems is not controlled under the Building Regulations. Evidence from many studies all over Europe demonstrates that when ventilation systems are too noisy, people turn them down to a tolerable noise level, or off entirely. In modern airtight dwellings ventilation is vital to prevent poor air quality and associated adverse health effects.

Environmental health officers expressed great interest in using planning conditions to require acoustic commissioning of ventilation systems. There was a request for information in the guide to assist environmental health practitioners to seek the appropriate information from developers to ensure that designs for sound insulation properly consider ventilation and overheating.

Our thanks go to Jack for presenting this work in progress and to BDP for providing the venue and refreshments. lacktriangle

Ninety-nine more applications for membership approved by Council

Ninety-nine membership applications have recently been approved by Council following the recommendations of the

Membership Committee. Of the total, 72 were new or reinstatement applications, the remainder upgrades. ○

Peter Young

Suzana Zekic

Affiliate

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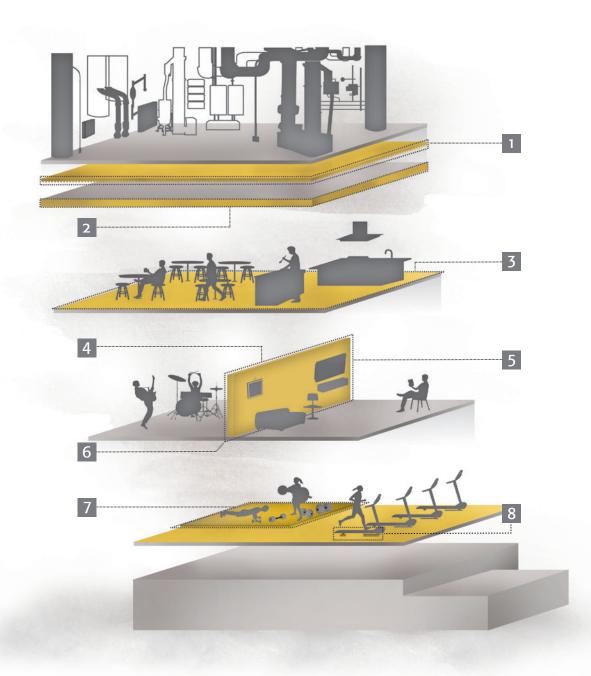
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The highs and lows of measuring sound

By Simon Bull BA(Hons), MIOA, MIDiagE and Rob Hawksworth BEng(Hons) Castle Group

What is a measuring range?

The fact that human hearing can detect everything from the faintest whisper right up to a large jet-liner taking off, is remarkable, especially when you consider that it is still difficult to make a sound meter that does the same. Yes, I know sound meters must do it accurately and need to filter frequencies in various ways, but still, the current fundamental electronic circuitry cannot cope with the same range as the ear. You can buy single range sound meters, but still most of these use a special "trick", by merging two sets of circuits together to create the effect of a single range. The technology is improving and faster processors will overcome this problem, but then this is the 21st century!

Dynamic range

We can identify this as the ratio between the highest and lowest sound pressure levels the sound meter can measure.

A typical microphone may have a 140dB dynamic range, which is a signal amplitude ratio of 10,000,000 but your sound meter must determine this massive ratio to deliver a result.

The large ratio in input signal needs to be injected into ultra-low noise amplifier circuits before being sampled by an analogue to digital converter (ADC). Briefly, inherent noise from the circuitry and microphone, coupled with the resolution, bandwidth and sampling rate of the ADC limit the signal to noise ratio and hence reduce the overall dynamic range. This is where new 24-bit ADC chips are producing ever-larger dynamic ranges to help us solve this problem.

Single range sound meters are still subject to the same conditions and use circuitry and software to identify the cross over point, with a possibility of minor misrepresentation. Other sound meters use selectable ranges by the user which only operate within the selected measuring range.

The International standard governing the specification and testing of sound level meters is called IEC 61672-1:2013 Electroacoustics—Sound level meters (They also can have BS EN instead of IEC at the front). The dynamic range of a sound meter is officially called the Total Range and is everything the instrument can measure from the smallest sounds to the highest levels, without error!

Linear operating range v display range

You will usually see on your sound meter a number denoting the bottom and the top of displayed range, which is often set to a round-number to help with creating a scale that can be graphed conveniently. This is called the display range and isn't necessarily the same as the measuring range of the meter. The



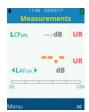
important factor is the ability for the instrument to measure in a "linear" way. This means that putting in a signal and changing it must result in a comparative change in the reading. Effects at the upper and lowermost extents of the range will change the output level until it is non-linear, where the errors will be larger than allowed by the standards. The correct term as used in the International Standard IEC 61672-1:2013 is linear operating range.

Noise floor v under range point

The noise floor of a sound meter is determined by two things. Firstly, and the largest factor is the "self-generated noise", which is simply the electrical signals travelling around the circuits inside the sound meter creating a signal of their own. You can hear this as "hiss" on an old FM radio when you tune off-station and turn up the volume. The trouble with a sound meter is that they will measure this as a level that cannot be distinguished

from the sound at the microphone. If you imagine an electrical noise floor of 20dB and say that you are trying to measure environmental sound of 20dB, then what you see on the sound meter would be 23dB (double the sound energy); a significant error. Now imagine a noise floor of 15dB. There will still be an effect on the 20dB you are trying to measure, but will it cause the result to be unusable? In fact, a sound meter should allow at least

10dB above the electrical noise floor before the start of the lower linear measuring limit of the instrument, below which, an "under-range" message should be shown. This is why it looks like you can still measure below the under-range point on a sound meter - just be warned that these numbers will not be in specification! Some instruments show dashes instead of numbers below the under-range point, but most still give



The second factor in determining the under-range point is the microphone, as this also creates electrical noise, which adds to the self-generated noise level of the instrument. The combination of these two factors give the overall noise floor of the system, to which the (at least) 10dB "buffer" is added. There is a slight complication to this effect, which is the sensitivity variation of the microphone. Modern electret microphones are very good compared with the past, but they still vary from one to the next with a nominal 50mV/Pa (50 millivolts per Pascal) microphone often ranging from around 35mV/Pa up to 70mV/Pa. This will effectively move the noise floor of the instrument by up to plus or minus 3dB. Some sound meters account for this in the lower limit by adding more than 10dB to the electrical noise, whilst others will show a different under-range limit depending on the individual microphone capsule in use.

There is another "trick" that manufacturers can use, and that is by measuring the noise floor of the microphone, it is possible to "correct" or "linearise" the bottom of the dynamic range to take account of this. Meters which have a linearity range down to 20dB can still use a microphone with a noise floor of 15dB for example. The electrical noise will be more like 10-11dB, so the microphone is the limiting factor. However, this should only be done for a specific microphone, rather than microphone type.

Audio recording at low noise levels

Many sound meters now have audio recording on them as standard. Fantastic, you might say! But beware, there are a few things to consider before lauding the technology too early. They all work well if you are recording high noise levels in a factory or for an industrial process based around the Regulatory action levels of 80-85dBA, or if you are just using it to annotate your measurements with voice-memo files. It is when you try to record low levels such as those found in rural outdoor settings, where you might find levels of 30-40dBA or even lower, you can encounter a few problems - especially if you are trying to listen to the audio afterwards for qualitative assessment!

To faithfully re-create sound that is audible and intelligible to humans means there must be enough detail stored in a file for a computer to re-play the sound through a speaker - that can be a lot of data!

Sampling rate and bits - what's it all mean?

Getting back to that sound means making a smooth wave out of single points of information. To do that, you need to break the wave down over the level and time. The smoothness of the change in level is determined by the number of bits used to describe it - the bit-depth. An 8-bit number is literally a series of 8 ones and zeros - 10111001, for example, which is 185 in "normal" numbers. The maximum number you can make is



▼P24

11111111, which is 255, so an 8-bit number can only represent 0 to 255 points on a scale, not very much if you are breaking down a measuring range of 20-120. You don't get a very smooth wave!

This effect gets worse at low levels because the scale for decibels is logarithmic where the steps between data points become bigger. Modern sound meters require at least 16bits audio recording to get anywhere near those low levels recorded properly. Many will now give you 24bit recording although some .wav file players will struggle to play these files.

The sampling rate is the smoothness over time, so a 44kHz sample rate will collect 44,000 points of information every second, and will give you a bandwidth of around 20 kHz. Lower rates will have lower bandwidths and may not be suitable for the task in hand. See figure 1.

Overload v peak

At the other end of the scale, you need to worry about overloading the electronics where the signal goes from the microphone pre-amplifier into the sound meter itself. Signals that are too large, get chopped off at the tops of the waves, which is called "clipping" and a sound meter must display an "overload" status to indicate that this occurred. Within the standards, it is possible



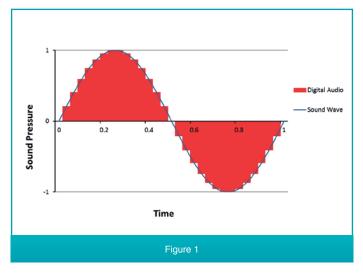
to measure "peak" to a higher level than sound pressure and this is because sound pressure (rms.) is calculated from the overall waveform and will always be lower than the largest wave peak – see diagram below. Most sound meters using a ½" microphone capsule tend to measure up to 140dB sound pressure and 143dB Peak. Commercially, it is only the Control of Noise at Work Regulations that bring such high levels to bear, with the exposure limit value set at 140dBC Peak, which should be 3dB below the capabilities of most decent sound meters.

The requirement to measure higher than this, only really exists in some firearms testing and for those people who like to fill the back of their "blinged-up" cars with amps and speakers to create insane pressure waves of up to 160dB although, of course, this is not really sound but air-over-pressure and requires specially constructed microphones and pre-amplifier attenuators to be able to measure it.

Audio recording at high levels will give you plenty of information and a good audible output even at low bit-depths and sampling-rates, but there is an upper limit to this too, which is also determined by the range of the sound meter, so if the numbers are overloading, then the audio file will become distorted and less discernible. See figure 2.

How low do you need to measure anyway?

The measurement of low noise levels is certainly important in the assessment of environmental impact and for planning, but how low is low? A 'quiet' bedroom at night can be as low as 30dB (A)? (depending on the activities of the inhabitants!) and you will



struggle to measure down to 25dB (A)? pretty much anywhere in the UK, unless you are in a specialist sound testing laboratory.

Quite surprising, then that manufacturers of sound meter are often asked for sound meters that measure down to 'at least' 20dB. Realistically, this is only possible with very specialised equipment and is not generally available in a standard sound level meter. Hmm.

As an extreme example of genuinely low noise levels, there was a gentleman, who once reported proudly that he was measuring in the peat bogs in Eire, and it was extremely quiet at night, as he got an answer of 18dBA everywhere he went! Didn't occur to him that that was the lowest his meter could read, so he wasn't measuring the actual sound at all! Most places aren't that quiet by a long shot!

Use your ears!

We increasingly tend to rely on technology in everyday life to solve our problems and we worryingly rely on the outputs, often to the exclusion of sense and reason – I expect most people have fallen foul of Sat-Nav routing anomalies leading you down a farm track you would normally avoid! Equally, relying on the numbers from a sound meter can lead to misinterpretation and false conclusions. One job we were involved in during March showed boundary exceedances every morning between 5am and 7am. It only took a human ear one minute to realise they were hearing a delightful, yet deafening, dawn chorus.

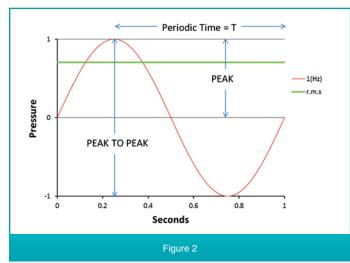
Conclusion

Understanding how the dynamic range of an instrument works can help prevent measurements on site being under or over range in the first place and whilst it is unlikely that measurements will overspill a dynamic range, where this is possible, careful selection of instrumentation will ensure good data. This is particularly important for meters with manual settings or multiple ranges.

You are likely to come across several phrases when dealing with this issue including "total range", "dynamic range", "linear operating range" (sometimes called linearity range), "measuring range" and "display range". It is important to note that "total range" and "linear operating range" are the only ones of any value, as they are the official terms used in the International Standard IEC 61672-1:2013 and are the basis for sound meter testing and verification.

Recording sound in the environment is increasingly popular as a means of providing a robust qualification of the acoustic events giving rise to measured sound. Where long duration sound recordings are required, particularly at high quality, this can be extremely memory intensive, and again should inform the choice of instrumentation used.

And finally, never forget that measurements and recordings, however robust, do not replace the need to perceive the sound directly using the human ear.



Optical generation of ultrasound via photoacoustic effect

imitations of the piezoelectric array technologies conventionally used for ultrasonics inspired a group of University College London researchers to explore an alternative mechanism for generating ultrasound via light, also known as the photoacoustic effect.

Coupling this with 3-D printing, the group was able to generate sounds fields with specific shapes for potential use in biological cell manipulation and drug delivery.

Piezoelectric materials generate mechanical stress in response to an applied electric field, resulting in a usable and precisely controllable force that can, for example, be used to create sound waves. But achieving this control with conventional piezoelectric arrays requires both complicated electronics and large numbers of extremely small individual components which are expensive and difficult to manufacture.

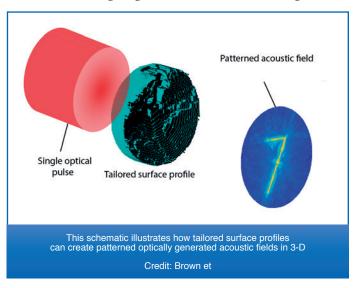
The photoacoustic effect, in contrast, occurs when a short pulse or modulated source of light is absorbed by a material, producing a sound wave. As the group reports in *Applied Physics Letters*, its work focuses on using the photoacoustic effect to control ultrasound fields in 3-D.

"One useful feature of the photoacoustic effect is that the initial shape of the sound that's generated is determined [by] where the light is absorbed," said Michael Brown, a doctoral student at the Biomedical Ultrasound Group of the Department of Medical Physics and Biomedical Engineering at University College London. "This can be used to create tightly focused intense points of sound just by depositing an optical absorber on a concave surface, which acts like a lens."

More generally, it is possible to manufacture samples with nearly any surface shape by using a 3-D printer and a transparent material.

"By depositing an optical absorber on this surface, which can be done via spray painting, a sound wave of nearly any shape can be created by illuminating this sample with a laser," Mr Brown said. "If you carefully tailor the design of the surface and therefore the shape of the acoustic wave, it's possible to control where the sound field will focus and even create fields focused over continuous shapes. We're using letters and numbers."

This is particularly significant because, in theory, the ability to control the shape of the wavefront – the surface over which the sound wave has a constant phase, somewhat like the edge of the wave – enables a large degree of control over the resulting field.





Sound-shaping super-material could transform personal audio

super-material that bends, shapes and focuses sound waves that pass through it has been created by scientists.

The creation pushes the boundaries of metamaterials – a new class of finely-engineered surfaces that perform nature-defying tasks.

These materials have already shown remarkable results with light manipulation, allowing scientists to create a real-life version of Harry Potter's invisibility cloak, for example.

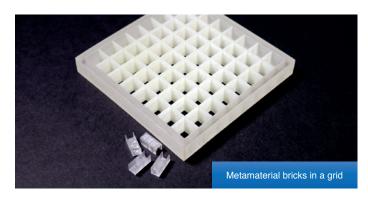
But a research team from the Universities of Sussex and Bristol have now shown that they also work with sound waves, which could transform medical imaging and personal audio.

Finely shaped sound fields are used in medical imaging and therapy as well as in a wide range of consumer products such as audio spotlights and ultrasonic haptics. The research, published in *Nature Communications*, shows a simple and cheap way of creating these shaped sound waves using acoustic metamaterials.

The collaborative research team assembled a metamaterial layer out of lots of small bricks that each coil up space. The space coiling bricks act to slow down the sound meaning that incoming sound waves can be transformed into any required sound field.

The new metamaterial layers could be used in many applications. Large versions could be used to direct or focus sound to a particular location and form an audio hotspot. Much smaller versions could be used to focus high intensity ultrasound to destroy tumours deep within the body. Here, a metamaterial layer could be tailor-made to fit the body of a patient and tuned to focus the ultrasound waves where they are needed most. In both cases the layer could be fitted to existing loudspeaker technology and be made rapidly and cheaply.

Dr Gianluca Memoli, from the Interact Lab at the University of Sussex who led the study, said: "Our metamaterial bricks can be 3D printed and then assembled together to form any sound field you can



imagine. We also showed how this can be achieved with only a small number of different bricks. You can think of a box of our metamaterial bricks as a do-it-yourself acoustics kit."

Professor Sriram Subramanian, Head of the Interact Lab at the University of Sussex, added: "We want to create acoustic devices that manipulate sound with the same ease and flexibility with which LCDs and projectors do to light. Our research opens the door to new acoustic devices combining diffraction, scattering and refraction, and enables the future development of fully digital spatial sound modulators, which can be controlled in real time with minimal resources."

Bruce Drinkwater, Professor of Ultrasonics at the University of Bristol, explained: "In the future I think there will be many exciting applications of this technology. We are now working on making the metamaterial layers dynamically reconfigurable. This will mean we can make cheap imaging systems which could be used either for medical diagnostics or crack detection."

Smart phone app will measure rail journey vibration

Passengers could soon be using their mobile phones to help rail companies around the globe improve the ride quality on their trains.

Scientists at the University of Birmingham have developed a smartphone app that allows passengers to measure ride comfort themselves using their smartphones.

Information collected by the app would give railway companies instant feedback from passengers about bumps, bangs and vibration on their trains.

The study is the first to use artificial neural networks to map data gathered from smartphones in order to evaluate ride quality. It reveals that accelerometers found in modern smartphones are good enough to be used in measuring ride comfort.

Dr Sakdirat Kaewunruen, Senior Lecturer in Railway and Civil Engineering, said: "Making passengers feel comfortable aboard their trains is something many railway companies strive to do. With the advent of smartphones, passengers can potentially measure the ride comfort themselves.

"Our research opens the door for many opportunities, allowing passengers to provide instant feedback on the comfort of their journey and equipping railway companies with information they can use to further improve ride comfort for passengers.

"There is also potential for this technology to be used to detect track faults and indicate which sections of track are in need of



maintenance, possibly saving on maintenance costs and improving the safety of the railway."

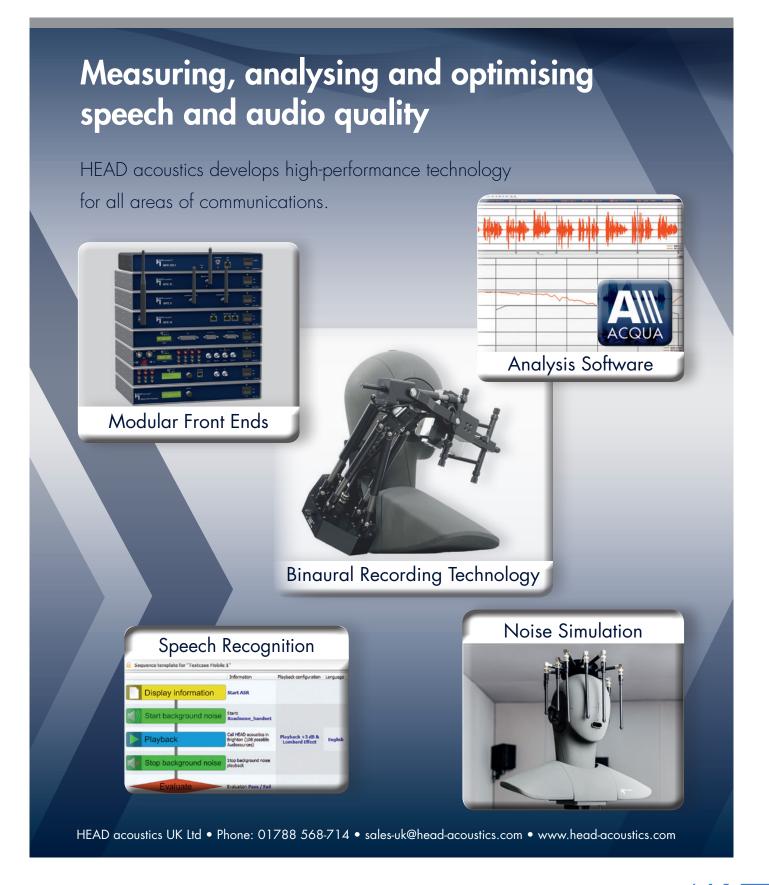
The study was published in *Frontiers in Built Environment*. Researchers used a specially designed smartphone app to record vibration data from a train running on a test track, comparing the information gathered with a reference accelerometer.

Researchers discovered that the technology used in modern smartphones is more than good enough to measure ride comfort aboard trains. They noted that mobile technology develops at a high rate and future smartphones would have higher quality accelerometers than those used in the experiment.

Vibrations in trains can be caused by welding and rolling defects, rail joints, poor track alignments, and various defects or roughness in the track or wheel surfaces. The types of vibrations experienced on board trains are different from the ones experienced in road vehicles.



Speech Quality Testing



Bong! Researchers uncover the secrets of Big Ben

team of researchers has become the first to vibration-map the bell of Big Ben in order to reveal why it produces its distinct harmonious tone.

The group, from the Advanced Structural Dynamics Evaluation Centre (ASDEC) at the University of Leicester, measured four of Big Ben's chimes, taking place at 9AM, 10AM, 11AM and 12 noon.

The ASDEC team used a measurement technique called laser Doppler vibrometry. This involved creating a 3D computer model of Big Ben and then using lasers to map the vibrations in the metal of the bell as it chimed.

ASDEC, working with the BBC, measured the structural dynamics of Big Ben in an unprecedented level of detail after being given exclusive access to the iconic structure.

Using two scanning laser Doppler vibrometers, the team were able to characterise Big Ben without touching it providing high-density vibration measurements without any loss of accuracy or precision.

The findings of the mapping project were revealed during a BBC documentary entitled *Sound Waves: The Symphony of Physics* hosted by Dr Helen Czerski.

Martin Cockrill, a Technical Specialist from the Department

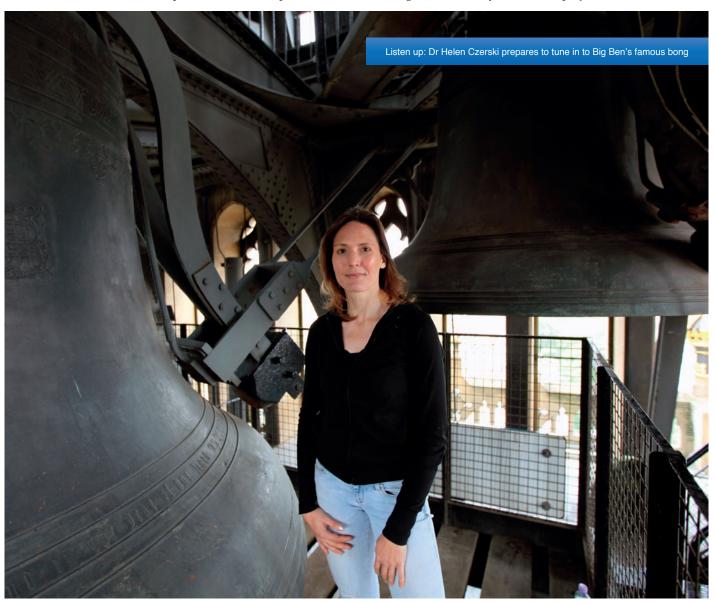
of Engineering, said: "Aside from the technical aspects one of the most challenging parts of the job was carrying all of our equipment up the 334 steps of the spiral staircase to the belfry. Then to get everything set up before the first chime, we were literally working against the clock.

"Many of the vibrations in the metal of Big Ben are too tiny to be seen by the naked eye. But this is what we were able to map using the lasers and not just one or two points on the surface; we were able to get over 500 measurements across the surface which just wouldn't have been possible with previous technologies."

According to the university research team, Big Ben is thicker than other bells of a similar size, weighing more and as a result having a higher pitch than expected for its diameter.

When a bell is struck, the impact causes a number of different vibrations or modes. The frequency and intensity of these modes are predominantly affected by the profile of the bell.

"This was such a once in a lifetime opportunity," said Martin Cockrill, "one which was perfectly matched to our skills and resources. You cannot just glue sensors to a national treasure such as Big Ben. Our ability to do the whole thing quickly without touching the bell was key to the whole project."



Sound wave technology set to aid cancer treatment

new technology that uses sound waves could show which cancer treatments work, and even help slow down cancer spread.

Cancer survival rates plummet when the disease spreads around the body. An estimated $90\,\%$ of cancer deaths are caused when tumours enter other organs or tissues, according to researchers.

One way to slow this down is to identify quickly which treatments are working and which are not, and researchers now believe they might be able to do this by sending sound waves into the body.

Body tissue is under pressure all the time due to blood running through vessels, but in cancer tissue this pressure rises as the blood vessels in a tumour are hastily built and rudimentary, exerting more pressure on surrounding body tissue.

In theory, pressure would be a good indicator of whether treatments are reducing the size of tumours. The problem comes in trying to measure it - at the moment doctors need to push a needle in, which can easily skew the result.

Using sound waves - something similar to the hum of an electrical shaver - could finally give them a way to check from the outside, if a research effort under way is successful.

"We send acoustic waves through the body and use the MRI (magnetic resonance imaging) machine to visualise the propagation of those waves," said Professor Ralph Sinkus of King's

College London.

As part of the EU-funded FORCE project, which started this year, he is trying to refine the sound wave technology - called magnetic resonance elastography (MRE) - so that it is sensitive enough to reveal the pressure exerted by the tumour on normal body tissue.

Changes in the way these sound waves propagate through tissue could be used to show if treatments are working, but they could also allow doctors to select the right drug for their patient. That is because it could be the pressure itself inside some tumours that dictates how well chemotherapy will work.

"If the pressure in cancer cells is very high, it could mean that drugs with a smaller molecular weight are better suited to entering the cell - larger molecules might not get through," explained Professor Sinkus.

"All things being equal, a certain drug might be considered more potent in most patients, but if it's too large to get into a high-pressure cell, then a smaller molecule could be the better choice.

His team is working with Sanofi, a pharmaceutical company, to see how MRE could guide treatment choices in breast, liver and brain cancer patients. In this study, breast cancer patients who receive chemotherapy to shrink tumours before surgery will be scanned before, during and after their treatment.

Professor Arnie Purushotham at King's College London, who led the breast cancer study, said: "This is a novel and exciting future for imaging breast cancer with widespread applicability in diagnosis and monitoring treatment."

The results could enable MRE to be used as a tool for predicting how well drugs work.

This report is based on one in Horizon, the EU research and innovation magazine.

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Portable device 'will revolutionise structural vibration-reducing technology'

revolutionary portable device invented in the US promises to make structural vibration-reducing technology universally accessible.

The PTMD – or portable tuned mass damper – significantly improves on existing technology by making it more compact, affordable, simple to set up and tune, and easy to integrate into a structure's design. The device has reduced vibrations by as much as 40 to 75 percent in laboratory tests as well as in buildings and a footbridge.

"With the increased use of modern, lightweight building materials to create elegant, flexible designs, we've also seen an upsurge in the problem of structural vibrations," said Professor Mehdi Setareh, a professor of architecture at Virginia Tech's College of Architecture and Urban Studies.

"While these vibrations are not necessarily dangerous, they can be disturbing to people and interfere with sensitive equipment and instrumentation. The PTMD improves upon an expensive and complicated dampening system by offering a cost-effective alternative that's easy to manufacture and use."

Tuned mass dampers are used worldwide to mitigate vibrations in structures like buildings and bridges, where excessive movement can be alarming or even sickening to occupants. They are employed in landmarks like London's Millennium Bridge, Trump World Tower in New York, and Taiwan's Taipei 101 skyscraper, where they help minimise swaying from foot traffic and wind. The vast majority are multi-ton devices that occupy an average of 1,000 square feet and are complex and costly to install, tune, and maintain.

Professor Setareh's PTMD presents a revolutionary alternative to its behemoth forefather. Smaller than a nightstand and under 275 pounds, the device can be easily set up and adjusted by nontechnical personnel using a \$5 iTunes application and Professor Setareh's instructions.

The PTMD also can be easily integrated into the construction of a building or added as a post-construction corrective measure. Its small footprint means it can be conveniently hidden away in a cupboard or even incorporated as a design feature.

"The nice thing about these units is that they are portable and it's easy to fit them inside the furniture. You can move them around and you can tune them easily," Professor Setareh said. "We are able to use them both as a fix or as part of the original design. You can cut down on the cost of construction by using lighter steel beams, and with devices like this, you can economically cut down the movement and vibration."

Professor Setareh, who has applied for a patent on the device, is working with his students to perfect it for commercial and industrial applications. They're also working on new prototypes that can be integrated even more easily and effectively into building designs.

He believes the PTMD shows great promise for use in such settings as theatres, malls, nightclubs, and monumental staircases, where high-traffic floor vibrations can be unsettling or frightening to occupants. It also holds strong potential in settings like hospitals and labs, where sensitive equipment demands very small environmental vibrations.



Sound waves 'may improve deep sleep and memory in older adults'

xposure to gentle sounds during sleep may improve memory in older adults, a new study has found.

Researchers at Northwestern University's Feinberg School of Medicine in Chicago found that sounds played to the rhythm of brain waves significantly enhanced deep sleep in study participants and improved their memory test scores.

Although the study was small, researchers say it could help with treatment of dementia, Alzheimer's disease and other cognitive disorders.

The study, published in *Frontiers in Human Neuroscience*, involved 13 participants over the age of 60. For one night, they slept in a lab where gentle sounds, such as the rush of a waterfall, were synchronized with their brain waves. On a different night, they slept in the lab with no sounds. Researchers tested the participants' memories before and after sleep.

Those who listened to the "acoustic pulses" during sleep recalled three times as many words the next morning, compared to people who received no sound at all, said study co-author Nelly Papalambros.

"So it kind of suggests to us that the degree of sleep enhancement



is related to the degree of memory improvement," she said.

Ms Papalambros said scientists have been studying the links between sleep and memory "forever."

"We know that deep sleep, also known as slow-wave sleep, is critical for memory consolidation," she said.

The so-called "slow waves", which are large brain waves that occur about once per second, "are thought to be important as a restorative process," she added.

Ms Papalambros said previous studies have looked at how sounds during sleep can improve the memories of young people, but there hasn't been a lot of similar research involving older adults.

"We know that deep sleep changes as we age. It decreases pretty substantially...and it's thought to play a part in the memory decline we see with age," she said.

Ms Papalambros said a larger study with more participants over a longer period of time is needed to confirm the results and better understand the impact of sound waves on sleep and memory.



Better method to predict speech intelligibility in noisy surroundings

niversity researchers in Germany have developed a more precise method for predicting speech intelligibility in noisy surroundings which they believe could speed up hearing aid development.

Specific algorithms in hearing aids filter out background noises to ensure that wearers are able to understand speech in every situation – regardless if they are in a packed restaurant or near a busy road.

The challenge for developers is to maintain high speech transmission quality while filtering out background noises. Before an optimised hearing aid model is released to the market, new algorithms are subject to time-consuming tests.

Researchers and industrial developers run hearing tests with people to analyse to what extent the respective new algorithms will ensure speech intelligibility. If they were able to assess speech intelligibility reliably in an automated process, they could cut down on time-consuming test practices.

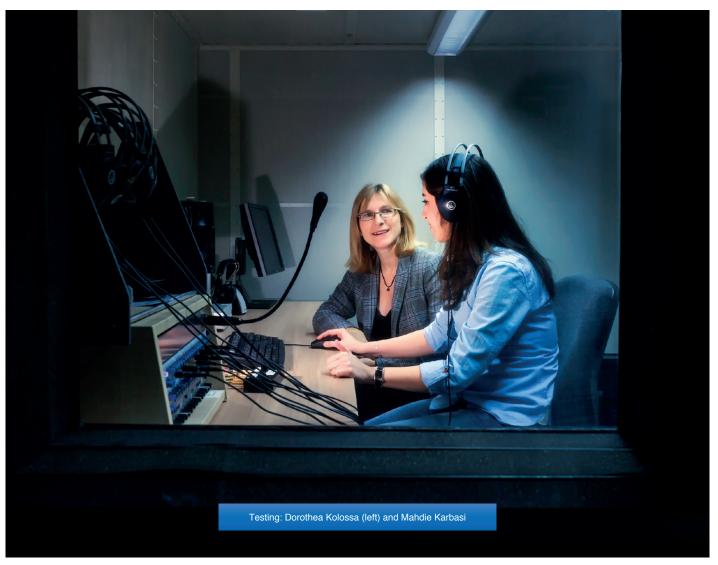
Current standard approaches for predicting speech intelligibility have included the so-called STOI method (short time objective speech intelligibility measure) and other reference-based methods. These methods require a clear original signal, i.e. an audio track that has been recorded without any background noises. Based on the differences between original and filtered sound, the value of speech intelligibility is estimated.

Professor Dr Dorothea Kolossa and doctoral student Mahdie Karbasi from the Ruhr-Universität Bochum (RUB) have found a way to predict intelligibility without needing a clear reference signal, which is still more precise than the STOI method. Consequently, their findings might help reduce test processes in the product development phase of hearing aids.

The RUB researchers tested their method with 849 individuals with normal hearing who were asked to assess audio files via an online platform. With the aid of their algorithm, they estimated which percentage of a sentence from the respective file would be understood by the participants. Subsequently, they compared their predicted value with the test results.

In the next step, Professor Dr Kolossa and Ms Karbasi intend to run the same tests with hearing-impaired participants. They are working on algorithms that can assess and optimise speech intelligibility in accordance with the individual perception threshold or type of hearing impairment. In the best case scenario, the study will thus provide methods for engineering an intelligent hearing aid.

Such hearing aids could automatically recognise the wearer's current surroundings and situation. If he or she steps from a quiet street into a restaurant, the hearing aid would register an increase in background noises. Accordingly, it would filter out the ambient noises – if possible without impairing the quality of the speech signal.



Spider web study will help develop sensor technology for vibration measurement

ew research, led by the Universities of Bristol and Oxford, will look at spiders' webs to investigate their computational capabilities and based on this research they will develop new sensor technology to measure vibrations and flow.

Spiders' webs have evolved over hundreds of millions of years and can be surprisingly complex. Their obvious functionality is to catch and hold prey. However, their remarkably complex structure suggests they can do even more. The web could potentially serve as a signal-processing device. It could therefore help the spider to locate and categorize robustly its prey and other events like broken threads or mates. The spider might use its web as a computer.

It is known that spiders have sensitive mechanoreceptors on their legs that allow them to measure vibrations. Spiders also probe their webs by sending out vibrations and observing how it responds in form of vibration patterns. This suggests that the web is not only a static, passive structure to catch prey, but can rather actively contribute to the pattern recognition task to locate and categorise everything that is happening in the web.

This interdisciplinary research project, which is funded by a Leverhulme Trust research project grant of more than £250,000, will look at the sophisticated structure of spiders' webs to understand how these morphologies can carry out computation. This is usually referred to as Morphological Computation. This is a

design approach, often used in robotics, which considers the body of a robot crucial for any intelligent behaviour. As in the case of morphological computation based robot designs, spiders seem to defer computational tasks to a morphological structure, such as, the spider outsources pattern recognition to the web.

Dr Helmut Hauser, Lecturer in Robotics in the Department of Engineering Mathematics at the University of Bristol, who is leading the project, said: "The idea of intelligent morphological structures is not just useful for spiders, but can be developed into novel, intelligent sensor technologies, especially for vibration and flow sensors.

"We also believe on-demand deployable morphology-based computational devices is of great interest for robotics. Potential uses for the technology include maintenance robots that swarm through tubes building flow sensors at key points to identify irregularities, or climbing robots that construct vibration sensors at strategic places on buildings to detect earthquakes or structural failure.

"The project will provide a fundamentally new way of building sensors by employing a design approach that carefully considers morphological features. The aim is to obtain highly robust and intelligent sensors capable of carrying out relevant signal processing through their structures."

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Listen up: city noise means Mancunians have worse hearing than Londoners

Trban noise pollution and hearing loss are closely linked, according to rankings of 50 large cities.
High-decibel urban areas, such as Guangzhou, New Delhi,

High-decibel urban areas, such as Guangzhou, New Delhi, Cairo and Istanbul, topped the list of cities where hearing was most degraded, researchers reported.

Of the three UK cities ranked in the study, noise levels and hearing problems were both worse in Manchester (21st place) followed by London (24th) and Birmingham (26th).

Likewise, cities least afflicted by noise pollution, including Zurich, Vienna, Oslo and Munich, registered the lowest levels of decline in hearing.

This statistical link does not necessarily mean the constant din of city life is the main driver of hearing loss, which can also be caused by infections, genetic disorders, premature birth, and even some medicines.

The findings are also preliminary, and have yet to be submitted for peer-reviewed publication.

"But this is a robust result," said Henrik Matthies, managing director of Mimi Hearing Technologies, a German company that has amassed data on 200,000 people drawn from a hearing test administered via cell phones.

"The fact that noise pollution and hearing loss have such a tight correlation points to an intricate relationship," he said

Researchers at Mimi and Charité University Hospital in Berlin explored the link by constructing two separate databases.

The first combined information from the World Health Organization (WHO) and Norwegian-based technology research group SINTEF to create a noise pollution ranking for cities around the world

Stockholm, Seoul, Amsterdam and Stuttgart were also among the least likely to assault one's ears, while Shanghai, Hong Kong and Barcelona came out as big noise makers.

Paris, one of the most densely populated major cities in Europe, scored as the third most cacophonous.

The ranking for hearing loss drew from Mimi's phone-based test, in which respondents indicated age and sex. Geo-location technology pinpointed the cities.

The results were measured against a standard for age-adjusted hearing.

On average, people in the loudest cities were 10 years "older" in terms of hearing loss than those in the quietest cities, the study found.

Scientists to investigate the health impact of skyscraper and bridge vibrations

he impact of vibrations from very tall buildings and "wobbly" bridges and floors on people's health and wellbeing is to be researched in a new £7.2 million government-funded national research facility.

Simulators recreating the experience of working in a high-rise office block, walking across a wobbly bridge or dancing in a crowded stadium are to be built in a joint project by the universities of Exeter and Bath.

Studies have already indicated that very subtle building motion can be perceived by some occupants, sometimes inducing motion sickness and causing fear. The simulators will help the research team better understand how this could affect the wellbeing of some people, their work performance, or behaviour.

By recreating the vibrations using virtual-reality simulators, a multi-disciplinary team of engineers, medics, physiologists and psychologists from the Universities of Exeter and Bath will explore how people can experience different forms of motion sickness such as tiredness, low mood, and difficulty concentrating, as well as a lack of motivation if they are working in a building that sways slightly in the wind.

The VSimulators will not only recreate the structural motion people experience, but the surroundings, temperature, humidity, noise, air quality and even smells of buildings.

The national testing facility, located at both the Universities of Exeter and Bath, will allow the researchers to measure not only the effect on people of vibrations from very tall buildings, but their impact in offices and condominiums, football stadiums and rock concert venues, including the impact of vibrations caused by crowds simultaneously exiting a stadium and walking across "wobbly" bridges.

State-of-the-art virtual reality and human body motion capture equipment will help the team to devise solutions to mitigate impact and help designers, planners, architects and engineers in the construction or refurbishment of buildings.

Over five years Exeter and Bath will inject £2.45 million into the project, with the Engineering and Physical Sciences Research Council (EPSRC) contributing a further £4.8 million to create the vibration simulator in a brand new building at Exeter university, with a major laboratory refurbishment in Bath.

Alex Pavic, Professor of Vibration Engineering at the University of Exeter, who was an adviser on the "wobbly" Millennium Bridge in London and on the design of the London Olympic 2012 venues, says the new testing facility will "place humans at the centre of future structural building design in the same way they are currently placed when designing cars".

"With over 400 tall buildings planned just for London between now and 2030, and many more in the rest of the UK and worldwide, VSimulators will potentially have major influence on the design of a future multi-£trillion worldwide portfolio of buildings. It will for the first time link structural motion, environmental conditions and human body motion, psychology and physiology in a fully controllable virtual environment."

Dr Antony Darby, Head of Civil Engineering at the University of Bath, said: "Just like sea sickness, our propensity to motion induced discomfort is situation and environment dependent. For example, people at a concert in a grandstand will accept completely different level of vibration than those in a hospital operating theatre."



On song: study will help musicians achieve the perfect vibrato

Scientists at Queen Mary University of London (QMUL) are bringing us closer to understanding the musical experience through a novel approach to analysing a common musical effect known as vibrato.

Vibrato is the up-down oscillation in pitch introduced during instrumental or vocal performance, intended to add expressivity and to facilitate sound projection, and commonly used in opera. A well-timed and beautifully executed vibrato can greatly enhance the sound quality of a note, and induce strong emotional responses in the listener.

The new approach to vibrato analysis, published in the *Journal* of *Mathematics and Music*, describes for the first time the use of the Filter Diagonalisation Method (FDM) in music signal processing. The technique has origins in quantum physics and is employed to study molecular dynamics and nuclear magnetic resonance.

"We are now one step closer to understanding the mechanics of music communication, the nuances that performers introduce to the music, and the logic behind them," said project supervisor and co-author Professor Elaine Chew from the Centre for Digital Music at QMUL's School of Electronic Engineering and Computer Science (EECS).

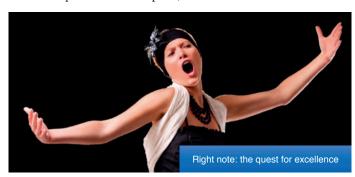
The technique's ability to detect and estimate characteristics from very fine slivers of information comes in particularly handy in vibrato analysis and allows researchers to analyse music signals with greater precision than before.

Vibratos typically oscillate at a rate of 4-8 cycles per second, or with a period of 125-250 milliseconds per cycle. The degree to which the pitch is bent up or down can be up to half a semitone.

Because vibratos happen so quickly, standard techniques which require a comparatively large window for analysing the music signal have so far struggled to accurately capture their characteristics.

"The FDM algorithm was initially developed to efficiently and effectively explore the complicated quantum dynamical resonances of atoms and molecules. Although musical signals are very different from their quantum counterparts, mathematically they share many similarities, including the characteristics of their resonances," said Dr Khalid Rajab, project co-supervisor and co-author from QMUL's School of Electronic Engineering and Computer Science (EECS).

"In fact, we found that, because they oscillate with time, the harmonics in musical signals can be more complicated to analyse than their quantum counterparts," he added. The research



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emerged from a project to model the differences between playing on violin and erhu, a two-stringed Chinese fiddle.

Professor Chew said: "When music for a folk instrument like the erhu is performed on a violin, it lacks the stylistic and expressive qualities of the original. One of the major sources of these differences lies in the way in which notes are elaborated (with vibrato) and the way in which the instrumentalists make their transitions

between notes (using portamentos). We were interested in creating computing tools that can help reveal these differences."

The researchers hope the new technique will help musicians and music teachers in their quest to achieve the perfect vibrato, assist sound artists in creating more natural sounding vibrato effects in audio production, and enable researchers to map stylistic trends in vibrato use across cultures and time.

New method 'will help reduce road traffic noise'

cientists have designed a new method to reduce road traffic noise.

The application of the European Environmental Noise Directive by various public administrations of the European Union member countries in relation to road traffic noise has generated a significant number of Noise Action Plans (NAPs) by the administrations responsible for European infrastructures.

However, the directive does not establish a regulated process to choose the most critical road stretches that require action and, once chosen, selecting the most suitable option to mitigate noise. In fact, the critical study of the noise action plans published in Spain shows the general lack of methodologies and criteria taken into account on the problem of prioritising the actions they include.

The research, carried out by scientists at the University of

Granada (Alejandro Ruiz Padillo, Ángel Ramos-Ridao and Diego Pablo Ruiz) and the University of Southampton (Antonio J Torija), proposes a practical methodology based on exclusively technical criteria using available data from the groups responsible for the infrastructures.

This methodology, called PATRON (Prioritising AcTions against Road Noise), consists of two stages. The first is defining and weighing the main criteria used to prioritize the road stretches included in a plan. In the second stage, the main criteria and choices to be taken into account are defined, and the appropriate options are chosen for each of the roads. In addition, weights are obtained for each of the criteria, which allows assessment of their relative importance in each problem.

The final product is an easily implemented method for decision making by choosing the most suitable alternatives for the reduction of the exposure to the noise generated in each road, once those roads are selected.

Alejandro Ruiz Padillo said the application of the PATRON methodology was possible regardless of the simulation or techniques used for measuring the noise. Therefore, it could be easily applied to future phases of implementation of the European Environmental Noise Directive, especially now that the CNOSSOS-EU method is to be used as the common method of generating strategic noise maps in Europe starting in 2017.

The acoustic performance of flanking paths for curtain walling systems

By Nick Conlan

Introduction

Curtain walling is defined as a non-structural system that weatherproofs the outside of buildings and supports no load other than its own weight and the environmental forces which act upon it, and for this article we will be concentrating on systems that are predominantly glazed systems within aluminum frameworks.

Many of us who work in building acoustics will come across curtain walling, in the design of offices, schools, residential buildings, or hotels and the sound insulation between spaces can often be limited by the flanking transmission of the curtain wall elements and it is useful to understand the limitations to sound insulation that the curtain walling introduces.

The aims of this article are to try and bring together what information is available and explain how it can be used to predict on site performance, or to produce flanking performance specifications for suppliers.

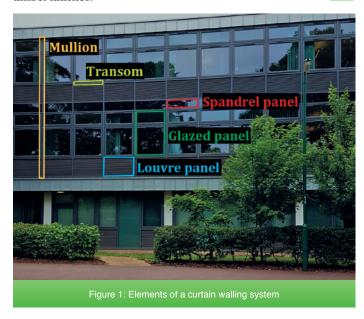
Terminology

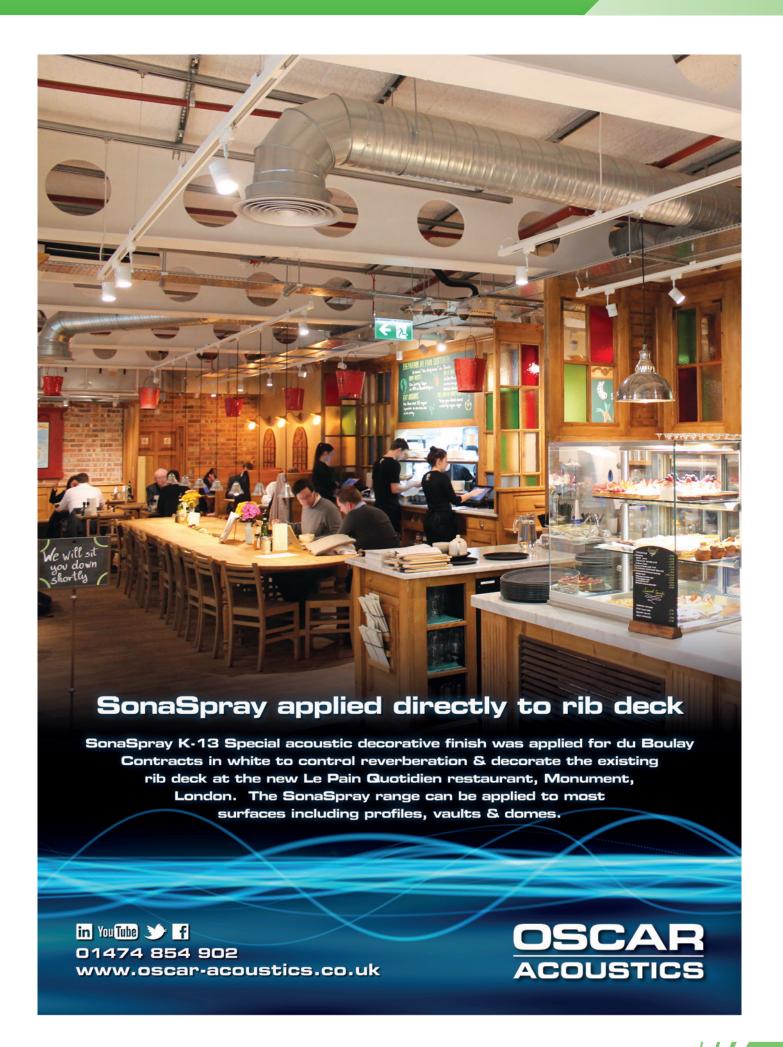
We'll start with some of the common terminology used for curtain walling systems. Figure 1 shows a typical external glazed curtain wall. The framework has vertical elements known as mullions and horizontal sections known as transoms.

Glazing panels are fitted within the framework, but they can also be fitted with louvre openings for ventilation, or opaque panels often called spandrel panels, both of which are shown in the figure.

As the spandrel panels are opaque they are often used to cover

unsightly items such as floor edges, or can be vertical and used to cover junctions with walls. These particular spandrel panels are glass with a film behind, but the panels can be metal, or timber finishes.





Types of curtain walling

There are two basic types of curtain walling installations that are used, known as stick systems or unitised systems.

The stick systems have the framework constructed on site. They get their name from the fact that the vertical structural mullions (sticks) are fixed first. Once they are secure, the horizontal transoms are added and then the glazing, spandrel panels and vents are installed in the completed grid.

Unitised curtain walling systems are installed as a series of factory-assembled frames, some with interlocking mullions and transoms. The glazing panels and spandrels panels are pre-fitted and seals are also applied or prepared in the factory.

Unitised systems are popular because they are quicker to install on site and they eliminate, or reduce, the need for on-site sealing, therefore making them less reliant on the standard of site workmanship.

Figure 2 shows a stick system during construction and Figure 3 shows a unitised system.

Flanking routes

Flanking routes can be separated into horizontal (across walls) and vertical (across floors) requirements.

For a horizontal arrangement where we have a wall which is butted up to a mullion we have:

- the sound passing through the separating element, although not really a flanking path (Route 1),
- sound flanking via the junction and sealing detail between the wall and the curtain walling (Route 2),
- sound that passes through the aluminum mullion section of the curtain walling (Route 3); and
- the flanking via the glazing system (Route 4).

When considering vertical performance, we have the same routes as the horizontal, through the floor, junction and aluminum



additional consideration of sound travelling via a continuous mullion between floors (Route 5). These are shown in Figure 4.

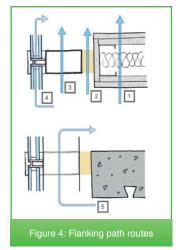
sections, but we also have the

Testing and performance

The flanking performance of curtain walling is usually given as a $D_{n,f,w}$ value, which is a laboratory performance measurement.

The method for testing flanking performance is covered in ISO 10848-2 [1] where the level difference is established between adjacent





rooms, and is normalized to an absorption area of 10m2.

It needs a specialised lab which can have the curtain walling installed across adjacent rooms.

Figure 5 is from the flanking test facility at the Vinci Technology Centre, in Bedfordshire. It shows three rooms - two on the ground floor and one on the first floor on the right of the picture.

The room sizes are important, and they appear similar in size to residential living rooms or small office type spaces. The rooms are arranged so that horizontal and vertical testing can be undertaken.

You can imagine that one reason for the lack of test data for systems is the cost of undertaking these tests, particularly if there are no commercial benefits or mandatory requirements, but that may be due to change.

Standards and CE marking

Most people will be familiar with CE marks on products, and they also apply to construction products for which there is harmonised product standard. For curtain walling that is BS EN 13830 [2] and in the UK the 2015 version has recently replaced the 2003 version.

However, it has not been approved in all European countries and the latest update from the Centre for Window and Cladding Technology website is that there is a holdup due to resources and the introduction of a number of new performance parameters, and that until it is approved, the 2003 version is applicable for CE marking. [3]

This is important because the 2015 version of BS EN 13830 includes flanking sound transmission as one of the new performance parameters. So when it is fully approved, flanking performance figures should become available for all CE marked products.

Predicting on site performance

For predicting the on-site performance, we are typically trying to estimate a D_{nT} , maybe with a C_{tr} correction, and these can be predicted using D_{n.f} values to establish the partial level difference via the flanking route. This can then be combined with the predicted performance of the separating element, and any other flanking routes to predict the global or overall $\boldsymbol{D}_{\!\scriptscriptstyle nT}$ value. The idea of partial level differences is covered more in the paper: Practical Acoustic Design - The Apex Method. [4]

But if we just look at the contribution from the curtain wall flanking we need to start with the two equations for $D_{n\text{\scriptsize T}}$ and $D_{n,\text{\scriptsize P}}$

$$D_{nT} = L_1 - L_2 + 10 \log \left(\frac{T}{T_0}\right)$$

$$D_{n,f} = L_1 - L_2 - 10 \log \left(\frac{A}{A_0}\right)$$

We can rearrange and then combine these equations using the common level difference terms, which gives us this equation:

$$D_{nT} - 10\log\left(\frac{T}{T_0}\right) = D_{n,f} + 10\log\left(\frac{A}{A_0}\right)$$

We can rearrange the equation and simplify it

P42▶





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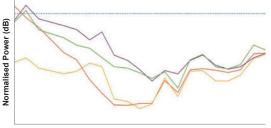
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The type of impact, the floating floor and the structure are all part of the same complex system but as with all types of projects Mason UK strives to support industry and produce the best possible solutions.

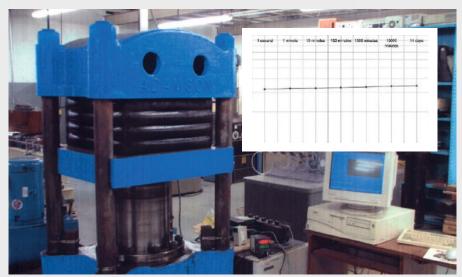




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$$D_{nT} = D_{n,f} + 10\log\left(\frac{A}{A_0}\right) + 10\log\left(\frac{T}{T_0}\right)$$

$$D_{nT} = D_{n,f} + 10 \log \left(\frac{A.T}{A_0.T_0}\right)$$

If we assume Sabine conditions apply in the receiving room, we can replace the A.T term with 0.16V.

Then we can introduce the A₀ and T₀ values of 10m² and 0.5s respectively and we have

$$D_{nT} = D_{n,f} + 10 \log \left(\frac{0.16 \, V}{5} \right)$$

$$D_{nT} \approx D_{n,f} + 10\log(V) - 15$$

Which becomes a straightforward formula to use.

The D_{n.f.w} values are specific for the length of the element tested and if the predictions are for elements that are longer or shorter than the ones tested in the laboratory a correction should applied and that is equal to 10 times the log of the tested element length (L_t) , over the element length in the predictions (L_n) so the complete equation becomes:

$$D_{nT} \approx D_{n,f} + 10 \log(V) - 15 + 10 \log(\frac{L_t}{L_p})$$

Where this is important is, for example, an office in the end of building, where the perimeter of a transom on three sides is say $25m (L_p)$, but the $D_{p,f}$ value was measured for a transom 2.5m wide (L_t). For that scenario with a factor of ten difference, there would be a 10dB correction.

Equally if a residential project had strip windows, just 1.2m wide and the element tested was 2.4m there would be 3dB improvement in the performance as the element used in the prediction is half the tested element length.

It should also be considered that the $D_{\mbox{\tiny nTw}}$ value is an on-site value and the D_{n,f,w} is in a laboratory so it maybe necessary to include for some allowance for testing tolerances and for workmanship. My personal thoughts are that they should perform relatively consistently provided the method of sealing on site is like that during the testing.

The amount of allowance will also depend on the contribution expected from the flanking path and whether it is the dominant sound transmission path.

 $\begin{array}{l} \textbf{Relationship between } R_w \ and \ D_{n,f,w} \\ \textbf{Occasionally you can have } R_w \ values \ provided \ for \ mullions, \ or \\ \end{array}$ aluminum sections and these can also be used in predictions. There is a relationship between $R_{\scriptscriptstyle w}$ and $D_{\scriptscriptstyle n,f,w}$ but it should be used with caution, especially when the R_w value is measured without any glazing attached to the section.

To establish the $R_{\rm w}$ value of a mullion ($R_{\rm mullion}$), it is fitted and sealed into a very high performing wall in a laboratory. The R_{mullion} value can be measured and calculated using the following equation, where S_{mullion} is the area of mullion.

$$R_{mullion} = L_1 - L_2 + 10 \log \left(\frac{S_{mullion}}{A} \right)$$

If we take the equation for Dnf

$$D_{n,f} = L_1 - L_2 - 10 \log \left(\frac{A}{A_0}\right)$$

these equations can be merged and re-arranged

$$R_{mullion} - 10 \log \left(\frac{S_{mullion}}{A} \right) = D_{n,f} + 10 \log \left(\frac{A}{A_0} \right)$$

$$R_{mullion} = D_{n,f} + 10 \log \left(\frac{A}{A_0}\right) + 10 \log \left(\frac{S_{mullion}}{A}\right)$$

and simplified,

$$R_{mullion} = D_{n,f} + 10 \log \left(\frac{S_{mullion} \cdot A}{A \cdot A_0} \right)$$

with the absorption value cancelling out and the value for A_0 = 10m² inserted we end up with

$$R_{mullion} = D_{n,f} + 10 \log \left(\frac{S_{mullion}}{10} \right)$$

So, for example, a mullion which is 2.7m long and 100mm deep the R_w value of the mullion is equal to the $D_{n,f,w}$ -16dB, or the other way around the D_{n,f,w} is the R_w value plus 16dB.

Performance of single piece sections

The performance of a single piece mullion can have typical $D_{n,f,w}$ values from 40 to 44 dB for sections ranging from 110mm to 190mm deep, and as you might expect the poorer performance comes from the deeper or larger sections. [5,6,7]

There is often a dip in the performance a frequency associated with the resonance of the section. The dip occurs at lower frequencies at the section depth increases.

It is not clear what causes the dip and it can appear when treatments are applied. It could be structural resonance of the walls, or due to resonances within the cavity, but it does happen in single piece sections.

Unitised systems performance

For unitised systems the performance can vary depending on the degree of isolation between the frames and to demonstrate this we will look at two separate types of unitised system.

The first type is referred to as a split mullion, as shown in figure 6, and even though they are built off site, when they are installed they can look like a stick system and there is rigid connection between frames.

Typical Dnfw values for a split mullion are not significantly more than a single piece mullion, perhaps on average 3dB better.

The second type of unitised system has independent frames, where the only connections are via a gasket or sealing material. Test data for these systems shows D_{n,f,w} values upto 54dB, typically 10dB better than the single piece mullions. [5]

This can be further demonstrated with measurements taken of a split mullion, both as a connected section and then with a 25mm gap between the sections. When it was tested, there was an

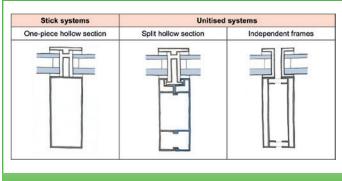
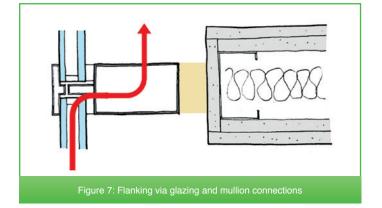


Figure 6: Types of section



Improvement of 10dB with the gap between the sections. [8]

So, it is important when systems are referred to as unitised, that the sections are reviewed as there is large variation in the potential performance of the systems between split mullions and independent frame systems.

Performance of glazing

The interaction between the glass and the curtain wall hollow section is important. The dynamics of the glass and the section are coupled and sound incident on the glass displaces as a membrane which applies bending at the boundary condition, or mullion, and excites the membrane on the opposite side.

When the mullions are filled and over clad to limit the sound transmission through the sections, $D_{n,f,w}$ values up to 59dB are predicted [5]

A recently published PhD [8] included the measured STC value of mullions in a laboratory, with and without the glazing. So first, they measured the STC of the mullion, installed the glass and repeated the measurements.

The tests were done on mullions with infills and ones with external cladding. The performance of the mullion dropped when the glazing was installed and for the highest performing section it dropped by 10dB.

If we assume the STC is equivalent to the $R_{\rm w}$ value, we can estimate the $D_{\rm n,f,w}$ as 58dB for the highest performing section and that is with glazing built up from 9mm outer pane and 12mm laminated inner.

What this indicates is that there are other flanking routes that we must also consider such as the one shown in figure 7 which passes from the glazing into the mullion, and the reverse of this from the mullion into the glazing.

This highlights that when using Rw values to predict the flanking performance of an aluminum section, allowance must be made for the reduction in performance that occurs when the glazing is installed.

Performance of junctions

When considering the performance of the junction it should be practical for the partition to be sealed to the curtain walling section and not reduce the performance of the section. Gaps up to 25mm can be infilled with filler rods and sealed with a flexible sealant without reducing the performance of the aluminum section.

Various staggered plate systems have been tested for curtain walling where some movement may be required and these again can achieve reasonably high Rw values.

There are acoustically tested products aimed at curtain walling junctions, such as from Siderise and these have often developed from fire stopping requirements.

Performance of mullion for vertical

The final flanking path we considered is via the mullions for vertical sound transmission. Sound can travel between floors via a mullion which is exposed in the rooms either side of the separating floor. The mullions can be continuous structures or can be broken and supported at the floor edge. The mullions are connected with an infill piece and this can be open or infilled, as shown in figure 8.

P44 ▶





Methods to improve performance – internal lining

There are three methods of improving the performance of an aluminum section. The first is to treat the inside of the sections, the second is to treat the outside and the third is to introduce an additional section so two mullions or transoms. And of course you could have a combination of these.

The internal treatments can be specific products or bespoke build ups that introduce further mass to the construction, absorption within the hollow section or damping to the hollow section material.

The greatest improvement can be achieved by infilling the section with dense boards to increase the mass.

Commercial products of absorptive foam and mass barrier laminate are available specifically for improving the performance of sections. [9]

External cladding

Systems which provide cladding to the outside have the potential to provide greater mass and damping, but with the obvious practical issues of aesthetics and sealing to the glass some tested systems have improvements between 6 and 14dB [6,8] although the greater improvements are for improvement to mullions alone and as discussed earlier the effect of the glazing is unknown so the measured performance needs to consider the flanking via the glazing and section.

Additional sections

When a single section is used, the performance will eventually be limited by the flanking via the glass, no matter how well the sections are treated. Where higher levels of sound insulation are required, a second hollow section must be introduced to reduce the flanking via the glazing. $D_{\rm n.f.w}$ values of 67 / 68 dB have been

measured with two sections, both over clad and for completed rooms, level differences close to 70dB have been achieved. [10]

The practical issue of using two sections is that the method of sealing the partition to the sections needs to be done correctly and not compromise the overall performance.

Conclusions

The sound insulation between spaces can often be limited by the flanking transmission of the curtain wall elements of the façade. If the $D_{\rm n.f.w}$ values for the system are known, the on-site performance can be predicted, however test data is often not available until suppliers are confirmed.

Initial estimates of the flanking performance can be made using typical performance figures, but these must be used with caution as there can be significant differences in performance between two curtain wall sections which have the same dimensions.

When R_w values are used for the performance of a curtain wall hollow section, the predictions should make allowance for a reduced performance once the glazing is installed in the system as the flanking via the junction of the glazing and the curtain walling hollow sections needs to be considered. \square

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References

A full list of references can be obtained from the IOA.

Development of a two-way loudspeaker system – a case study

By Mark Dodd

Introduction

The LS50 is a two-way loudspeaker system, inspired by the LS3/5A and conceived to celebrate the 50th anniversary of KEF. Like the LS3/5A, the LS50 has been developed with the extensive application of the latest engineering techniques, along with meticulous attention to detail. It uses KEF's latest 5" mid-range and 1" high-frequency driver units in a compact two-way system. Extensive listening tests were performed to ensure the right engineering choices were made to achieve the best possible balance. Both systems could be described as "Engineers loudspeakers", where the design has been determined by engineering parameters and sonic performance, rather than marketing requirements.

Historical context

The design of the LS3/5A is unusually well documented. The product brief was somewhat curious in that bass extension was only specified to 400Hz as the speaker was intended for use with male vocals in small studios, such as outside broadcast vans. The size of the enclosure was also an important part of the brief. In practice it was found that the KEF B110 bass-midrange driver could extend the response to below 100Hz, although, it could not be reflex loaded in such a small enclosure. The closed box is almost certainly a key aspect of its performance and is a feature shared by the Yamaha NS10. Somewhat ironically, the NS10 was originally a Hi-Fi design but became one of the most widely used desktop monitors in commercial studios, thus mirroring the LS3/5A's history. In [1] the BBC research department's design approach to the LS3/5A is discussed in some detail and in [2] some of the

material measurements, and methods for assessing enclosure resonances, are introduced with many results. It is evident from these papers that a great deal of work and considerable expertise went into the enclosure design, making use of the BBC's extensive material knowledge and world leading methods for the measurement of acoustic output from the enclosure walls.

By today's standards the LS3/5A is a somewhat unusual and costly design. The walls are fabricated from birch ply, selected for its combination of damping and stiffness, with a similar thickness of bituminous damping material applied to the centre of the faces. The rear mounted driver requires a removable baffle, which is fastened to beech fillets by numerous screws. Laser measurements of similar removable panels at KEF have shown that they have a significant impact on the vibrational behaviour of enclosures. Compared with a glued joint, the rigidity of a removable panel is somewhat reduced, the mechanical losses are increased and there is some degree of decoupling of the panel from the rest of the cabinet. Cabinet diffraction was, to an extent, also considered and reflections from the grille recess around the tweeter are absorbed with felt. The rear mounting of the bass driver results in a cylindrical cavity in front of the driver. Nevertheless, the balance seems successful in ameliorating any adverse effects of this. Relatively little attention was given to standing waves, with a simple lining of acoustic foam on the interior. The final balance, and various aspects of the enclosure design, were refined in an iterative process drawing on the BBC's expert listeners. The drivers had no modification other than the addition of a protective grille to the tweeter. It is also interesting to note that the BBC recognised a difference in sound quality between different capacitor types, but not between different manufacturers. It is a tribute to the designers that their work has survived the test of time to such a remarkable extent that the LS3/5A still has a place in the market after so many years.

The development of the LS50 Introduction

Much progress has been made over the 35 years since the LS3/5A was developed. Computer-aided modelling [3], computer-aided measurement [4] and scanning laser Doppler velocity measurements [5] were pioneered at KEF and Celestion. CNC manufacturing, rapid prototyping and modern materials are also available to today's engineer, along with high power computing and modern software. The LS50 benefits from these technological advances and, also, the further 35 years of experience the KEF design team has gained since the LS3/5A. Furthermore, modern high bit-rate recordings are now in common use and digital media has at last come of age, along with high power amplifiers, allowing the potential for higher performance.

As a result of the improved performance of audiophile analogue and high bit-rate digital systems, it was felt that the focus should be on producing a system with very low colouration, relatively extended low-frequency response and high power handling. The aim was to reveal the fine detail and image focus that the best systems can provide on good recordings, but with a faster leaner bass. Although KEF has a long history of well implemented three-way systems, in the LS50 the benefits of a minimalist compact two-way system have been explored using a "no holds barred" approach, owing much to the work on the Concept Blade system.

The use of modelling and measurement in the development of the LS50 $\,$

The use of modelling in loudspeaker design started around the time the LS3/5A was being developed. Initially loudspeaker systems were analysed in terms of "lumped elements" in an

equivalent circuit. The mass of the loudspeaker moving parts, the motor strength, the stiffness and damping of suspensions and enclosed air volume in the cabinet are all that is required to describe the low-frequency behaviour of a loudspeaker. Neville Thiele showed that loudspeakers could be considered as high-pass filters allowing known filter theory to be applied [6]. The extreme simplicity of these models is a virtue in that they clearly underline the basic principles of operation, allowing the gross characteristics to be predicted and designed in a deterministic manner. They are still an essential first step to designing a loudspeaker system.

Richard Small clarified the "lumped element" technique for closed boxes and reflex boxes adding all the information required for the designer to work in a deterministic way towards a target response [7][8]. At KEF this work was embraced; an extremely expensive digital fast Fourier transform (FFT) analyser and computer were purchased. This allowed measurement of loudspeakers in the time domain, modelling using "lumped circuits" and computer optimisation of crossovers to be carried out. The design of drivers, boxes and enclosures to achieve a target response became a reality.

Meanwhile, at Celestion, scanning laser Doppler velocity meters produced animations clearly showing the structural resonances in loudspeaker diaphragms and enclosures, making the complexities neglected by "lumped element" models tangible for the first time [5]. Improved driver and enclosure designs resulted.

In 1992 the Gold Peak group bought KEF and Celestion, bringing together these two approaches to loudspeaker design.

Mathematically, all acoustical behaviour is described using partial differential equations. The direct solution of these equations is only easily performed for a very few special geometric cases, such as the radiation from a flat rigid piston or the propagation of waves in a straight cylindrical duct. It is possible to approximate the behaviour of complex acoustical systems by using combinations of these special cases. This type of analysis can be very powerful as the equations are often soluble concisely, and from these concise solutions a great deal of information can



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be learnt about the underlying acoustical behaviour. However, it is only through the application of numerical techniques that the designer is free to analyse arbitrary shapes and geometries to within decibel accuracy.

Finite element analysis (FEA) is a numerical technique for modelling many different types of physical behaviour, such as acoustics, vibration, magnetism, electricity and thermal behaviour. A simple mechanical example of FEA is shown in Figure 1. FEA not only gives a results for "spot values", such as the pressure at a point, but also provides the pressure at all points and allows the visualisation of sound to help the engineer understand the physics involved [9]. The wealth of information produced by this technique, along with its ability to deal with iterative changes to geometry, make it a natural choice for design.

To model the sound radiation into infinite spaces, another numerical technique, boundary element analysis (BEA), is used. To model drivers and enclosures fully, a BEA model of the radiation environment may be fully coupled to a FEA model of the driver or enclosure.

The application of FEA is not straightforward: it has taken a couple of decades for the research team at KEF to progress from analysing the static behaviour of axisymmetric magnets in two dimensions to being able to carry out appropriate modelling of non-axisymmetric drivers and enclosures in three dimensions. The skills to do this are not trivial and encompass many disciplines, furthermore a significant financial investment is required both to purchase software and allow engineers time to acquire the necessary body of knowledge. At KEF, in-house software allows results from vibroacoustical FEA/BEA to be visualised and responses at chosen points viewed. Most significantly the software enables results from magnetic FEA, mechanical FEA and analytic models to be combined producing virtual prototypes of loudspeaker drivers and systems. This gives the KEF engineering team unrivalled power to explore new innovations and designs.

Driver selection

The LS3/5A drivers were exceptionally well refined for the time, using somewhat stiff and well damped materials. However, the driver diaphragms do not move as rigid bodies over the upper part of their frequency range. Such traditional diaphragms rely on having resonances and damping optimised for a clean sounding tonal response, but none the less they impart their own tonal characteristics to the sound.

2. The geometry is split into simply shaped elements

3. For each element the computer uses a simplified approximation to the underlying behaviour spring 2

spring 3

4. This results in an accurate approximation of the overall behaviour force applied to spanner

resulting flex (exaggerated)

Figure 1. Finite element analysis illustrated for a mechanical analysis of a spanner

The Uni-Q driver array selected for the LS50 is only similar to the LS3/5A in that it has a 5" nominal diameter midrange unit. This driver array produces a smooth and wide dispersion response with diaphragms behaving close to rigidly over their working bands. It produces exceptional point-source characteristics of great purity, both tonally and spatially. The midrange driver incorporates a mechanism to damp the diaphragm resonances, so the usual large peak found in metal diaphragms is absent from the response. Aluminium magnet rings are provided to reduce flux modulation and the corresponding midrange distortion. A Z-Flex surround ensures that the surround does not cause an excessive discontinuity for sound radiated from the high-frequency driver.

The high-frequency driver is derived from the Blade and uses a similar waveguide design to produce an apparent point source at the cone apex. This is achieved by means of a combination of patented technologies: The "optimal dome waveguide geometry" allows extended high-frequency response from a shallow spherical cap diaphragm at the apex of a conical wave guide [10]. The "tangerine waveguide" uses radial air channels to produce spherical waves up to the highest frequencies allowing a deeper "stiffened dome" diaphragm [11]. The increased depth raises the first diaphragm resonance resulting in a response that extends beyond 40kHz with wide dispersion and good efficiency. The unit also has a rear venting tube with a carefully optimised acoustical foam filling to avoid non-linearity and the associated distortion.

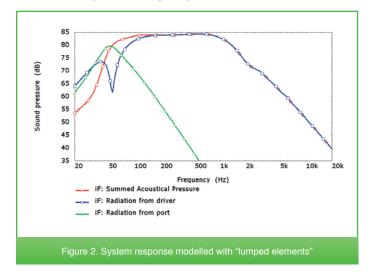
It is worth mentioning the new driver has significantly lower power compression and higher power handling than the LS3/5A drivers, due to the relatively large diameter voice coils, high temperature polyimide formers and long voice coil of the mid/bass unit.

The development of the LS50 has presented an interesting engineering opportunity to explore the audio performance potential of this driver array. It is perhaps not surprising that during the course of the LS50 development a number of minor refinements were made to the driver array, such as altering the voice coil to achieve the desired low-frequency response and improving some of the acoustic and mechanical damping.

Low-frequency alignment

The LS50 engineering project began with some initial "lumped element analysis" followed by the building of a number of prototypes to explore the balance. It was found that a reflex-loaded enclosure with a somewhat over-damped alignment, tuned to 55Hz, allowed music to be reproduced at satisfying levels with some low bass without losing the impression of clarity. The gentle roll-off from below 100Hz also gives good flexibility to position the speakers in smaller rooms where the boundaries will provide some bass lift.

It is worth noting that the effect of bass level on the perceived sound is not straightforward. A psycho-acoustical phenomenon called spectral masking must be considered: quiet sounds will be concealed by similar-frequency louder sounds. This



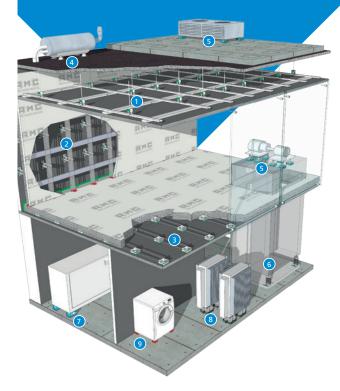
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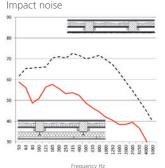
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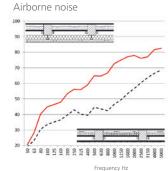
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effect is particularly strong when a loud low-frequency sound is present along with a quiet midrange sound. Reducing the level of the low-frequency sound reveals the midrange sound and so a decrease in bass benefits the perceived detail. Since the transient part of bass lines is also somewhat emphasised bass rhythm is especially easy to follow.

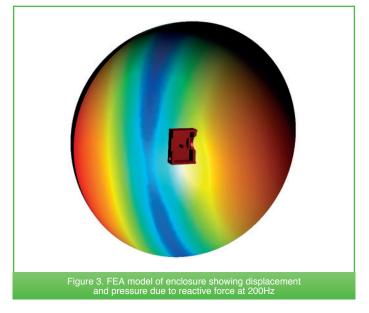
The decision to use a reflex enclosure led to some engineering challenges that required much time and effort to overcome. The initial design used two folded port tubes located near the bottom corners of the enclosure and the driver centrally positioned in the horizontal plane, 2/3rds of the way up the enclosure. Subjectively the design had some promising qualities: the bass was tight, well extended and could go satisfyingly loud. The midrange sound was reasonably clean but not quite to the desired standard. Detailed measurements showed defects due to structural resonance of the enclosure and unwanted port radiation above the tuning frequency. While it was decided to proceed with an enclosure of this low-frequency alignment, it was felt necessary to do some extra work to improve the midrange performance.

Enclosure design

Other than the output from the drivers themselves and port output due to the tuning frequency, any secondary radiation from the loudspeaker is undesirable and will cause colouration. With the majority of loudspeaker enclosures, there are some frequencies where the enclosure walls move and radiate some sound. This wall motion may either be caused by air pressure in the enclosure or due to vibration transmission from the driver.

For the initial design, "lumped element" models, with an approximate calculation for diffraction, were used to model the driver and port output, and determine the necessary driver parameters. FEA modelling techniques were then used to produce a detailed model including accurate calculation of diffraction, standing waves, wall motion due to acoustical and vibrational excitation and port output. Where desired, these may be calculated independently. This gives shorter calculation times and allows the impact of each mechanism to be separated. Furthermore, the sound pressure and vibration may be visualised on a computer, giving great insight into the mechanisms and allowing efforts to be focused on the areas requiring most improvement.

For this detailed modelling, 3D CAD models were used to directly generate FEA models allowing vibration and the internal acoustics to be calculated. These FEA models may be fully coupled to BEA models of the radiation environment allowing the sound output from the enclosure and drivers to be calculated. Where the enclosure has symmetry, only part of the system need be modelled since sound and vibration will also be symmetrical. The acoustic performance of different geometries, structures and materials may then be fully explored.



Vibroacoustical analysis of the enclosure

The reactive force on the driver magnet, due to current passing through the voice coil, is a source of vibration which causes the enclosure walls to vibrate and possibly to radiate as an unwanted secondary sound source. Because the enclosure walls are resonant, this radiation has large peaks and decays slowly. This results in colouration and masking of detail.

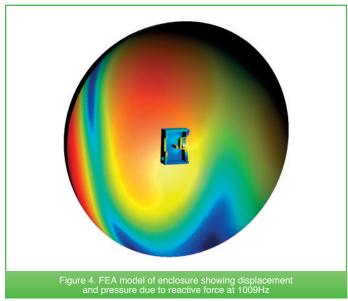
The most effective technique for avoiding this radiation is force cancelling, where two identical drivers rigidly coupled together are driven with the same signal. In this case, the reactive forces are equal and opposite so cancel and no net vibrational force is produced. An alternative method of preventing the reactive force reaching the enclosure is to use decoupling where the driver is connected to the enclosure by a soft material that reduces vibration transmission.

For loudspeakers with a single driver, force cancelling is not an option. Decoupling provides effective vibration control for midrange drivers, but is not readily achievable for drivers covering the low-frequency range. The very soft materials required would not provide adequate support for the driver. As a result, an alternative approach is required for two-way loudspeaker systems

To illustrate the effect of enclosure vibration, results from an early design are shown below. This design has one plane of symmetry, so only half the enclosure need be modelled. Using FEA one can look at the enclosure radiation due to the reactive force in isolation.

At low frequencies the box simply moves backwards and forwards: the model does not include any constraints to "anchor" the enclosure. Since the wavelength at this low-frequency is much larger than the enclosure, this type of motion results in a dipole radiation characteristic. FEA results for this case are shown in Figure 3. The enclosure is moving as a rigid body and is consequently one colour. The sound pressure is displayed on a hemisphere around the enclosures. The null pressure region that one would expect from a dipole source can be seen. In practice this rigid-body motion may be controlled by the use of a high mass stand, preferably sand filled to absorb some of the vibration. The FEA results for the first highly coupled structural resonance at 1009Hz are shown in Figure 4. The enclosure is now moving in a much more complicated manner and the radiation is no longer simple.

Figure 5 shows a close up of the enclosure at this frequency, with the geometry displaced by an exaggerated amount to make the result easily visible. The diaphragm is also shown with its displacement scaled by the same amount. It is interesting to note that, due to the large area of the enclosure walls, this enclosure resonance causes a 2dB peak in the modelled response even though the diaphragm is moving much further than any other part of the loudspeaker.



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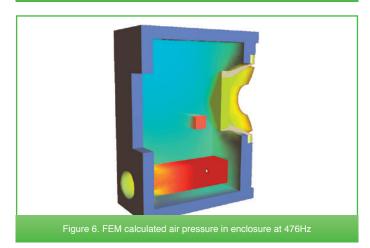
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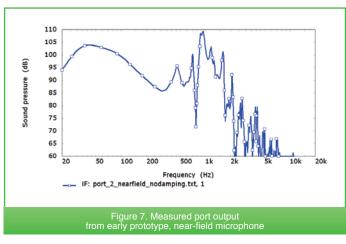
The pressure inside the enclosure was also modelled. The most notable issue was the presence of longitudinal resonances in the port tube. The initial port was a folded design with a circular tube going from back to front and external box section outside the tube going from front to back. Figure 6 shows the pressure: the port is red indicating very high pressure in its middle section. Figure 7 shows the acoustic radiation from the port with a microphone placed 1cm from the port. From 400HZ upwards the peaks in the response are due to longitudinal resonance.

Reducing the enclosure-wall vibration

An initial FEA/BEA model was created without braces or port to separately evaluate the diaphragm and enclosure-wall output. This was achieved with the enclosure walls excited only by internal air pressure and then with the walls excited by the reactive force on the magnet. The results are shown in Figure. It can be seen that in such a small enclosure, with relatively thick walls, the internal air pressure produces acoustic output which is almost 40dB lower

Figure 5. Results from FEA model of early prototype of LS50 showing diaphragm and walls displaced with colour also representing

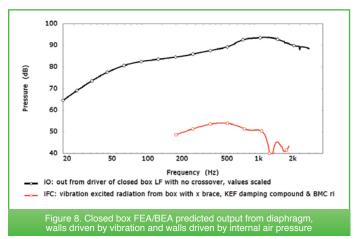


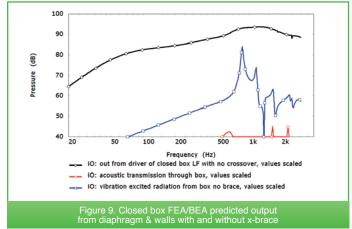


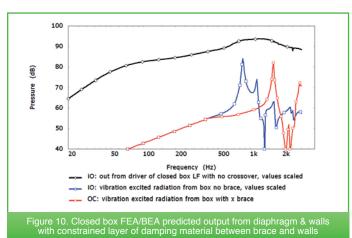
than the diaphragm output.

A brace positioned centrally on the plane of symmetry cannot buckle: in effect the symmetry adds stiffness to the brace. A brace placed on one of the enclosure the planes of symmetry centrally supports the enclosure walls. A pair of braces, crossing behind the driver, were added to the model in an attempt to prevent the lowest enclosure resonance. However, while the resonance was raised to a higher frequency, its amplitude was not reduced relative to the driver. Indeed the frequency is raised towards the ear's most sensitive region. The resulting enclosure output predicted by a FEA/BEA model is shown in Figure 9.

It was found that adding material with high mechanical resistance and low stiffness between the walls, baffle, driver and brace results in extremely effective suppression of the resonances. This arrangement proved highly effective at damping the wall resonances as can be seen from the modelled result shown in Figure 10. As with the BBC approach, using thick damping pads, the frequency of box resonances is not increased. However, the KEF approach allows a





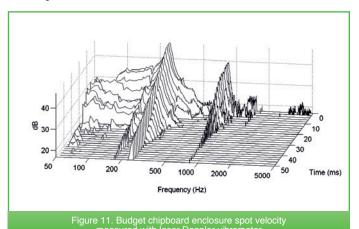


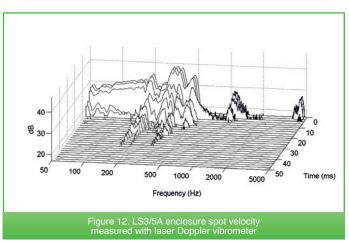
theoretical reduction in cabinet vibration of about 30dB which is approximately 20dB greater than could be expected with conventional damping material directly attached to the panels.

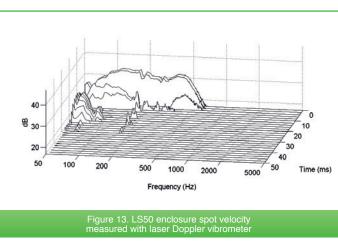
To illustrate these results in practice, some spot measurements were taken with a laser Doppler vibrometer of the rear panels of three loudspeakers. Figure 11 shows a cumulative decay spectrum (CSD) of the rear panel velocity of a budget chipboard enclosure. Three panel resonances can be seen, the one at 250Hz has an initial level of 47dB and is still visible within the 30dB display window after 50ms.

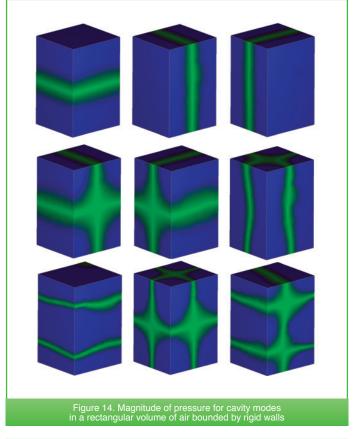
By comparison it can be seen from Figure 12 that the LS3/5A fares much better, the three resonances between 300Hz -400Hz have a level of 38dB and have decayed to below the display window minimum after 30ms.

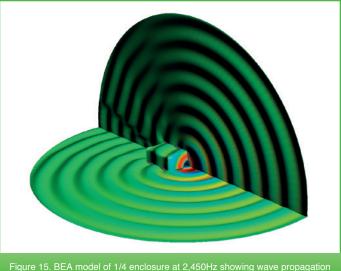
Figure 13 is a CSD of the LS50 enclosure velocity. It shows what appears to be rigid body motion which decays rapidly. The resonant tails appear to indicate a level of about 23dB showing a very significant improvement on both of the other enclosures.











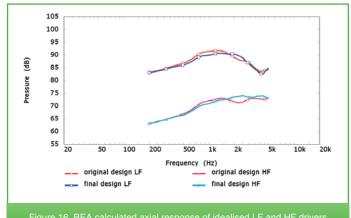


Figure 16. BEA calculated axial response of idealised LF and HF drivers

Controlling enclosure standing-waves

Acoustical cavity modes, or standing-waves, can cause response deviations of the driver motion and also unwanted response peaks in the output of the port. Using FEA it is possible to calculate the pressure distribution and frequency of the resonances in a volume of air due to standing waves. Figure 14 shows the FEA calculated pressure magnitudes of the first six cavity resonances for a volume of air enclosed by rigid boundaries. The blue regions are high pressure and the green regions are low pressure. A central position of the driver on the left hand side face will be in the low pressure region and thus avoid exciting five of these resonances

Given the limited number of modes excited by adopting this driver position, acoustic damping material may then be optimally positioned to maximise the reduction of the remaining resonances. A similar approach may also be applied to the port position: this is a subject of a patent application so will not be discussed further here.

Enclosure baffle diffraction

Another consideration in the enclosure design is finding the best shape of front baffle to mitigate the effects of diffraction. The use of one of the latest generation Uni-Q drivers with "optimal dome waveguide geometry" and the "tangerine waveguide" ensures wide and even dispersion without interference between drivers. Experience from the work on the Blade showed that avoiding reflections and diffraction was key to revealing the full spaciousness and stereo image of recordings.

Enclosure diffraction may be modelled using BEA. Since the geometry of the LS50 is symmetrical in two planes, only a quarter model of the enclosure is necessary. The results of one such model for a single solution frequency are shown in Figure 15, with the amplitude of the acoustical waves represented by displacement and colour. The pressure on the symmetry planes has also been calculated to illustrate the effects of diffraction.

A variety of geometries, ranging from rectangular enclosures to more complex shapes, were analysed and the axial frequency response of idealised mid-range and high-frequency drivers evaluated. The geometry was refined over a number of iterations to produce the smoothest response in the hemisphere in front of the loudspeaker. The initial and final axial responses are shown in Figure 16.

Port design

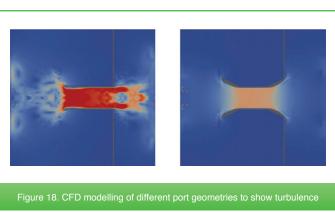
The purpose of a reflex port is to act as an acoustic mass that, together with the compliance of the enclosed air volume, forms an acoustic resonator. However, in a practical loudspeaker it is necessary to consider a number of other issues as well. Firstly, the air flow must not become turbulent at high levels since this causes distortion and power compression.

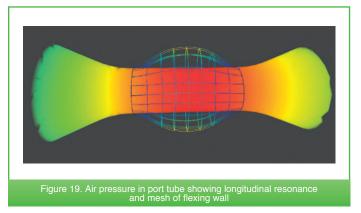
Work carried out at KEF, using computational fluid dynamics (CFD), has shown that using a suitable port profile does much to control turbulence allowing the bass output of the system to fulfil its potential.

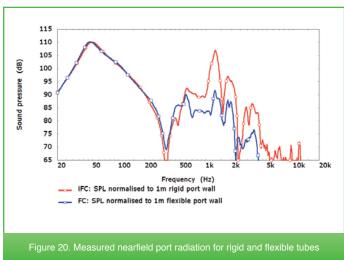
Secondly, where the wavelength of sound is a multiple of half the port length, longitudinal resonances in the port tube occur which radiate unwanted acoustic output as can be seen in Figure 17. This output tends to be in the midrange and causes similar colouration and masking effects to the box vibration.

Reducing the magnitude of the longitudinal resonances cannot simply be achieved by filling the port with acoustic foam since this would reduce output in the bass region and prevent an efficient alignment. An alternative method to control the longitudinal resonance was devised for the LS50, by creating a port with flexible walls. This is achieved by fabricating the middle part of the port from carefully selected closed-cell foam. At midrange frequencies the port walls allow sufficient sound to escape for the resonance to be reduced by as much as 15dB with little effect at low frequencies. Figure 19 shows the air in the port at resonance, the red colour indicates high pressure. The mesh of the flexible wall can be seen with the motion exaggerated. The effect on the port response, in Figure 20, is that the unwanted port output is reduced by 15dB. The rear orientation of the port gives a further reduction in this







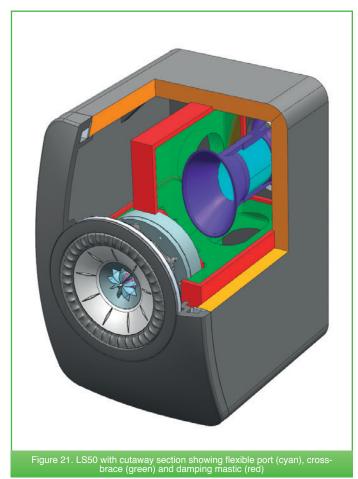


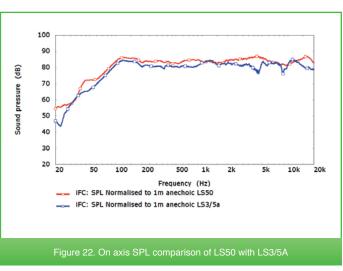
colouration, so in total it is approximately 30dB lower than the driver midrange output at the listening position. The above design approach is the subject of another patent application. The complete design is shown in Figure 21.

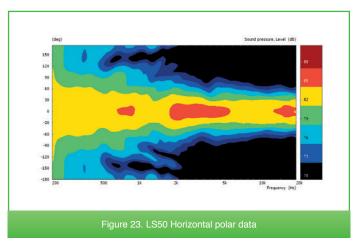
Voicing the loudspeaker

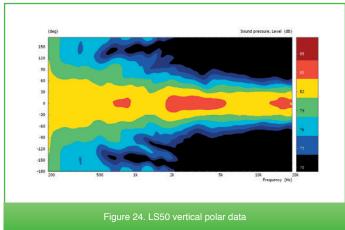
The crossover was initially designed from measured responses of the individual drivers mounted in the final enclosure. It was found that the combined driver response and diffraction characteristics required a relatively sophisticated circuit: after all the aim was for a smooth response not for the flattest response. It is perhaps worth noting that during the balancing process the priority was on the subjective performance not obtaining the flattest response.

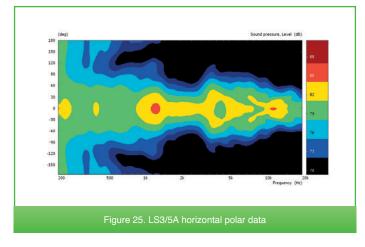
The acoustic balancing of the LS50 was carried out by the KEF listening panel. There are some passing similarities to the methods used for the LS3/5A. Some use was made of anechoic voice

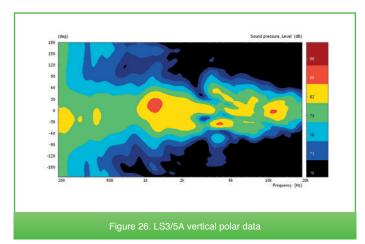












recordings of KEF R&D team members since this is a very sensitive way of checking for colouration. Additionally, a wide range of commercial music recordings were used to evaluate the balance. The reference loudspeakers used were the LS3/5A and the KEF Blade (production version).

The key components for the crossover were individually auditioned to ensure they did not limit the perceived sound quality. The capacitors for the higher-frequency section are vibration damped with mastic, to prevent sonic deterioration due to vibration. Initial prototypes were bi-wired but during the voicing it was found that the system actually sounded better with bi-wire loudspeaker cable connected together both at the amplifier and the loudspeaker. Consequently, the final product incorporates a single pair of binding posts. Nevertheless, the low-frequency and high-frequency circuits are on separate boards to reduce interaction between the inductors, since this has been found to have a significant impact on detail.

LS50 performance summary

The frequency response of the LS50 compared with the LS3/5A is shown in Figure 22. Perhaps unsurprisingly, the LS50 is somewhat more regular and slightly more efficient. Indeed, the LS50 response is slightly smoother 10 degrees off axis and in many cases this is a preferable listening position.

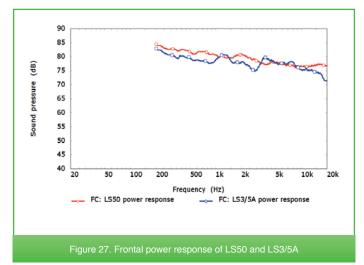
Both horizontal and vertical polar data was measured for the LS50 and LS3/5A. Rather than displaying this as polar diagrams for a few frequencies, the more modern technique of showing a contour plot with contours 3dB apart is used to display the data. The vertical axis shows angle: the centre of the contour corresponds to the front or 0 degrees, and the top and bottom are directly behind the enclosure at +/- 180 degrees. Frequency is on the horizontal axis from 200Hz to 20kHz. Colours represent SPL, as shown on the legend on the right.

In Figure 23 and Figure 24 the polar response of the LS50 is shown. The -3dB contour narrows only slightly and has few irregularities. The remaining contours also narrow as frequency increases. From 500Hz to 1kHz some lobing behind the enclosure is evident.

For the purposes of comparison, the same data was acquired for the LS3/5A and is shown in Figure 25 and Figure 26. It can been seen that the LS3/5A becomes more directional between 1.5kHz and 4kHz due to the increasing directivity of the LF driver. The vertical polar response of the LS3/5A is much less regular than that of the LS50 due to interference between drivers at the crossover frequency.

The power response of the two systems are shown in Figure. It is interesting to note that the power response of the LS50 is very much smoother than the axial response which was shown in Figure 22.

Finally, the cumulative spectral decay spectra of the LS50 and LS3/5A are shown in Figure 28 and Figure 29. These are both relatively well behaved with no major enclosure ringing. The LS50



decay is extremely rapid for the first 10dB and is significantly cleaner at mid- and high-frequencies.

Conclusions

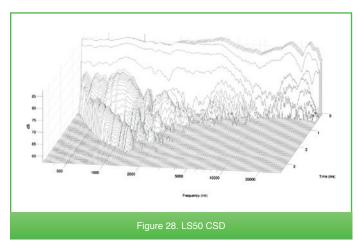
The development of the LS50 was based on a highly technological approach. Simulation and measurement is used wherever possible to identify, quantify and resolve performance shortcomings. This philosophy is classic KEF and is one which has been consistently applied over the company's 50 year history. The recent maturity of numerical techniques, such as FEA and BEA, make the approach more effective than ever – especially when guided by critical listening and engineering intuition. Recent products such as Blade, R-series and now the LS50 are testament to the efficacy of this process.

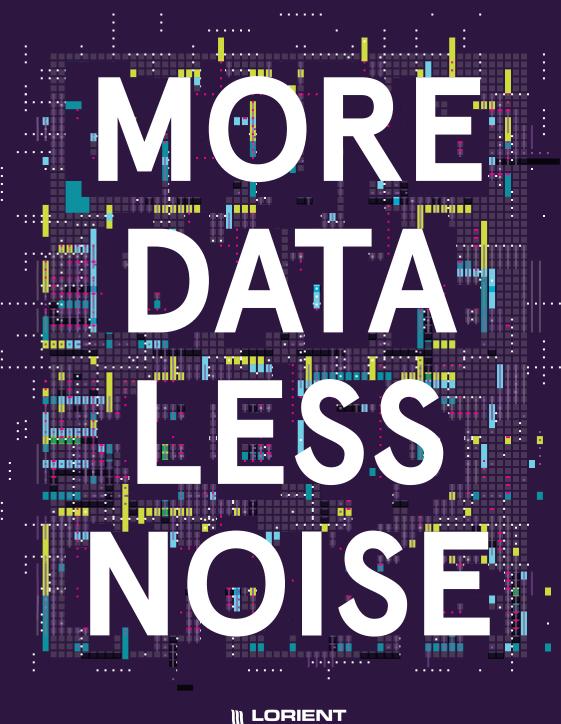
The LS50 uses a central driver position and computer optimised acoustical damping to avoid exciting resonances due to standing waves. A combination of bracing on the symmetry planes and constrained layer damping within the enclosure construction is extremely effective at absorbing the driver vibration and effectively eliminates cabinet colouration due to wall radiation. The baffle design provides a smooth response over the entire forward region, reducing tonal variation in different listener positions and ensuring the most spacious sound with precise stereo imaging. The port design has a profile optimised to avoid turbulence with the accompanying distortion and bass compression. A flexible section in the port reduces resonant midrange output from the port.

Mark Dodd has been head of research at GP Acoustics, a group including KEF and Celestion, since 2001. He was previously Chief Acoustic Engineer at Tannoy and before that he was Design Engineer of Vitavox. In 2016 he received the IOA's Peter Barnett Memorial Award for excellence in electroacoustics.

References

A full list of references can be obtained from the IOA.







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A holistic-based approach to residential sound insulation regulation

By Peter Turner

Introduction

For more than 50 years Approved Document E to the Building Regulations (AD-E), originally Part G, has helped to protect the welfare of residents in England and Wales, with respect to transmitted sound within the same building or other attached buildings.

In my recent presentation *Let's Get the Part-E started?* to various IOA branches, I, a former consultant for National House Building Council (NHBC), gave my personal views on AD-E, based on my experiences and discussions with homeowners, and interpretations of AD-E whilst determining compliance with the Building Regulations. The aim of the presentation was to get us talking about the meaning and overall objectives of the Requirements and to discuss new ideas; for inclusion in AD-E or a separate guidance document.

What is 'reasonable' resistance to sound?

Regulations E1, E2 and E3, given in Section 0, state that there shall be a "reasonable" resistance to sound in a dwelling, or prevent more reverberation around the common parts than is "reasonable".

So what is "reasonable" in the context of transmitted sound? If a home dweller considers that their neighbour is behaving in a fair manner, but due to stress and illness caused by transmitted sound they must move home, should the resistance to sound in the dwelling be considered "reasonable", because the airborne and impact tests have passed?

Noise from non-domestic sources

According to AD-E the "normal" way of demonstrating compliance with Requirement E1 between dwellings is to meet or exceed the values given in Tables 0.1a and 0.1b of Section 0.

Paragraph 0.8, which addresses sound transmission between domestic and non-domestic spaces, is often missed or not considered at the *design* stage, and so presents difficulties when assessing compliance following a complaint from a homeowner. It states that the performance values in Tables 0.1a and 0.1b are appropriate for "normal domestic purposes" and that a "higher standard" of sound insulation may be required, depending on the use of the non-domestic space. However, it provides no further guidance or reference to other standards.

Paragraph 5.12 makes a brief reference to BS 8233:1999 with regards to building layout at the design stage, although the design target values in BS 8233 are based on anonymous noise sources such as road traffic. Target values for noise with character (e.g. impulsive, tonal, intermittent), as experienced in many residential dwellings are not given, apart from noise from communal lifts (25dB $L_{\rm AMax}$) which is now included BS 8233:2014. Guidance from other documents or standards can be applied at the design stage, although it would be difficult to justify using them retrospectively to demonstrate non-compliance with E1.

A few examples, where the values in Table 0.1a were comfortably exceeded but the homeowner's rest or sleep was disturbed by non-domestic noise, are given below:

- $1. \ \ \, \text{Low frequency noise and vibration caused by falling weights in a gym}$
- 2. A poorly isolated water pump, separated from a flat by a corridor but seated on a continuous floating screed
- Timber communal stairs with hollow enclosure, constructed against a lightweight living room wall
- A lift motor fixed directly (without isolation) to a party wall, adjacent to a bedroom
- Structural lift noise from an adjacent hotel. The hotel existed before the flats
- 6. A supermarket security door underneath a bedroom slamming throughout night time deliveries.

- 7. Delivery cages rolling along a warehouse floor beneath a bedroom
- 8. Wind induced noise in the steel frame of a high-rise building transmitted into a flat.

The above is just an illustrative sample and consultants reading this, may have their own examples. Given the wording in paragraph 0.8, if the offending noise is considered unacceptable after completion, who, if anyone, is obliged to carry out improvements? If so, what measures should be undertaken and what is deemed reasonable? Paragraph 0.8 states that "specialist advice" may be needed to determine the "appropriate" level. Although the potential for noise disturbance could spotted at the design stage, the set target values may not always be appropriate.

Structure-borne noise between dwellings

Structure-borne noise transmission (excluding vertically transmitted impact noise above 100Hz) is common in residential buildings, but outside the scope of AD-E. Noise from doors, switches, sockets, worktops, pipes, motorised units and creaking floors can be a result of minimal isolation or poor design. Such noise can be amplified by plasterboard linings in rigid contact with noise transmitting elements.

Some other examples include:

- 1. Tiled masonry ground floors adjacent to structurally bridged cavity party walls. The measured impact levels exceed 62dB $L_{\text{nT,w}}$, yet measured airborne tests pass comfortably. The transmitted impact noise then flanks up the 100mm masonry wall leaf to other floors.
- 2. Low frequency impact noise across party walls from stairs and landings..
- 3. A neighbours poorly isolated kitchen extractor fan transmitting a 100Hz tone via a structurally bridged cavity wall. The fan was located on a wall *opposite* the party wall.
- 4. WC noise between flats via a continuous floating screed
- Contact of SVP pipes or structural steel columns with plasterboard linings
- 6. Washing machine noise and vibration.

The lining of pipes is primarily intended for the prevention of airborne flanking transmission through a party floor; however, if the pipe is not isolated from, say, a wall, its lining or a floating screed, small vibrations from the pipe can re-radiate into the room as sound. If an occupant knows the sound is waste water, this can be particularly unpleasant - yet the floor may comfortably comply with AD-E.

Floor coverings and bridged screeds

Despite many years of guidance, bridged floating screeds continue to result in some impact test failures or marginal passes. An impact sound insulation graph from a masonry construction with bridged screed is typically flat, with significant sound energy at high frequencies, where the human ear is more sensitive. Until the 1990s many party floors were carpeted at completion, which helped to supress high frequency transmission; however, modern hard floor coverings can now result in complaints, when previously, such issues may have gone unnoticed.

Paragraph B2.13 of ADE, states that Impact tests should be conducted on a floor without a soft covering. However, it is not uncommon to find wood laminate flooring with an unknown underlay material installed throughout the flat at the time of the test. We therefore do not know the true impact performance of the floor and how it would perform if the floor covering was replaced. For example, if a neighbour decided to replace their laminate

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flooring with hard tiles, then a sharp rise in high frequency impact noise could occur, leading to a complaint.

Entrance doors

The design guidance given in Sections 2-6, if built correctly, enables minimum performance values in Tables 0.1a and 0.1b to be achieved, although there is no statutory obligation to follow the guidance. Included in these sections is advice on entrance doors (e.g. paragraph 2.26). It recommends that entrance doors to flats have "good" perimeter sealing including the threshold "where practicable". It also references AD-B for fire protection.

Brush seals can satisfy AD-B but even *good* ones can be acoustically poor. Gaps under the door can also satisfy fire regulations, but there have been several instances of 15-20mm gaps, through which airborne sound is easily transmitted.

The mass of the door can be increased to help reduce sound transmission from communal areas; however, it is the frame and perimeter seals, (including the threshold) that are probably the most important. Careful consideration should also be made regarding the closing force, as excessive force could induce vibration into the structure or result in undesirable low frequency noise.

It would seem prudent therefore, to consider the $R_{\rm w}$ performance of the door, frame and seals collectively and not just the door.

E1 or not E1? Now there's a question...

Requirement E1 applies to a flat built over a garage which is not associated with the flat. If the garage does not contain a door, then it is classed as a car port and subject to planning, because it is now an external space. Suppose then that the party floor is of timber construction and the walls are cavity masonry. Significant flanking transmission is then likely to occur up the walls. Should it then not follow that, to protect residents, all carports and under-croft parking should be subject to Requirement E1? Could it then follow that the same rules should apply to partially enclosed spaces such as plant rooms, bin stores or similar?

Requirement E1 applies to enclosed residential, communal or commercial spaces located above a flat, however there has been confusion as to whether an open roof with an area suitable for foot traffic is subject to E1 because it also an external space. If E1 (impact transmission) applies to, say, a residential roof terrace, then surely it should apply to all spaces where foot traffic can occur? If so, what level of impact sound is deemed reasonable – the values Section 0 or something different? Should the frequency of its use be considered perhaps?

Internal sound insulation (Requirement E2)

In 2014, NHBC Foundation reported that between 2004 and 2010 (sampled period) the number of homeowner enquiries relating to sound transmission between attached houses fell steadily each year¹¹. In contrast, owners of detached houses were 2 to 3 three times more likely to contact NHBC due to noise within their own home, but with no decline in such enquiries over the same period.

Prior to 2003, there were no acoustic requirements for internal walls and floors. Subsequently Requirement E2 was introduced, and a minimum laboratory performance of $40 \, \text{dB} \, \text{R}_{\text{w}}$ ensured some degree of acoustic separation between rooms not separated by a door. However, some issues remain. A few examples include:

- Continuous floating screeds, carrying WC noise which then flanks up internal walls
- Footfall noise through internal floors (particularly when no mineral fibre is present)
- 3. Flanking transmission, particularly in masonry cavity walls
- 4. Structure-borne noise (creaking floors & stairs, doors, draws, switches, sockets etc.)
- Airborne flanking transmission via ventilation systems or acoustically weak junctions and the perimeter of the wall or floor

Paragraphs 5.14 and 5.16, advise filling gaps *around* a wall or floor to "avoid air paths between rooms". Although the advice

suggests that air paths should be avoided where possible, the wording is limited to the perimeter of the wall or floor only. In one example a clear conversation was made between floors via a ventilation duct.

Improving transmission through an internal wall or floor may not simply be a matter of increasing its laboratory performance; flanking transmission should also be considered. In one instance, a builder attempted to raise an internal floor performance to around 50dB $R_{\rm w}$; however, the increase in performance was limited by flanking transmission down the adjacent walls. As a result, there was no noticeable improvement, despite the builder's best efforts to satisfy the homeowner.

Performance criteria for internal walls applies to bedrooms and WC walls not containing a door, but does not include walls adjacent to living rooms or other spaces used for rest or concentration. Furthermore, if a flanking element acts as a medium for an offending sound (airborne or structure-borne), then what benefit is the wall giving?

Some homeowners are surprised to learn that internal walls and floors do not necessarily require a mineral fibre fill to meet the Requirements. Empty internal floors voids in particular, can increase drumming effects from footfall, although impact transmission of internal floors is not covered by AD-E.

Reverberation in corridors, lobbies and stairwells (Requirement E3)

Requirement E3 (control of reverberation) is intended for reducing noise from communal areas, which flats open onto directly.

As discussed earlier, the minimum performance values in Tables 0.1a and 0.1b do not necessarily apply to walls adjacent to non-domestic spaces. If a communal corridor adjacent to a party wall is not subject to E3 and so not acoustically treated, the rise in reverberation time will increase the noise level from the corridor. Could it then be argued that the performance of the wall should be greater than the tabulated minimum values in Section 0, to compensate for the rise in noise level in the corridor?

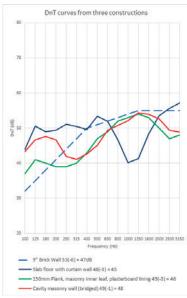
Areas such as emergency stairs could be an exception to the above argument. Perhaps then the frequency of use should be considered when determining the acoustic performance of a party wall adjacent to a communal area.

On the meaning of the C_{tr} term

The spectral adaptation term C_{tr} is heavily weighted at low frequen-

cies below 200Hz but has least weighting around 1kHz. It was introduced to resolve issues relating to low frequency airborne sound such as amplified bass, especially through lightweight constructions. In recent years, the author has experienced few comments relating specifically to amplified bass. This may suggest that the C_{tr} term has been effective in tackling low frequency airborne noise transmission; however, there have been many instances of speech reported through walls and floors where the tests have passed under current E1 requirements.

Three overlaid graphs



from sound insulation tests are given above. Also included is a D_{nT} curve ($D_{nT,w}(C_{tr}) = 53(-6)$), the same curve used for rating $D_{nT,w}$ which is based on the performance of a nine-inch plastered brick wall. Each example passes under AD-E but achieves no more than 49dB $D_{nT,w}$. This is due to a good performance at low frequencies. In one development, many of the floors showed a similar





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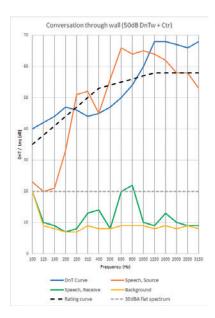
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performance, such that the whole development would have failed under the previous AD-E, yet it passes under the current AD-E. This same development was situated in a very quiet environment, well away from local roads, and so there was little to mask the offending noise, including speech.

Masking noise

If we were to raise the existing performance requirements, what would be a suitable level of performance? In the following example, a party wall separating two bedrooms achieved 50dB $D_{nT,w} + C_{tr}$, yet a clear conversation could still be made through the wall. The graph right combines the measured D_{nT} with a speech spectrum measured in the source and then the receiving room (the neighbour was asked to count to ten). The dip in sound insulation at mid frequencies coincides with the peaks in the speech spectrum. Because the underlying background (masking)



noise level is very low in the receiving room, there is enough aural information for the speech to be intelligible. If the underlying background was higher due to say a busy road or mechanical ventilation (a simple example with 30dBA flat spectra is shown) then the likelihood of intelligibility would have reduced significantly.

In many instances, very low background noise can exacerbate internal noise issues. In high rise developments adjacent to busy roads, high specification glazing is installed to protect residents on the lower floors from road traffic noise. However, if the same glazing performance continues up to the highest floors, the external noise source many be virtually inaudible. This results in even the slightest noises from within the building starting to cause annoyance.

A careful balance should therefore be considered, between noise transmission within the building and background noise. This has led the author to believe that guidance on façade insulation should be considered for future publications of AD-E.

Factors not governed by the Requirements

There are many factors not considered in AD-Ê. These can include: structure-borne noise; low frequency noise and vibration; sound intensity from localised sources (e.g. untreated flanking surfaces); room reverberation (which raises noise levels); noise character; and background noise levels to assist masking.

The Regulations are designed to satisfy the majority of the population; however, there will be groups of people, who find living with neighbour noise unbearable; resulting in their poor health, wellbeing and comfort. Aspects governing the *subjective* judgement of sound insulation could include: Expectations (e.g. value of property); past experience (e.g. moving from detached to attached or from house to a flat); noise control (e.g. asking neighbour to change their behaviour); noise character (e.g. tonal, impulsive, spectral shape); environment; relationship with neighbours ("open-door" or insular types); health (e.g. house-bound and sick, autistic or dyslexic); personality (e.g. extrovert/introvert); lifestyle (e.g. night workers, early risers, party hosts, regular exercisers, quiet readers); building use (e.g. owned, shared, tenant, student, holiday, business).

All the above maybe cannot not be addressed solely by the Building Regulations, however if we were to approach building sound insulation holistically in one document or with one accompanying guidance document, then this may go some way to addressing the outstanding issues.

A holistic based approach to future residential sound insulation regulation

This article has briefly highlighted some of the difficulties experienced when trying to determine if a residential property has "reasonable" resistance to sound, as stated in the Requirements, to protect the welfare (health and comfort) of the occupant. Although it was impossible to discuss them all in detail, it is hoped that they demonstrated the complexities of the subject; and how airborne and impact sound insulation testing alone may addresses some, but not all, of the underlying issues.

A questionnaire was handed out at the end of the talk. Suggestions by me, and supported in subsequent feedback, are given below:

- 1. A new public survey addressing specifically noise heard in the home. A carefully structured survey should help us to pinpoint and better understand the outstanding issues.
- 2. Good practice guides for the whole building industry, with clear illustrations and photographs, perhaps like the (non-acoustic) guides previously issued by Zero Carbon Hub (see Reference 12)
- 3. Training and education. To reduce design and workmanship errors and to drive up standards; perhaps with an emphasis on isolation and "prevention is better than cure".
- 4. Re-introduction of $D_{nT,w}$ in addition to $D_{nTw} + C_{tr}$
- Noise rating system. Like that proposed by Cost Action Group TU0901, with ratings A-F. This could help inform home buyers, address expectations and drive up standards.
- 6. Internal noise level measurement L_{Aeq} , L_{A1} . As already used in Requirement E4 (BB93).
- Privacy rating for airborne noise D_w + L_{Aeq}. This is already a well-established method which could be applied to residential, perhaps with a suggested rating scale: A>85dB to F<60dB.
- 8. Protection rating for impact noise $L_{\rm w}$ $L_{\rm Aeq}$. With suggested rating scale: A<15dB to F>40dB.
- 9. Improved guidance on MVHR and MEV ventilation systems (currently given in AD-F), to minimise unwanted noise, but raise background levels in quiet environments.
- 10. A façade insulation section in AD-E. Just as Approved Documents C, F and L already protect the building from the external environment, an optimal façade design would help to minimise disturbance from external noise and help mask internal noises.
- 11. $R_{\mbox{\tiny W}}$ requirements for complete doorsets doors frames and seals
- 12. A horizontal impact noise criterion. Subjective listening tests or surveys could help determine appropriate noise limits.
- 13. Structural noise level measurement. Perhaps a similar method to the Japanese falling ball¹⁰, but using a heavy rubber pendulum. Else try a shaker, vibration speaker or rubber tipped force hammer. If measurement is impractical then perhaps a simplified vibration level difference calculation that the building industry can understand.
- 14. Impact specification for internal floors (e.g. $L_{n,w}$)
- 15. Plant noise limits (with NR criteria, to address tonal noise)
- 16. Further development and marketing of structural isolation products
- 17. Requirement E3 to apply to all noise from non-domestic and circulation spaces as well as entrance doors
- 18. Raise public awareness.

Some further ideas and thoughts given in the subsequent feedback include:

- 1. A minimum D_{nT} criterion spectrum
- 2. Spectrum adaptation term for speech
- 3. Assessment of strong room modes
- 4. Speech interference criterion
- 5. A more user-friendly format for AD-E
- Resolve the conflict between AD-F (ventilation) and façade sound insulation
- 7. Acoustic advice on trickle vents to go in AD-F



- 8. Descriptor on sound quality
 - 9. Special guidance on washing machines
 - 10. Reference to BS EN 12354¹⁴, particularly at the design stage
 - 11. Noise break-in assessment at the design stage
 - 12. Low frequency impact noise criterion.

Conclusion

After 14 years of Approved Document E in its current form, it is perhaps time to review its achievements, failures and future objectives so we can better protect all home occupants. There are many factors governing the response of home dwellers to noise. By approaching these in a holistic way and collating the knowledge and experience we have gained so far in the 21st century, we may come closer to protecting the health and wellbeing of all dwelling occupants.

Acknowledgements

I would like to give very special thanks to those who gave their time

filling in the post-talk questionnaire and who sent further details of what they would like to see added or discussed, as well as some background reading and information. I would hope to include some of the ideas in future discussions and surveys. Thanks also to all those who gave their support and positive feedback.

Peter Turner has worked in research, consultancy and compliance for more than 20 years, specialising in building acoustics with particular interests in objective and subjective acoustic assessments in occupied buildings. Following experience at BRE, Cole Jarman and the NHBC, he has recently formed Assured Acoustics Ltd, which aims to raise standards and improve the health and wellbeing of building users.

References

A full list of references can be obtained from the IOA.

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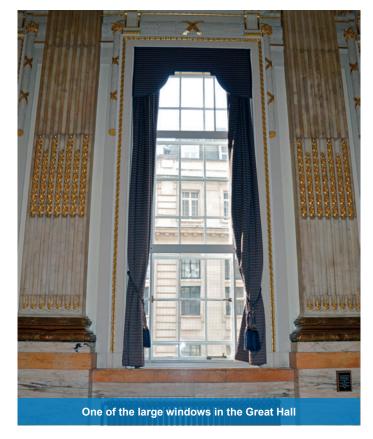
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Wind farm noise did generate thousands of complaints...

refer to the letter published in the March/April issue from Mike Lotinga concerning "astonishing" wind farm noise complaints.

I note Mr Lotinga's incredulity in the number of complaints received by the Huntingdon senior EH officer as reported at the IOA seminar in Birmingham in December 2016. I also note that Mr. Lotinga, using an FOI request, had asked the Huntingdon District Council (HDC) for the 2016 records of noise complaints. He was advised of just one complaint in 2016 and apparently assumed that the large number of complaints mentioned by the officer did not exist. He also intimates the seminar delgates were "misled" by the officer's comments.

I have to advise Mr Lotinga that there *has* been a very large number of complaints

r Lotinga simply delivered his FOI request to the wrong council. The noise problem in question is Cotton Farm wind farm, in Huntingdonshire. It abuts a county boundary with South Cambridgeshire, where the closest residents are less than 500 m from and downwind (when prevailing) of the nearest turbine. Residents in the village upwind of the wind farm are over 1km from it. Unsurprisingly

made to both HDC and its neighbouring council, South Cambridgeshire District Council (SCDC). Mr Lotinga simply did not look in the right place. He may also be surprised to know all the complaints have all come from one wind farm, Cotton Farm,

From the beginning of turbine operations in January 2013 many local people living near Cotton Farm immediately experienced EAM noise nuisance from the turbines and these were reported to the two councils. SCDC had a lot more complaints due to the proximity of the turbines to the SCDC village of Graveley. After about 800 recorded complaints in less than a year, both council EHOs stopped logging further noise complaints. Sometime later both the HDC and SCDC EHOs resigned their positions. The SCDC EHO, on leaving, admitted he could not cope with the number

therefore the complaints came from South Cambridgeshire residents and were addressed to South Cambridgeshire Council. Had Mr Lotinga inquired of the correct council he would have learnt that his estimate of thousands of noise complaints about the Cotton Farm turbines was indeed correct.

Mr Lotinga's error is understandable as he is relatively new to wind turbine noise of complaints and the complexity and impossibility of trying to use statutory nuisance laws as suggested in the planning approval. Both council leaders in a joint letter in December 2015 asked for assistance from the then Secretary of State of DECC but none has been forthcoming.

In the meantime, the villagers have continued to complain by email to the councillors of both councils and EH officers in a round robin email list. These complaints, and sample logs of complaints, are in the public domain, including the INWG WP9. The number of complaints, however, continue to grow and the number now exceeds 2,000. □

Bev Gray

Address withheld by request

issues, but his enthusiasm to belittle the serious noise problems now faced by so many wind farm neighbours reflects very badly on his own professional objectivity and most unfairly on the council officer he quoted at the IOA Birmingham workshop.

Dr John Yelland MIOAIndependent consultant

...but official figures reveal just two complaints last year

write to follow-up my previous letter in the last Bulletin, which presented the result from an FOI request I made to fact-check the claim printed in the Noise Bulletin that EHOs in a district council within Cambridgeshire were inundated with "hundreds of complaints a month" about wind turbine noise. The response to the request confirmed that the number of complaints received by Huntingdon District Council in 2016 was one. After that letter I received comments highlighting the concern that my request had ignored other areas in Cambridgeshire, and that these areas were much more affected by wind turbine noise. So I followed this up with requests to all the district councils in Cambridgeshire (excepting Cambridge City Council, on the basis that I am not aware of any significant wind turbine installations within the city limits). The numbers of complaints recorded by the Councils are shown above:

District council	Number of complaints recorded about wind turbine noise in 2016
Huntingdonshire	1
East Cambridgeshire	0
South Cambridgeshire	1
Fenland	0
Total	2

The outcome of this extended exercise shows that across the entire county of Cambridgeshire, two complaints about wind turbine noise were recorded by district councils in 2016; substantially fewer than the very large number of complaints suggested within the quoted publication.

Hopefully this addresses the concerns that areas of Cambridgeshire had been left out of the previous request, and the results provide further evidence that the statement printed in the *Noise Bulletin* would potentially, if accepted at face value without taking the time to check on the figures, be very misleading.

The next step, of course, would be to expand the checks temporally as well as spatially; I am well aware that there have been past issues in some areas highlighted above that have caused some concerns. But the purpose of this limited study was to corroborate the statement that had been made, which referred to the current situation. There will be more information on wind turbine noise complaints and controls presented at the ICSV24 conference in London, and I encourage readers to attend and participate.

Mike Lotinga MIOA

Principal Engineer, Acoustics, Noise and Vibration, WSP|Parsons Brinckerhoff

Key point to remember about AM penalty

an I just make a brief comment about the article in the last Bulletin by Mike Lotinga, Richard Perkins and Toby Lewis with regard to an AM penalty? I have regularly raised the point that the AM penalty must be related to the LA90 not the LAeq. I just want to comment on the following phrase in the article: "The ETSU-R-97

methodology uses L90,10min as a proxy for Leq,10min". We are talking about a penalty scheme for incorporation in a planning condition. Compliance with such a condition requires that we measure the sound levels as LA90. We measure as LA90 because the limits are in LA90. We are not using LA90 as a proxy. The only time LA90 was ever used as a proxy was in ETSU-R-97 when the arguments for the derived limits were put forward. From that point on everything is LA90.

So my point is that a penalty must be derived by comparing a modulated sample of noise with an unmodulated sample so that they are equally annoying and then finding the difference between the levels as **LA90** not as LAeq. This can quite simply be done in the case of the RUK research – and, indeed, is in their report.

Dick Bowdler FIOA Culross, Fife



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H&H Acoustic Technologies acquires architectural acoustic business

&H Acoustic Technologies has acquired the architectural acoustics business of the Hodgson & Hodgson group from the group administrators.

The acquisition included not only the stock and production equipment but also all the products, trademarks and intellectual property associated with the business. In addition, key staff from the Hodgson & Hodgson group joined the new business.

The business is based on the Earlstree Industrial Estate in Corby, Northamptonshire

in a 40,000 sq ft unit which includes areas for manufacturing, offices, product showroom and acoustic testing facilities.

The company intends to develop and expand the current product range which includes:

- REDUC acoustic flooring
- SoftSound acoustic wall panels
- Ceiling panels and clouds
- Acoustic SilentDoors
- Acoustic materials
- Acoustic consultancy.

In tandem with product range development under way, H&H is investing significantly in enhanced production capabilities. This includes CNC cutting equipment, printing and laminating equipment. The products will also be available as NBS BIM 3D objects shortly.

For more details ring 01536 270540, email info@acoustictechnologies.co.uk or visit www.acoustictechnlogies.co.uk

NPL launches underwater acoustic recorder calibration service

he National Physical Laboratory has launched a new service that provides calibration of underwater autonomous acoustic recorders traceable back to international standards.

The aim is to enable equipment manufacturers and consultancies to offer a better service to customers, through NPL's independent validation, enhancing data utility and giving them a competitive advantage.

The service is also designed to provide end users and researchers with increased confidence in their data to reduce the risk of invalid results or halted operations and improve the quality of work.

Dr Tanja Pangerc, a Higher Research

Scientist in the Ultrasound and Underwater Acoustics Group at NPL, said: "We have seen a huge uptake in underwater acoustic measurement, driven by the introduction of new legislation and regulation, alongside the availability of new sensing technology.

"However, there are currently few assurances of the quality of the data obtained with uncalibrated equipment. After speaking to device manufacturers, we realised that there was a pressing need for a calibration service to ensure the data being recorded was accurate and traceable, and to reduce the risk of non-compliance.

"Our service - the first of its kind - will enable users of underwater acoustic sensors to record robust, actionable data, and give equipment manufacturers the competitive edge in a growing market."

Dr Federica Pace, Marine Technical Director at Baker Consultants, an ecological consultancy service which recently worked with NPL, said: "Data without traceability is useless. Without calibration, it is difficult to compare the results of monitoring or draw actionable conclusions from them. Working with NPL has enabled us to provide comprehensive and accurate data to our clients.'

For more details email acoustic_enquiries@npl.co.uk 🖸

Cole Jarman celebrates first year in Manchester

ole Jarman has been celebrating the first anniversary of the opening of its Manchester office.

Among the significant projects it has worked on since the launch has been phase two of the MediaCityUK development in Salford. This included conducting noise surveys and impact assessments and working on the internal acoustic design for the first of many new residential blocks.

It has also completed the acoustic design and a planning assessment for a new industrial training facility in the North West, full design and commissioning for the new Light Cinema in Bolton, a hotel refurbishment in Liverpool and various other industrial, commercial and residential projects within the north of England and Scotland.

Projects for existing clients in the region have involved retail units, gyms and takeaway units.

Office head Matthew Heyes said: "It's



been an exciting year for everyone involved and we are delighted to report that it is going from strength to strength. This has included welcoming additional staff to support the

existing team due to high demand for our services. We move into our second year of operation with a significant number of new and exciting projects lined up."



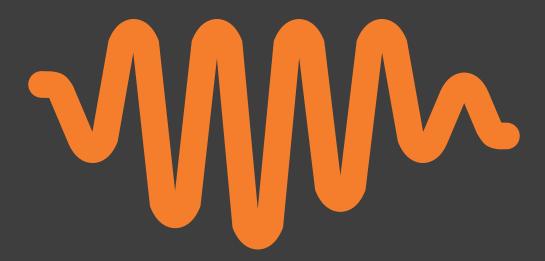
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www.msacareers.co.uk/acoustics

Redux clinches \$5 million funding to boost expansion

aptics and surface audio technology pioneer Redux has raised \$5 million in funding to enable it to grow the business.

The money will also be used to support original equipment manufacturers (OEMs) as they look to bring products to market based on Redux's award-winning technology

The series B funding round was led by Golden ARIE Hi-Tech Ltd, a fund managed by ARIE Capital, with the participation of

existing investors.

Redux, based in St Neots, Cambridgeshire, brings surfaces to life with sound and touch. It says it is the only company in the world that can provide device manufacturers with commercially viable surface audio and high-fidelity, multi-touch haptics.

It is working with leading brands in the consumer technology and automotive markets. The company is set to capitalise on the growing demand for interactive user interfaces that fully exploit the potential of combining tactile feedback and panel audio.

Nedko Ivanov, Chief Executive Officer, said: "We have developed a disruptive technology protected by more than 170 granted patents globally. With potential applications in many different market segments and wide engagement with tier one customers, we are on a mission to redefine the user experience for billions of consumers worldwide."

HAVS monitoring specialist secures £700,000 backing

eactec, a hand and arm vibration syndrome (HAVS) monitoring specialist, has completed a further £700,000 round of fundraising to develop its HAVwear personal monitoring equipment and reporting technology.

The funding round was led by business angel investment syndicate, Archangels, with co-funding from Scottish Investment Bank, the investment arm of Scottish Enterprise. The funding round included £122,000 of investment from Reactec's board, management and staff.

HAVwear is a wearable device that

monitors the vibration individuals are exposed to when using hand held tools, providing real time personal data highlighting their exposure risk. The system, launched in 2016, provides data analysis to customers designed to support measures to reduce workforce exposure

Reactec, which is based in Edinburgh, will use the funding to build on the growth achieved since the release of HAVwear which saw it ship 10,000 units in its first year, resulting in the company recording its first £1 million sales quarter. The funding will support the

recruitment of four additional sales and engineering team members, taking staff numbers to 27, and enabling international expansion and further research and development.

Jacqui McLaughlin, Chief Executive of Reactec, said: "I am thrilled that so many of our own people have chosen to invest their own cash in Reactec's future, alongside Archangels and Scottish Investment Bank. This will help us to grow the business internationally and undertake further R&D."



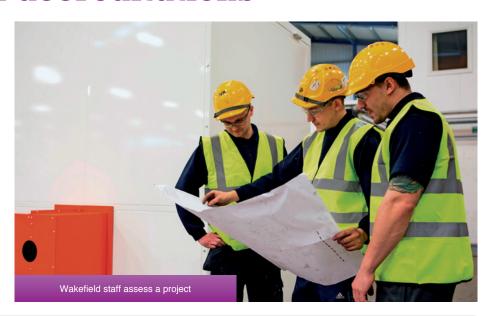
Wakefield Acoustics achieves international accreditations

Industrial and environmental noise control manufacturer Wakefield Acoustics has achieved the latest internationally recognised health and safety and environmental accreditations.

As part of the company's ongoing development of its Quality Health and Safety and the Environment (QHSE) management system, it is now accredited to BS OHSAS 18001:2007 and ISO14001: 2015.

Wakefield Acoustics managing director Lee Nicholson said: "We are proud and delighted to announce we have secured these accreditations. Securing the accreditations alongside the existing ISO 9001 certification underlines the company's commitment to operate the highest QHSE standards.

"The operation of robust QHSE systems has been central to our business for many years and I would like to thank all our staff for their contribution in achieving this certification."



Turning on the Style at biomedical research centre

Style has completed the installation of London's first stepped-dividing wall system at the 450-seat auditorium of the Francis Crick Institute.

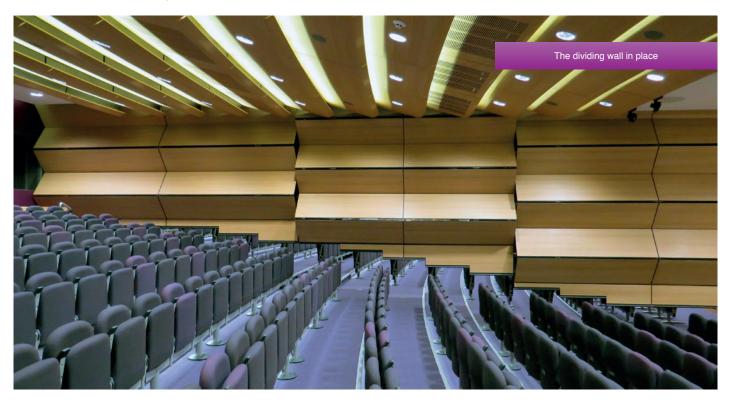
Installed within a cavity in the ceiling, the Skyfold wall descends into place at the press of a button. With the bottom edge customised

to form a firm seal with the staircase rising through the auditorium, the wall delivers a 49dB acoustic performance on site, allowing two events to take place simultaneously in complete privacy.

The building took five years to complete and will be home to up to 1,500 biomedical

research staff when fully occupied. It also boasts some 12,560m² dedicated laboratory space, 1,700 m² of rooftop solar panels and a BREEAM excellent award in design and procurement.

☐



Brüel & Kjær management system for new Royal Navy ships

the design development agreement to deliver a Hull Vibration Monitoring System (HVME) for the Royal Navy's Type 26 Global Combat Ship (T26 GCS).

Designed to replace the eight Anti-Submarine Warfare (ASW) variant Type 23 frigates, T26 GCS has been designed to undertake a number of roles – from high-in-

undertake a number of roles – from high-in-tensity warfare to humanitarian assistance – and will operate independently or as part of

Brüel & Kjær's HVME is a customer-specific solution, comprising a network of commercial-off-the-shelf (COTS) sensors, data acquisition, and vibration measurement/ analysis and listening capabilities. Acoustic signature management is made by monitoring structure-borne noise, and presents vibro-acoustic information to aid ship staff in the control of machinery, hydrodynamic and

HVME provides instant control of the radiated sound of the ship via permanently installed sensor arrays mounted internally to uous vibration monitoring of the ship's hull and assists crew in maintaining a low

HVME is a modular, scalable platform based on Brüel & Kjær's COTS PULSE data acquisition and analysis platform. A distributed data acquisition network architecture provides installation flexibility, a minimal foot-print and radically reduces the amount of sensor cabling throughout the ship, which in turn provides cost and weight reduction.

More information can be found at www.bksv.com 🖸

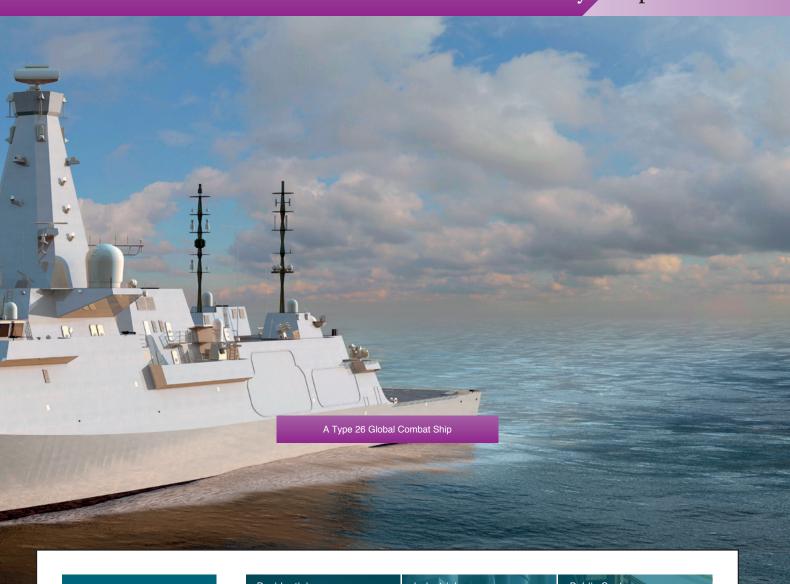


ngineers in Chile turned to Cirrus Research to help them develop strategic Using an Optimus Green SLM, a Cirrus CK:670 for outdoor measurements and a Cirrus CK:171B, which included the outdoor kit CK:1710, a team from Austral University of Chile in Valdivia compiled measurements of both traffic flow and noise levels.

The study concentrated on the cities of Coquimbo - La Serena, Valdivia, and Temuco - Padre las Casas. As an additional activity, a study of the soundscape of Valdivia was included and this element included binaural recordings and synchronized noise measurements.

The project, directed by Dr Enrique Suarez, compiled measurements of both traffic flow and noise levels. The noise levels were measured in order to verify and calibrate the traffic noise model employed in the study. In addition, long-term acoustic measurements were carried out to characterise a week's cycle in the different types of roads.





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Troldtekt tiles Loom large in warehouse conversion

roldtekt 2000 x 600mm natural wood wool acoustic ceiling panels were specified by architects converting the Loom, a former Victorian wool warehouse in London's East End, into offices.

The scheme won best refurbishment project at the 2016 Brick Awards. Judges praised the building as "well considered' and "elegantly refurbished" achieving its objective of maintaining the building's originality,

while introducing new "exquisite details." For more details ring **01978 664255** or visit www.troldtekt.co.uk



Jon Lee heads Cundall's new Middle East acoustics team

on Lee has been appointed by Cundall to lead its new acoustics team in its Middle East and North Africa (MENA) division, which has offices in Dubai, Qatar and Tripoli.

Jon was previously an acoustics consultant at Waterman Energy Environment and Design and RPS, both in Manchester. A corporate member of the IOA, he was presented with its Distinguished Service Award in 2013. He also helps run the Middle East Acoustic Society, promoting professional standards in all matters of acoustic practice in

Richard Stratton, MENA Managing Director, said: "The last three years have seen significant change in our MENA business. Our team has grown from 30 to just over 100

staff offering design and consultancy services in building services (MEP), structural and civil engineering as well as specialist design and consultancy in sustainability, lighting, IT and audio visual serving most sectors. We have seen significant growth in our infrastructure business and in particular serving the rail sector in Doha. To complement our engineering and specialist consultancy services for our clients, we are very pleased to now offer acoustics."

Jon said: "It is a great time to join Cundall and to be working alongside both familiar and new faces. The team is continuing a trend of strong global growth and I'm very excited with what the future will bring."



Jon Lee receives the IOA Distinguished Servic Award from President Bridget Shield in 2013



Obituary

Dr Bill Lang (1926-2016): Renowned physicist who was founder member of the International Institute of Noise Control Engineering

By Bernard Berry

here is a particular sadness in hearing of the passing of an old friend when you have not seen them for a while. I wanted to share some recollections of him. by way of introducing the obituary below which we have been given permission to reproduce here.

I first met Bill in 1982 at the Internoise conference in San Francisco - the first I ever attended in the USA. I recall a small drinks reception in his penthouse suite overlooking the city. He was a warm-hearted and genial host with an engaging smile. He made sure that those of us who were new to such events were made to feel at home.

Thankfully our paths crossed on numerous other occasions over the years. In 1993, at Leuven in Belgium, I presented the formal bid which I, together with Cathy Mackenzie and Roy Lawrence, had prepared for the IOA to host Internoise 96 in Liverpool. Bill chaired the selection panel and his questioning was rigorous but fair, and he played an important part in ensuring that I had a good chance to present our ultimately successful case.

Bill's meticulous planning and determination to achieve targets soon manifested itself. I recall a day in July 1995, when I received the first in a long series of emails from him, regarding conference planning, headed "D-365 days, one year to go". His military background was now in evidence.

Bill was very hospitable, and I was fortunate to be invited to stay with him and his wife Asta at their home in upper New York State, on my way to a NATO meeting in Ottawa. The house was a short walk through the snowy woods to the IBM Acoustics Laboratory he had set up. Asta was keen to show me how they fed the local wild whitetailed deer which used their garden as a short cut through the woods. She also showed me Bill's office in his basement den. Every square inch of surface was covered in stacks of papers, with no semblance of any kind of filing system. This private space was in stark contrast to Bill's highly organised public life and work.



Dr Bill Lang (1926-2016)

I am proud to have known him as a friend and will miss him.

Below is an obituary that appeared in the Poughkeepsie Journal

William Warner Lang, 90, physicist, b. Boston, August 9, 1926; d. October 23, 2016. The only son of William Warner and Lila Gertrude (Wheeler) Lang, Bill joined the Navy and served from 1944 to 1947. He continued to serve in the Naval Reserve and was promoted to Captain in 1968. He studied physics and received BS and PhD degrees from Iowa State University and a MS from MIT. In the summer of 1954, he met the love of his life, Asta Ingard, visiting her brother, Uno, from Sweden. They were married two months later and spent nearly 50 happy years together.

After finishing his PhD in acoustics in 1958, Bill was recruited by IBM to build an acoustics laboratory in Poughkeepsie and develop a noise control program for the company. In the early 1970s, Bill worked with Senate staff in Washington, DC, on details of what would become the Noise Control Act of 1972. This initiative led to the formation of the Institute of Noise Control Engineering (INCE) in 1971, of which he was a founding member. He was also a founder of the International

Institute of Noise Control Engineering (I-INCE) in 1974 and the INCE Foundation in 1993. Bill was recognized for his contributions to noise control throughout his career with fellowships in the Audio Engineering Society, American Association for the Advancement of Science, Acoustical Society of America, and the Institute of Electrical and Electronics Engineers. He was a fellow, Distinguished Noise Control Engineer, and a past president of INCE-USA, as well as an honorary member of the Institute of Acoustics (UK) and the National Council of Acoustical Consultants. He encouraged others to become engaged and was a mentor to many noise control engineers. The achievement he was most proud of was his election to the National Academy of Engineering in 1978. He was honored to represent IBM not just in the field of acoustics but all of engineering. He realised that IBM could benefit from a similar institution to recognise its best engineers and nurture collaboration. He pushed his idea to create the IBM Academy of Technology, which today boasts more than 800 members from 40 countries. Bill dedicated his career to influencing US and global noise policies through annual INCE sponsored international congresses, now in their 44th year. His work continues today through the NAE Technology for a Quieter America initiative.

Bill was an active member of the community. In his "free" time, he counselled students as a member of the MIT Educational Council, started a Toastmasters Club, which he attended every week, was an Adjunct Professor of Physics at Vassar College, was a member and President of the Poughkeepsie/ Arlington Rotary Club, and was a devoted member of Christ Episcopal Church where he sang in the choir. Bill loved life and challenged himself mentally and physically every day. He skied until he was 87, went to the gym, and walked every morning. Always cheerful and positive, he loved his family, friends, and animals big and small.

He is survived by his son Robert, daughter-in-law Bogumila, and two grandsons Lucjan Olaf and Colin.

Suceendra Thirumal comes aboard at Campbell Associates

uceendra Thirumal has joined Campbell Associates' in-house calibration team. With more than four years' experience in the acoustic and environmental testing field, she specialises in sound level meters and vibration monitors.

Before joining Campbell Associates, Suceendra successfully implemented and ran a vibration calibration laboratory in Singapore.



Suceendra Thirumal with her new colleagues

Echo Barrier launches major new product range

oise reduction specialist Echo Barrier has updated its range with a number of new products.

The H4 barrier has replaced the H2 barrier but with a better noise reduction performance (up to 39dB). The H5 barrier is flame retardant while the H6 offers the highest absorption performance and is waterproof.

The H8 barrier is the biggest in the range, suitable for larger sites such as site perimeters.

The Echo CS (cutting station) has been specifically designed to house loud cutting equipment on site, and has windows either side for ease of access for materials.

Technical Director Peter Wilson said: "We have been working for a long time on this new range of products, all of which are based around the technology of our award-winning H2 barrier but with a multitude of extras and adjustments to make them suitable for different uses and different markets.'

For more information visit www.echobarrier.co.uk

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Committee meetings 2017

DAY	DATE	TIME	MEETING
Thursday	11 May	11.00	Publications
Tuesday	16 May	11.00	Research Co-ordination
Thursday	18 May	10.30	CCHAV Examiners
Thursday	18 May	1.30	CCHAV Committee
Wednesday	24 May	10.30	Executive
Wednesday	14 June	10.30	Council
Tuesday	20 June	10.30	CCENM Examiners
Tuesday	20 June	1.30	CCENM Committee
Tuesday	20 June	10.30	CCBAM
Wednesday	21 June	10.30	Distance Learning Tutors WG
Wednesday	21 June	1.30	Education
Tuesday	27 June	10.30	ASBA (Edinburgh)
Thursday	29 June	11.30	Meetings
Thursday	03 August	10.30	Diploma Moderators Meeting
Thursday	10 August	10.30	Membership
Wednesday	13 September	10.30	Executive
Monday	25 September	11.00	Research Co-ordination
Wednesday	27 September	10.30	Council
Thursday	12 October	11.30	Meetings
Thursday	19 October	11.00	Publications
Thursday	02 November	10.30	Membership
Tuesday	21 November	10.30	CCWPNA Examiners
Tuesday	21 November	1.30	CCWPNA Committee
Wednesday	22 November	10.30	Diploma Tutors and Examiners
Wednesday	22 November	1.30	Education
Thursday	23 November	10.30	CCENM Examiners
Thursday	23 November	1.30	CCENM Committee
Thursday	23 November	10.30	CCBAM Examiners
Tuesday	28 November	10.30	ASBA Examiners (Edinburgh)
Tuesday	28 November	1.30	ASBA Committee (Edinburgh)
Wednesday	29 November	10.30	Executive
Wednesday	13 December	10.30	Council

Refreshments will be served after or before all meetings. In order to facilitate the catering arrangements it would be appreciated if those members unable $% \left(1\right) =\left(1\right) \left(1\right)$ to attend meetings would send apologies at least 24 hours before the meeting.

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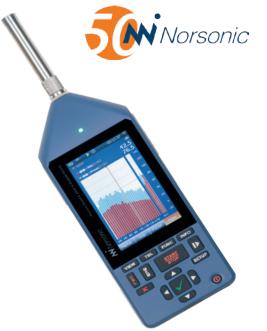
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