Vol 40 No 4 July/August 2015

ACOUSTICS BULLETIN

in this issue... **Electroacoustics – a review of major developments during the past 40 years**

plus... **41st annual report of the Council**

An efficient filter-based model for calculating absorption coefficient and directivity of resonator panel absorbers

The propagation of low frequency sound through an audience

Institute of Acoustics

ACOUSTICS BULLETIN

Vol 40 No 4 July/August 2015

Front cover photograph:
Milestone in electroacoustics – the MP3 player

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

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

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Conference programme 2015

9 July
Organised by the Musical Acoustics and Speech and Hearing Groups
Hearing impairment and the enjoyment and performance of music
London

7-9 September
Organised by the Underwater Acoustics Group
Seabed and sediment acoustics: measurements and modelling
Bath

17 September
Organised by the Sustainable Design Task Force and the Building Acoustics Group
Acoustic design for sustainable buildings
London

27-30 September
Organised by the Galpin Society in association with the IOA
Musical instruments in science and history
Cambridge

15 October
Organised by the IOA
Acoustics 2015
Harrogate

29-31 October
Organised by the IOA with support from the French Acoustical Society (SFA)
Auditorium acoustics
Paris

10-12 November
Organised by the Electroacoustics Group
Reproduced Sound
Moreton-in-Marsh

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

Dear Members

How time flies! My first year as President has already passed and it is an opportune time to reflect.

Looking back on the year, there is a lot to celebrate and be proud of at the Institute. I have been fortunate to preside during our 40th anniversary and attended many meetings, although maybe not as many as I hoped – the trouble is you think you have time! However, it reminds me of all our volunteers who give their time endlessly in support of the Institute – and it is to all of you I give grateful thanks for your contribution. The greatest gift you can give is TIME, because when you give your time, you are giving a portion of your life that you will never get back.

The dedication in pursuit of acoustics excellence has allowed me to present medals to many worthy recipients. This year has been particularly difficult for the Medals and Awards Committee, as the standard of entrants for the various awards has been exceptionally high. Listening to their achievements and their passion is uplifting and inspiring for all, but should especially be for young members as they commence their careers in an exciting and rewarding discipline. A discipline that allows us as an Institute to work closely with many other disciplines, support the STEM initiatives and achieve a following of more than 8,000 members in our LinkedIn group.

Moving forward, we have an exciting year ahead with the continued groundwork on our strategic initiatives. As part of our acoustic promotion, in addition to the continuous event programme, we will be planning in earnest the ICSV24 (International Congress on Sound and Vibration) in London on 23-27 July 2017.

Communication within the membership is being developed further in order to ensure closer and more frequent interaction with the groups and branches to enable further feedback.

As mention in the last Bulletin, we have commenced a strategic review of our education provision. Twelve companies had been asked to tender, of which eight submitted tenders and four were shortlisted for interview. From these, we have selected and awarded a contract. To date, five members have been interviewed and research conducted in order prepare the questions for the detailed interviews and surveys. A further 25 in-depth interviews are planned, along with an online survey of members and those on the Institute's LinkedIn site. The project is on track to report in early September.

The above cannot be achieved without a solid financial foundation and we continue to fund the initiatives from our operational activities. We have many more plans (within our strategy) to ensure we support our membership and develop the Institute.

Your membership is appreciated and I want you to know that we have flourished. Overall, it was a good year and we have much to look forward to this year.

Your feedback is important and we are eager to hear from you about our services for you. We appreciate your input on our surveys and sharing your thoughts and ideas on our LinkedIn page. We value your insights on how we can better serve you and we are dedicated to providing you with the best service possible. We want you to excel in your profession and to know how much we value your continued support.

William Egan, President

Progress achieved on several fronts during 2014 as nearly 230 new members join

41st annual report of the Council

The 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:

1. 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 2014 is listed.

Objective	Progress in 2014
Advise Policy Makers on acoustics	Members of the Institute have been involved in national working groups and the institute has responded to consultations on BS 4142, BS 8233 and Acoustic Standards in Schools. The Institute is also a member of the Parliamentary and Scientific Committee and members have attend several meetings of the Committee. *Science of Sound* Booklet published and distributed to members of both Houses of Parliament.
Increase public awareness of good acoustic design	The first Peter Lord Award for Good Acoustic Design was awarded
Create opportunities for other professionals to gain a better understanding of acoustic and its interaction with their specialist field	Discussions have taken place about joint activities with IoP and RIBA. NPPF/PPG Guidance was jointly commissioned with ANC and CIBSE Sustainable acoustic guidance produced Guidance notes issued for wind turbine noise assessment
To develop links with undergraduate students	The new student e-zine was produced and 277 student members recruited
To support the teaching of acoustics at AS/A2 level	Under review
To improve the operational efficiency of the Institute	New website launched with branches and groups being given the option of having dedicated pages which they can edit directly TORs for groups and branches reviewed
To develop mechanisms for supporting members professional development	CPD monitoring introduced. Members given ability to record CPD on their personal records Series of conferences and events held during the year

Standing Committees

The operation of the Institute is guided by Council through standing committees concerned with Education, Engineering, Medals and Awards, Meetings, Membership, Publications and Research Co-ordination. The reports of the various committees follow.

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 seventh year since revision in 2008. As a result of grades obtained in 2013/14, the Diploma was awarded to 75 students from five institutions and four distance learning centres. Jen Taylor (London South Bank University) won the prize for best overall performance and Gareth Thompson (DL Dublin) for the best performance by an Irish student. Six students received special commendation letters for achieving five merits. Southampton Solent and London South Bank Universities are both centres, the latter after a gap of 17 years. Sadly the University of Salford is no longer offering the Diploma, and Colchester Institute was unable to recruit enough candidates. NESCOT is considering re-starting the Diploma for the academic year 2015-16. The Education 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, and agreed purchase of video tutorial facilities at St Albans when suitable network access is installed.

In 2014/15, the Certificate Courses recruited as follows: Management of Hand-Arm Vibration 16 students (10 passes), Environmental Noise 222 students (200 passes), Building Acoustics Measurement 25 students (22 passes) and Workplace Noise and Risk Assessment 36 students (29 passes). The Certificate of Proficiency programme in Anti-Social Behaviour (Noise) continues to run in Scotland by Bel Education and Strathclyde University and recruited 28 students (22 passes).

Since 2011, Diploma members have been able, for CPD or other reasons, to register for additional specialist modules. In 2014 one person has taken advantage of this opportunity. Additional

Leo Beranek at the 40th Anniversary Conference

"formal" CPD courses (with a syllabus and assessment) are being considered in conjunction with groups and branches. Options for alternative delivery of courses (including e-learning) continue to be considered. 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).

In 2012 Council approved the purchase of sets of demonstration equipment to support the "You've Been Banned" acoustic workshop for presentation to schools. Twelve "You've Been Banned" presentations were given during 2014.

Simon Kahn, Chairman, attended two functions on behalf of the President, a launch of the "STEM Alliance" at the House of Lords, and "Tomorrow's Engineers" at the Shell Centre. Both events recognised the current predicted shortage of STEM graduates and the need to promote STEM subjects to 11- to14-year-olds.

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

The committee met twice during the year, confirmation of approval of registration for some candidates being given by email correspondence with committee members. The number of enquiries for registration from Institute members remained strong, but many potential candidates still deferred or failed to complete their applications, despite the personal support provided.

The number of formal applications for Chartered Engineer and Incorporated Engineer registration was similar in 2014 as in recent years. Seven candidates presented themselves for Professional Review Interview, of whom three were "Standard Route" candidates, holding accredited degrees, and four were "Non-standard Route" candidates with diverse backgrounds, including physics degrees. Their areas of employment were equally diverse: aerospace engineering, architectural and building acoustics, and naval noise and vibration engineering. Five candidates were successful.

Following a visit in October, the Engineering Council has granted IOA a further five-year licence for CEng/IEng registration and invited IOA to discuss an extension of our licence to encompass the accreditation of academic degree courses.

Medals and Awards Committee

The majority of the 2014 awards were made at the 40th Anniversary Conference/ Reproduced Sound in October 2014.

The Raleigh Medal was awarded to Professor Timothy Leighton and Dr Leo Beranek received a specially issued Rayleigh Medal.

Delegates at the 40th Anniversary Conference

The Tyndall Medal was awarded to Dr Stephen Dance and the Engineering Medal to Dame Ann Dowling. The Peter Lord Award was awarded for the first time, to Professor Jian Kang and his team from the Acoustics Research Group in the School of Architecture at the University of Sheffield. Honorary fellowships were awarded to Trevor Cox, Ken Dibble and Rob Hill for their exceptional service to acoustics and the Institute. Professor Malcolm Hawksford was awarded the Peter Barnett Memorial Award and Alex Krasnic the award for Promoting Acoustics to the Public. Sam Daintree was presented with an award for the best performance in the IOA's 2013 Diploma. Leah Evans was awarded the Professor D W Robinson Prize at her graduation ceremony at ISVR in July and John Bowsher the Award for Services to the Institute in December.

Meetings Committee

The committee met four times in 2014. Its membership has changed quite significantly since last year's report. The chairmanship passed to Hilary Notley, although Jeremy Newton remains a valued member of the committee. The new Chairman would like to take this opportunity to thank Jeremy Newton for his excellent contribution to the committee and is delighted he is still willing to contribute. His experience, knowledge and mentoring is greatly appreciated. Chris Turner remains as Secretary and Young Member. Unfortunately, both Ken Dibble and Paul Lepper felt they needed to step down; the committee will miss their input greatly and would like to thank them both for their time and efforts over the years. Two new members have been recruited to the committee – Chris Skinner and Robin Woodward. Additionally, Peter Rogers has been co-opted to allow the meetings programme to be designed with the aims of the Sustainable Design Task Force in mind at all times.

The committee presided over the organisation of 14 events covering a wide variety of topics. There were 11 single day meetings/workshops and three two-day events; an underwater acoustics conference, the Reproduced Sound conference and Acoustics 2014, which was badged as the IOA 40th Anniversary Conference. 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.

The 40th Anniversary event covered new ground and was judged to have been a great success. The first unusual aspect was the co-location of this event with Reproduced Sound. Both events were two days, with an overlapping day in the middle. Around 50 members took advantage of the opportunity to attend both events because of this. Secondly, all specialist groups organised parallel sessions. This provided a great opportunity for members to attend not only the sessions closest to their professional needs, but also to explore areas not often encountered in their day-to-day working lives. Feedback was excellent and in particular the provision of an opportunity to network across the profession was appreciated.

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. Specifically, the committee aims to meet a target of an average surplus of £1,000 per event. During 2014, this target was exceeded by more than100%.

Membership Committee

The committee met four times during 2014. Ellen Harrison was welcomed to the committee as a representative of our Young Members. The CPD review team agreed to review the CPD records of 5% of the membership and a series of meetings was held over the year to achieve this aim. The Institute's CPD record forms were revised and members reminded of the need to participate in appropriate CPD. As well as revised CPD forms, the committee revised the sponsor member application forms to provide improved information on applicants.

Discussions were held with officers of the Environment Agency on the reporting of environmental issues. During the year the committee proposed a new grade of sponsorship to recognise

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those organisations that had been key sponsors since the inception of that grade. The grade of founder key sponsor was proposed and was subsequently approved by Council.

A total of nine Code of Conduct complaints were received during the year of which one was withdrawn, two were proved, four were not proved and one was held in abeyance due to active planning issues. One is still actively being considered. Two of the cases were appealed and in both cases the appeals panel and Council confirmed the original decisions. Paul Freeborn completed his three-year term of office as Chairman, but, being eligible for a further term of office, the committee proposed that he should serve a further three years. This recommendation was endorsed by Council.

During the year 333 membership applications were assessed by the committee, a slight increase on the previous year. Of these, 316 were elected to membership of various grades, again representing a small increase on the previous year's figures.

2014	FIOA	MIOA	AMIOA	Tech	Affil	Student	Sponsor	Total
Applicants	9	113	159	23	3	24	2	333
Elected	9	101	155	22	3	24	2	316
New Members	2	42	134	22	3	24	2	229
Resigned	4	18	12	1	0	1	2	38
Deceased	1	3	0	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 2014 an editorial board was set up to provide technical opinion on the technical contributions for the Bulletin to aid Charles Ellis in his editorial duties. Electronic distribution of *Acoustics Bulletin* was trialed through 2014 and members are now being given the option to opt out of receiving the paper version in 2015 with a view to reducing the amount of paper the IOA produces. Options are being investigated for a potential electronic version in the future. The revised website came on-line at the start of 2014, and this continues to be developed. During 2014 agreement was reached to get a blog on the site aimed at students/teenagers making decisions about careers, which will be managed by the Young Members' Group, and also for the index of the IOA library to be searchable on the website. It has also been agreed that abstracts will be collated for all payable meetings. During the year the committee has been joined by Chris Middleton, with Dave Sproston leaving. Thanks are due to all committee members for volunteering their time and enthusiasm throughout the year: Daniel Goodhand, James Hill, Rebecca Hutt, Mark Lawson, Mike Lotinga, Allen Mornington-West, 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 with meeting reports, technical contributions, letters, book reviews and everything else.

Research Co-ordination Committee

During 2014, the committee (RCC) met in May and November at the Defra offices in London. The committee welcomed its new tier one members: D. Olga Umnova (University of Salford), Dr Benjamin Fenech (PHE) and Dr Andrew Bullmore (Hoare Lea Acoustics). The committee noted that there was no democratic mechanism for the election of new members and membership rotation within the RCC. This topic will be discussed at our next RCC meeting in May 2015. Some of the groups within the Institute are strongly research active and it makes sense to have their input each time there is a need to eject new blood into the RCC. It makes sense to develop a process for the RCC to make a call for new nominations to become tier one or tier two members of the RCC and for Institute members to make on-line application. These matters will be discussed further at the next RCC meeting in May 2015.

The committee reviewed the current level of research funding related to acoustics and maintained close contacts with the EPSRC via teleconference calls to the programme managers, Dr Daniel Smith and Dr Andreas Kontogeorgos. It was noted that the total value of grants related to acoustics, ultrasonics, audio engineering, noise and vibration has gone down a little over the last year. In November 2014 it was estimated that approximately 142 acoustics-related grants were funded by the RCUK with a total value of £84 million (down from 223 grants with the value of £120 million in April 2014). The committee also discussed the potential for funding of acoustics-related research in the UK from €70 billion of research funding available through the EC Horizon 2020 Programme.

The committee discussed various options for promoting acoustics as a research discipline and agreed to seek to achieve it through better cooperation with various professional bodies, i.e. the Institute of Physics (via Dr Umnova), Public Health England (via Dr Fenech), Defra (via Mr Turner/Ms Notley) and with the industry (via Dr Williams and Dr Bullmore). The promotion of acoustics as a research discipline can also be achieved through a new EPSRC Network Grant in Acoustics. This opportunity was discussed with Dr Andreas Kontogeorgos of EPSRC in November 2014. An action group comprising Professor Horoshenkov, Dr Williams and Dr Bullmore was set up to develop this initiative in 2015 in collaboration with the EPSRC.

The committee expressed concern that there were not enough students studying acoustics at the UG /PG and PhD levels in the UK to service the number of acoustics-related grants awarded annually by the RCUK. Therefore, the appointment of research staff on these grants will continue to depend on the supply from outside the UK. This situation presents a potential problem for the future of acoustics-related research in the UK. The committee also noted that the number of publications on acoustics and ultrasonics co-authored by researchers from the UK has been stagnant since 2009-2010.

The committee's pages on the RCC's website were revised. These pages also contain the past agendas and minutes of the committee. These are accessible to IOA members only. It was noted that a new research database should be developed under the IOA website. This database could list names of the research active members of the IOA and their research interests. It can then be populated via the usual on-line membership renewal form issued by the IOA once per year. The committee noted that it would also be

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Networking at the 40th Anniversary and RS Conferences

William Egan presents the Engineering Medal to Dame Ann Dowling

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helpful to link the list of research active members of the IOA with the search engine which is available through the RCUK website (http://gtr.rcuk.ac.uk). This link will enable the RCC webpage to scan regularly the RCUK site and update the list of the current research grants won by the IOA members. It may also be possible to link it to the EU Horizon 2020 database. These and other actions are detailed in the meetings notes which have been submitted regularly to the IOA.

Specialist Groups

Building Acoustics Group

2014 was very much focused on celebrating the Institute's 40th anniversary. The main event was the 40th Anniversary Conference at the NEC in Birmingham in October. The event was a huge success – the main highlight was listening to the 100-year-old Leo Beranek who, in acoustic terms, is something of a legend.

Due to the continued success of the multi-room, multi-discipline conference format, 2015 will see another similar event taking place in the Harrogate International Centre on the 15 October and BAG will be organising a full day to include acoustic issues arising from flexible structures such as CLT, post-tensioned concrete and lightweight steel framing systems.

We are also organising a one-day meeting on 17 September focusing on acoustic design in sustainable buildings.

Our members have also been busy with writing and consulting on several acoustic documents including the *Acoustic Design of Schools*, CIBSE guides, sound and impact isolation field testing, pubs and clubs and many more. We are looking forward to the long-awaited release of the guidance document that will accompany the new revision of the schools document BB93, which many of our members have been deeply involved.

The industry is buzzing again with a huge boom in residential and commercial development and there is a real excitement centred on all aspects of the industry i.e. academic, manufacturing and consultancy.

I would like to personally thank all of my committee members and everyone else who provides their valuable time for free – the Institute would not function without you. Here's to a bigger and better 2015!

Electroacoustics Group

The main activity of the group during 2014 was the organisation of the annual Reproduced Sound conference. This year, the 30th conference was timed to coincide with the Institute's 40th Anniversary Conference, with an overlap of one day. Although precise numbers are impossible to gauge due to the overlap, attendance at the conference is estimated to be more than100, including a healthy number of student delegates. The conference included two notable keynote lectures from Peter Mapp and Leo Beranek, who had recently celebrated his 100th birthday. The 2014 Peter Barnett Award was presented to Professor Malcolm Hawksford, who also gave a lecture. At the group AGM, held at the conference, the committee thanked Paul Malpas for five years as Chairman of the group and the position of chair was handed to Keith Holland. Helen Goddard remains as Secretary and a new member, Robin Dibble, joined the committee. The conference is moving venue for 2015 to the Fire Services College in the Cotswolds.

The group committee met on three other occasions during 2014. On 8 January the call for papers for the conference was decided, the review of abstracts took place on 24 April and the details of the conference were finalised on 24 September. As in past years, each member of the EAG committee has a defined role in the organisation of the conference and the fact that this is a real team effort is acknowledged here.

Environmental Noise Group

In April the group held a workshop in London attended by 70 members to debate the proposed revision of BS 4142, Method for rating and assessing industrial and commercial sound. This fed into the submission of an IOA response to the consultation on the standard that is widely used by many of our members. The revised standard was published in October and a series of workshops is being planned to help ensure members apply the expanded standard consistently and as intended.

A committee was formed to progress national guidance to fill the gap left by the repealing of Planning Policy Guidance 24. The committee secured IOA support to develop Professional Practice Guidance on Planning and Noise with the Chartered Institute of Environmental Health and the Association of Noise Consultants. A series of meetings was held to progress the draft guidance with a view to a consultation in 2015.

The group made a substantial contribution to the IOA's 40th Anniversary Conference in Birmingham in October, through contributing a history of environmental noise for *Acoustics Bulletin* and holding a six-paper session at the event, which was well supported.

Measurement and Instrumentation Group

During this period, the group has organised two one-day meetings and two sessions of presentations at the 40th Anniversary Conference.

For the first meeting of the year, 12 March, we were in Birmingham to take a look at *Railway noise – on the right track* with an eye on both the developments of the HS2 rail link and the Crossrail project through London. A short presentation from HS2 Ltd was followed by details of the assessment methods and sustainability of the project. Measurements and predictions of noise and vibration relating to Crossrail were covered by multiple speakers in an extended presentation and other speakers covered different aspects of noise and vibration from railways, some by measurement and some by prediction, which was obviously appreciated by the 47 delegates present.

On 25 June we were at London South Bank University to hear *How noisy is that machine?* Nine presentations were organised and introduced by the inimitable Liz Brueck from HSL with information coming from HSE and HSL as well as guidance on declaring noise emissions in the workplace, for HVAC systems, lawnmowers and a variety of machinery. It was a pity only 26 people attended, as the information available would have been of use to a wide range of manufacturers, but three presentations were thought so useful that they were recommended for transfer to *Acoustics Bulletin* at a later date.

For the 40th Anniversary Conference at the NEC in Birmingham, two sessions of presentations, four on the first day, and three on the second, were organised by the group, and John Seller presented a retrospective look at a variety of less-well-known measuring devices and techniques at the group's plenary session. A good attendance at the papers was realised, and relevance of such topics as measuring sound with light, International Standards, sound level and power declarations, reverberation time sound stimuli and outdoor propagation modelling covered a wide variety of measurement and instrumentation topics.

Over the past year, the group's committee members have continued contributing to the regular *Instrumentation Corner* article to *Acoustics Bulletin*, 33 to date, which has produced some interesting discussion and articles, and this is scheduled to continue for the forthcoming year.

For 2015, it is hoped the group can introduce webinars as well as two one-day meetings, which will be an interesting development to see unfold.

My thanks go to all members of the committee for the active roles they take in all aspects of the group's activities and to Martin Armstrong for his secretarial skills on behalf of the group.

Musical Acoustics Group

For the group, 2014 could be considered as a "vintage" year of activity with a wide range of topics relating to musical acoustics covered at the meetings. First was a half- day meeting held by the Southern Branch in collaboration with the Musical Acoustics Group and the Brighton Science Festival held in Brighton on 28 February. Entitled *Creative Soundscapes* 2014, it examined the role of soundscapes within sustainable acoustic design. Professor Jian Kang picked up on some musical elements in his presentation on the design of urban elements. These elements were even

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more prominent when Professor Trevor Cox presented *Sonic Wonderland: A Scientific Odyssey of Sound*, providing examples of an alto saxophone playing within some incredibly reverberant locations. Dan Pope from Atkins followed this with a presentation based upon his work on the video game *Call of Cthulhu: The Wasted Land*. There was also a glimpse of the possibilities provide by the use of Aeolian harps. With around 50 people attending, including some from outside the Institute, the meeting surely helped to publicise the aims of the IOA.

In March, the impressive MediaCityUK centre in Salford saw 30 delegates attend a joint one day meeting on *Sound Recording Techniques* with the Electroacoustics Group. This raised some important questions about the relationship between technology and the art of music. The efforts of Trevor Cox and colleagues provided an excellent and stimulating opportunity for experienced acousticians and sound engineers to meet with students entering the field and to hear a number of very well prepared and delivered presentations. They included Professor Patrick Gaydecki, with his talk entitled *From Electric to Acoustic Violin: digital synthesis and emulation*. Dr Bruce Wiggins looked at *Ambisonics: the pros, cons and pitfalls of 3D audio*, and Dr Rob Toulson examined *Case Studies in Modern Music Production: where science meets art* illustrated by his own work in recording groups such as the Mediaeval Babes. Professor Mark Plumbley gave a wide-ranging talk on *Analysing Digital Music*. Finally, Trevor Cox described *How Distortion Affects the Perceived Quality of Music: psychoacoustic experiments*, derived from work carried out with students at the University of Salford Acoustics Research Centre.

April saw further collaboration, this time with the London Branch, with Dan Pope repeating his presentation *Calling Cthulhu* and Mike Wright repeating his argument about the "right temperament in music".

The group held its main one day meeting and AGM at the Royal Academy of Music Duke's Hall, London in July. It focused on the new organ recently built by Orgelbau Kuhn of Switzerland and funded by past students, Sir Elton John and Ray Cooper. The meeting looked into ways that architects, acousticians, organ builders and consultants can successfully match a fine pipe organ to its acoustic space in the course of fitting out new performance buildings and refurbishing existing ones. It included contributions by the past Chairman of the British Institute of Organ Studies, John Norman; Nicholas Edwards, principal consultant at Acoustic Dimensions; Alan Woolley, University of Edinburgh; and David Howard, University of York. Paul Wiseman and John Miller of Bickerdike Allen described their further work since the 1990's refurbishment. To finish the event, Chris Stanbury explored the design of the new organ, concluding his observations by performing a jazz-inspired Homage to Fats on the fine new instrument.

The group's involvement in the 40th Anniversary Conference saw a very wide range of musical acoustics topics. On the first day, Stephen Dance presented the Tyndall Medal Lecture: *Conservatoires – acoustics and music working together*. This described collaborative work to address the new Control of Noise at Work Regulations. In the group sessions, Murray Campbell, University of Edinburgh, described why brass instruments sound "brassy" on the basis of recent research. Kurijn Buys, Open University, described and demonstrated work in developing and evaluating a hybrid wind instrument excited by a loudspeaker. Ongoing experimental investigations of the motion of a cello bridge in the low- to mid-frequency range were described by Ailin Zhang, University of Cambridge. Meanwhile, Richard Seaton explained why choirs performing Western music a cappella are not always able to maintain pitch. Owen Woods described a good example of the contribution that acoustics and vibration can make to organology, the science of musical instruments, by analysing a plucked stringed instrument from the Andes region and linking the musical sound to the ethnomusicology. Carl Hopkins reviewed recent research on the potential for using vibrotactile feedback to facilitate interactive musical performance for deaf musicians.

The group management committee held six meetings during the year. Most of these were possible using Omnijoin video conferencing, the only way possible to economically enable members as far apart as Edinburgh and Devon to hold such meetings. There were two issues of *MAG MAG* in 2014 with Christopher Stanbury taking over temporary editorship from Owen Woods.

Noise and Vibration Engineering Group

Two full committee meetings were held during the year, by teleconference in both cases, supplemented by a number of sub-group meetings to focus on planning for the two events that were run during the year. The first was a meeting on *New Technology for Noise Control Engineering*, held in July at the Royal Society in London and chaired by Simon Stephenson, which focused on noise control within large process and petrochemical plants. The speakers and audience reflected the diversity seen within this particular speciality and there was a good turnout and lively discussion. The group also organised two sessions at the 40th Anniversary Conference in October, focussed mainly on automotive NVH (chaired by Stephen Walsh) and on vibration transmission in buildings (chaired by Malcolm Smith).

The group also contributed an item to the Anniversary Bulletin reviewing changes in the field of Noise and Vibration Engineering over the past 40 years. Since the new year we have sadly lost Andrew Wolfindale as our Young Member, killed in an accident, and Reuben Peckham is stepping down from the committee due to his other IOA commitments (examiner for the Noise and Vibration Control section of the Diploma). As a result, recruitment of new members to the committee is now a priority.

Physical Acoustics Group

After some while with little activity, the group (PAG) will be re-established in 2015. A small interim-committee is to be formed to provide a modest programme of events whilst recreating the link with the Institute of Physics (IOP), and its programme, including the time-honoured Anglo-French Physical Acoustics Conference (AFPAC).

In 2014, a joint meeting between the IOA and the IOP PAG committee, defined two possible ways for a rejuvenation of PAG activities for IOA the membership: a modest programme of IOA events and visibility of IOP activities. Access to parallel PAG activities run by the two institutes will assist with our common goal of promoting physical acoustics. A programme of events should be expected in 2015. To achieve this, we do need some help from anyone with a passion for physical acoustics, who could offer a few hours, to be a potential committee member, or speaker at one of our future events.

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. We have had only one meeting during the year and this was held in conjunction with our fourth AGM in March 2014, which was kindly hosted at IOA headquarters in St Albans. Alison Codling, Senior Occupational Health Nurse, Centre for Workplace Health, Health & Safety Laboratory Buxton, Derbyshire, gave us an interesting talk about her work in otoacoustic emissions (OAE) testing and hearing conservation. The talk gave rise to much discussion on this important topic which raises the prospect of detecting the effect of noise on the ear before it becomes evident by conventional audiometry, and is not dependent on a conscious response by the patient. Arrangements for a half-day meeting at RAF Henlow dealing with aircraft noise did not, unfortunately, come to fruition in time. However, it is hoped that this meeting will go ahead in 2015. Ian Campbell proposed a meeting at his office with the fifth AGM for late in 2014. However, following discussion it was agreed that it would be better to hold the AGM in conjunction with *The ear and hearing – a tutorial for acousticians* meeting on 29 January 2015 at London South Bank University.

The group is cooperating with the CPD committee and this scheme is now operating. The group is looking for further volunteers to review members CPD. In particular your chairman is

looking for someone to replace him.

At the beginning of the year it had been hoped by the committee that the group could take an active part in the 40th Anniversary Conference. Sadly this was not possible, and due to the diversity of SMG members it was not possible to hold an anniversary meeting, such as was held by most IOA branches. The group continued to support Geoff Kerry with his History Project. The document is almost ready and will be published 2015.

For the future we still have to revise our terms of reference but are awaiting advice and guidance from Council. Your Chairman has volunteered to serve one more term but will then be definitely standing down.

Speech and Hearing Group

The group hosted one event during 2014. This was a talk entitled *Hearing Aid Signal Processing Strategies to Improve Speech Discrimination* by long-standing group committee member Graham Frost, held on 9 April (and followed by the group's AGM). It was particularly good to have Graham speaking, not only due to his in-depth knowledge of the topic, but also because it signified his return to being active in the group following a period of poor health.

The group also co-organised meetings with both the Young Members' Group and London Branch. A special screening of the film *Lost and Sound* – a documentary made by Lindsey Dryden, a partially-deaf filmmaker, which followed a music critic, a dancer and a pianist over three years as their experiences change following hearing loss – was given on 11 March. A talk entitled *Cochlear Implants – the second most successful medical implant ever produced is evolving. How much better can it get?* was given by Bradford Backus of Audio3 Ltd on 19 February. (The re-scheduled talk on Protecting the professional ear by Andy Shiach of Advanced Communication Solutions was also co-organised with the London Branch and held in December 2013.)

Members of the group were active in the organisation (particularly with respect to reviewing submitted papers) of the sessions on topics relating to speech and hearing at the 40th Anniversary Conference. The sessions included papers on a wide spectrum of subjects, ranging from assistive speech technology, through speech perceptual and audiometric measurement, to concepts such as "speech security" and "speech privacy".

A half-day co-sponsored tutorial meeting is due to be held in late January 2015 on *The ear and hearing – a tutorial for acousticians*, and another workshop meeting is being planned (possibly in collaboration with the British Society for Audiology) on *Audiology for Acousticians*. Preparations are also under way to hold a joint one day meeting with the Musical Acoustics Group on *Hearing impairment and the enjoyment and performance of music* in July 2015.

The group are also liaising with the British Library to arrange a visit to and talk on their Sound & Vision Section. A talk on *Looking after your voice*, and a follow-up to the successful one-day tutorial workshop on *Speech recording and analysis*, held in London in 2010, are also planned.

The group committee met four times (in January, April, July and November) during 2014. The group's AGM, as noted above, was held on 9 April 2014. This meeting was quorate, and reasonably well-attended.

During the course of the year, Graham Frost returned to the committee following a successful recovery from his health problems, but Emma Greenland temporarily stood down due to going on maternity leave. Long standing co-opted member Roz Commins asked to stand down late in the year, and a replacement for her is currently being sought. The remaining committee members due for re-election were re-elected nem. con.

Underwater Acoustics Group

As in previous years, the group's main endeavour for the past year has continued to concentrate on the dissemination of knowledge via its conferences and other activities. A synthetic aperture sonar

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conference in Lerici, Italy, in September 2014 was successful with 30 good quality papers and 40 delegates. The group organised an underwater session at the IOA 40th Anniversary Conference with seven papers. Group members also organised four sessions at the 2nd Underwater Acoustics Conference in Rhodes in June 2014, and the 2013 AB Wood Medal was presented to Brian Todd Hefner at this meeting. Some members of the committee are on the ISO TC43 SC3 Working Groups 1, 2 and 3. These are working on measuring ship noise, measuring piling noise and acoustical terminology. WG 2 and 3 plan to produce their ISO standards in 2015. The group is now dedicating its efforts to future meetings, including sessions at UAC 2015, collaboration with Michel André on Oceanoise 2015, a meeting on seabed and sediment acoustics in Bath in September 2015 and, looking further ahead, a conference on acoustic and environmental variability, fluctuations and coherence in Cambridge in 2016.

Young Members' Group

The group committee meets quarterly with three meetings by telecom and one meeting in person. In 2014 our face-to-face meeting was held in December before a London Branch meeting which was then followed by a social, open to all members, not just young.

We held a good number of educational events in 2014 including a joint meeting with the Society of Light and Lighting (with the Sustainable Acoustics Task Force) and a CPD event at the Illustrious Company in London. We also held a quiz as part of the 40th Anniversary Conference and Young Members' reps helped with various 40th anniversary offerings.

In addition to the December social we also had a social event at Bounce, a table tennis bar in London. To promote the IOA to students we gave presentations at London South Bank University, University of Salford and the University of Southampton about the benefits of IOA membership and chartership. To promote the IOA further afield we participated in an inter-professional networking event in Manchester and an inter-professional football tournament in London.

There have been a number of group reps who have not participated in YMG activities or meetings. I have been monitoring attendance and will discuss the less active reps with the relevant chairmen to discuss if the rep is active within their group, branch or specialist committee or whether it might be better to suggest they step aside and allow someone else to replace them.

For the year ahead we aim to present to students at more universities (e.g. Anglia Ruskin University, Southampton Solent University, University of Derby, University of Liverpool, Edinburgh Napier University, University of Edinburgh). We are also hoping to provide more events outside of London, including a mock planning appeal in Birmingham. The largest ambition for the year ahead is to organise an inter-professional networking event in London, similar to that in Manchester. We have so far received positive responses from IMechE, IStructE, the Landscape Institute and CIBSE which show that they are as keen as we are. I am hoping for responses from at least 10 other professional bodies before the end of January.

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

Table 1. Membership

Grade	2013	2014
Hon Fellow	35	38
Fellow	174	174
Member	1751	1761
Associate Member	731	758
Affiliate	69	58
Technician Member	88	100
Student	72	80
Totals	2920	2969
Key Sponsor	2	2
Sponsor	50	49

Table 2 Group Membership

Group	2013	2014
Building Acoustics	1234	1357
Electro-Acoustics	340	387
Environmental Noise	1563	1723
Measurement & Instrumentation	546	641
Musical Acoustics	299	377
Noise and Vibration Engineering	998	1123
Physical Acoustics	206	246
Senior Members	96	116
Speech & Hearing	183	214
Underwater Acoustics	190	236
Young Members	172	266

Table 3. Branch Membership

Branch	2013	2014
Central	194	222
Eastern	261	276
Irish	125	126
London	789	843
Midlands	380	397
North West	385	387
Overseas	345	331
Scottish	168	171
South West	271	270
Southern	472	490
Welsh	77	74

Table 4. Details of Employment

Employment Category	2013	2014
Architectural Practice	56	183
Consultancy	1455	1654
Education	221	419
Industry/Commerce	170	419
Public Authority	390	401
Research & Development	219	428
Retired	146	135
Other	88	142

Table 5. Meetings and attendance in 2014

Topic	Date	Venue	Attendance
Railway noise-on the right track?	12 March	Birmingham	30
Wind turbine noise-AM, and where to next for ETSU-R-97?	20 March	Cardiff	92
Sound recording techniques	26 March	Salford	30
BS4142 workshop	3 April	London	72
Acoustic standards for schools	15 April	London	54
Wind farm noise	15 May	Glasgow	57
Casting light on sound	17 June	London	41
How noisy is that machine?	25 June	London	27
The acoustics of organs	4 July	London	21
New technology for engineering noise control	8 July	London	34
Synthetic aperture sonar and radar	17-19 September	Italy	40
Reproduced Sound 2014	14-15 October	Birmingham	107
40th Anniversary Conference	15-16 October	Birmingham	297
AM workshop	27 November	London	68

Council		Ordinary members
President	Mr W Egan MIOA	Mrs A L Budd MIOA
President Elect	Mrs J Webb FIOA	Dr K Holland MIOA
Immediate Past President	Prof B M Shield HonFIOA	Mr R Mackenzie MIOA
Honorary Secretary	Mr R Richardson MIOA	Ms H Notley MIOA
Honorary Treasurer	Dr M R Lester FIOA	Mr G A Parry MIOA
Vice President Engineering	Mr R A Perkins MIOA	MR P J Rogers FIOA
Vice President Groups & Branches	Mr G Kerry HonFIOA	Mr A W M Somerville MIOA
Vice President International	Dr W J Davies MIOA	Mr D L Watts FIOA

Committees & Sub Committees	Chairman
Education	Mr S W Kahn MIOA
Diploma in Acoustics and Noise Control, Board of Examiners	Mr S J C Dyne FIOA
Certificate of Competence in Environmental Noise Measurement	Dr M E Fillery FIOA
Certificate of Competence in Workplace Noise Assessment	Mr D Lewis MIOA
Certificate of Proficiency in Anti-Social Behaviour (Scotland) Act 2004 (IOA/REHIS)	Mr S Williamson MIOA
Certificate in the Management of Occupational Exposure to Hand Arm Vibration	Mr T M South MIOA
Certificate of Competence in Building Acoustics Measurement	Mr C Steel MIOA
Engineering Division	Mr R A Perkins MIOA
Medals & Awards	Mr W Egan MIOA
Meetings	Ms H Notley MIOA
Membership	Mr P T Freeborn FIOA
Publications	Mr A Lawrence MIOA
Research Co-ordination	Prof K Horoshenkov FIOA

Specialist Groups	Chairman	Secretary
Building Acoustics	Mr R O Kelly MIOA	Mrs A L Budd MIOA
Electro-Acoustics	Mr P R Malpas MIOA	Ms H M Goddard FIOA
Environmental Noise	Mr S C Mitchell MIOA	Ms N D Porter MIOA
Measurement & Instrumentation	Mr R G Tyler FIOA	Mr M J Armstrong MIOA
Musical Acoustics	Mr M Wright MIOA	Mr D Sharp MIOA
Noise and Vibration Engineering	Dr M G Smith MIOA	Mr M D Hewett MIOA
Physical Acoustics *(Joint with the Institute of Physics)*	Prof V F Humphrey FIOA	Mr M R Forrest MIOA
Senior Members' Group	Mr R J Weston MIOA	Mr D Nash MIOA
Speech & Hearing	Dr G J Hunter MIOA	Mr A P Holden MIOA
Underwater Acoustics	Dr P F Dobbins FIOA	Ms E Keon MIOA
Young Members' Group	Ms A Lamacraft MIOA	

Regional Branches	Chairman	Secretary
Central	Mr R A Collman MIOA	Mr M Breslin MIOA
Eastern	Mr M Jones MIOA	Mr C M Pink AMIOA
Irish	Dr M R Lester FIOA	Mr S Bell MIOA
London	Mr J E T Griffiths FIOA	Mrs N Stedman-Jones MIOA
Midlands	Mr P J Shields MIOA	Ms F Rogerson MIOA
North West	Mr M Hewett MIOA	Mr P Stringer MIOA
Scottish	Mr A W M Somerville MIOA	Ms L Lauder MIOA
Southern	Mr P Rogers FIOA	Mr D Saunders MIOA
South West	Mr D C Pope MIOA	Mr D O'Neil MIOA
Welsh	Mr G O Mapp MIOA	Mr J M Keen AMIOA
Yorkshire & North East	Prof K Horoshenkov FIOA	Mr D Wallis MIOA

Chief Executive:	Mr A Chesney

Workshop on sustainable design in practice marks another first for IOA

By Peter Rogers

This fully attended Sustainable Design Task Force (SDTF) workshop on General Election day marked another first for the Institute by providing members across the country with the opportunity to listen and participate wherever they were. The main hub venue (kindly hosted by Mott MacDonald in London) was linked to supporting locations in Birmingham, Edinburgh, Leeds and Southampton. In addition, thanks go to ARUP Manchester and Atkins Bristol who also opened their doors and acted as host venues. In all, this gave members unprecedented geographic access. Members were also able to join remotely via an Internet link to receive an audio stream live at their desks, and ask questions that could be shared with the main venue. A remarkable 146 members booked to attend in one way or other, reflecting the strong interest in the content as well as the unprecedented accessibility. The technical challenges of the set-up were largely overcome (thanks again go to Simon Kahn and his team) and lessons were learnt for the future. However, it was generally agreed to be a ground-breaking event in content as well as format. All presentations and the feed from the event will be made available on the IOA website in due course (currently see the Groups and Branches section in the member area, but this may move).

The main drivers behind the SDTF are Peter Rogers and Richard Cowell, Co-Chairmen, who joined forces with a broad range of speakers. They included Dan Pope of Atkins Global and Chairman of South West Branch who shared a slot with Dr Ben Fenech of Public Health England; Julie Godfrey, Sustainability Consultant for Hoare Lea (one of the top 40 influencers in sustainability in 2014) and Kim Hampton of Mott MacDonald (also a sustainability lead) who facilitated the workshop discussions.

Peter began by talking about the progress made by SDTF. He spoke of the growing need and the group of volunteers who are to be entrusted to take forward the work of the group, which is due to scale down the stimulation phase after completing goals agreed with Council. The legacy, however, is a commitment that sustainable design will be at the core of the Institute's activities. The work of the SDTF will be felt in education, CPD, meeting topics and guidance notes and a tool box of resources for members.

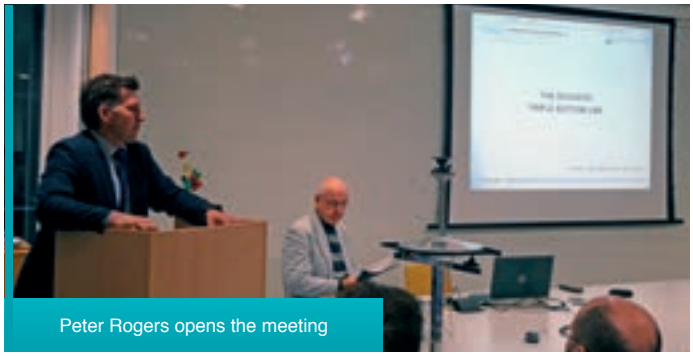
The workshop was intended to offer a first step in sharing thinking relevant to acoustic practitioners trying to introduce sustainable design into their work. It is acknowledged that much more needs to be done, but that this is a coherent and inclusive start.

Peter then introduced the acoustic "triple bottom line" and its importance for acoustics. This was followed by Dan Pope and Ben Fenech who blended their talks to set out the evidence and opportunities for using positive sound to enhance health. This included such ideas as sound being an "essential nutrient" for humans, and they also looked at how soundscapes could be designed for health. Richard Cowell then shared his thinking on materials, and announced the launch of the first Sustainable Design Practice Note, SPGN1, on materials, which has been vetted externally and is now available to members on the website. (The second SPGN2 , on personal security, is also now available on the website).

Julie gave a thought-provoking talk that identified the need for closer collaboration between sustainability experts and acousticians, citing overheating in buildings as one example.

A free -flowing discussion session ranged across the hub venue and satellites and settled mainly on how in practice to fit such approaches into price and compliance-driven projects. This tension was explored by all speakers and the way forward was seen to need good clear communication of the wider benefits for good evidence-based acoustic design. Richard then talked about acoustics and the importance of holistic design, and Peter finished the formal presentations by developing the triple bottom line concept further, describing what he thinks should be meant by "acoustic value" (i.e. the value beyond the immediate direct benefits of the acoustics), with numerous case studies and practical examples given from across the fields.

Thanks go to all who assisted in organising this unique event, to the volunteers who contributed to it and those who will continue the task force's work. An open invitation was made by Peter to any member wishing to be involved in the work to embed the ideas within acoustic practice. If you are interested please contact him via linda.canty@ioa.org.uk



Peter Rogers opens the meeting

Delegates tune into a presentation

Institute Council approves further 86 applications for membership

Eighty-six applications for membership were approved by Council at its June meeting following the recommendations of the Membership Committee. Of the total, 64 were new applications, the rest upgrades.

FIOA

Glenn Leembruggen
Jon Richards

MIOA

Daniel Boote
Kevin Brown
Matthew Burdett
Cesar Bustos
Luke Chalmers
Wai Pui Chan
Trevor Cheng
David Clough
Nicholas Dobinson
Fatimah Dzaharudin
Karen German
John Greenough
Philip Hackett
Alex Hancock
Andrew Harrison
Heikki Helimaki
Matthew Hickling
Jonathan Jones
Vincent Jurdic
Eleni Kontesidou
Sarah Large
Lucas Longman
Alba Losada-Amor
Barry Mart
Eugene McKeown
Marek Olik
Claire Parsons
Duncan Powell
Pau Santamaria
Jai Shikotra
Kapil Thirwani
Andrew Vepers
Weigang Wei
Kevin Witty
Michael Wood

AMIOA

Jorge Berenguer
Adrian Carnegie
Radoslaw Ciszewski
Ben Claridge
Christopher Davis
Lee Denson
Kyran Ebanks
Ezekiel Edwards
Rodrigo Espinosa-Garcia
Nathan Green
Nicholas Haigh
Benjamin Hammond
Iain Harper
Matthew Jackson
Andrew Johnston
Chris Jones
Paul Klabou
Michal Kubicki
Felix Larrieu
Kenneth Macleod
Paul McDonald
Doushiant Mohith
David Monk
Edward Morgan
Paul Murphy
Jim Nelligan
Anishaben Patel
Joanathan Pears
Calum Sharp
Gennaro Sica
Andrew Symons
Keith Torrington
Adrien Viney
Josh Wilson
Kuqian Yang

TECH

Amir Awadalla
Suresh Babariya
Christian Dolphin
Nicholas Jackson-Callen
Duncan Rogers
Nicholass Rowswell
Gavin Smith
Richard Twist

Affiliate

Robert Campbell
Daniel Cranfield
Ed Howe
Samantha Liu
Thomas Poli
Colin Wright

BS 4142:2014 workshop

By Tony Higgins

The BS 4142:2014 workshop, organised by the Institute's Measurement and Instrumentation Group, was intended to address the practicalities of measurement and reporting to the new standard, as well as setting the scene for how and when to use the standard. This drew a mixed group of attendees from both consultancy and local authorities. There was a significant amount of interaction between presenters and delegates which helped enhance the day and was exactly as intended.

Richard Tyler (AVI) opened the meeting with a short introduction highlighting the history of the standard and its place in helping determine impact, and his hope is that this new incarnation will continue to play a valuable role in helping demonstrate acoustic impacts.

Tony Higgins (Enviroconsult) provided an overview of the new standard with some commentary on how to implement it in practice. Of particular interest was the revised scope of the standard, which clarified its intended use, extending it beyond that of the former edition. Tony also highlighted the "new" content, uncertainty and competence, and specifically dealt with the issue of demonstration of competence. In his view, competence needed to comprise two elements: knowledge and experience. The interpretative nature of the new standard, where context was now a more important factor, necessitated a good grounding in acoustics, as well as direct experience of the practicalities of measurement in order to avoid inconsistency and potential errors. Some examples were provided to illustrate the points, and a "straw poll" of opinion amongst delegates was inconclusive as to whether a formal endorsement or certificate of competence was needed, but it was acknowledged that it might help… Tony's key message was that acoustic consultants liaising with their regulators to agree methodologies and reporting styles would help reduce potential tension, particularly where acoustic correction factors needed to be applied.

Stephen Turner (ST Acoustics) reviewed the policy position as to when BS 4142 should and could be used. He reviewed the historic development of the standard in order to show how it had evolved over time to reflect the needs of society. In particular, he identified that there was no absolute requirement to use BS 4142 to help determine impact save for activities operating under the Environmental Permitting regime where the guidance appeared to make it a requirement. This contrasted with planning and statutory nuisance where its use remained optional. He reviewed the current high level policy including the National Planning Policy Framework 2012, the National Planning Practice Guidance 2014 and the Noise Policy Statement for England 2010 and he helpfully outlined the differences in policy between England and the devolved administrations. He also raised a note of caution about interpretation of the standard, in particular over the use of the word "context" within the standard, which seemed to have different meanings depending on the "context" in which it was used. Stephen highlighted a number of different meanings, including context of assessment, context of diurnal patterns and context of measurement period, all of which might require subtly different interpretations by the acoustician in order to provide the required information for an assessment. In particular, he noted that the use of context within BS 4142 may not be the same as that in NPSE. He concluded that, even though the standard was not specified absolutely, there were clear links to it within policy but that environmental health practitioners were not bound to use it. Additionally he noted that other impact assessment techniques might be more applicable in some circumstances.

Stephen Turner presents policy and planning context

Mark Dowie (Brüel & Kjær) picked up on the themes of when and how to use the standard by providing an insight into the implementation of an assessment in line with BS 4142:2014. Mark emphasised the need for planning measurements to ensure they met the requirements of the end recipient was of paramount importance and he went on to cover the practicalities of measurements as well as analysis of the data obtained. There was significant discussion around the use of proxy locations and measurement of ambient and background data and assigning particular levels for subsequent assessment, including when to use modal, mean or median background measurements. The consensus of opinion was that the most representative value needed to be used (in context) and evidenced within the report. Preferably values should be agreed between consultant and regulator wherever possible. There was also significant discussion in relation to the need for and use of weather data and preparation of final reports, and their content. The consensus view was that ticking all the BS 4142 boxes was preferable, however if acousticians needed to deviate from the standard they should evidence the reason within their reports.

Having covered the practicalities of measurement, the issue of correction factors and carrying out the assessments were dealt by Jon Tofts (Environment Agency). It quickly became apparent that one of the key issues faced by delegates was that perception of sound and when to correct for acoustic characteristics was open to a range of interpretations. Jon's pragmatic advice was that for tones, apply a +6dB penalty to any sound with obvious tones that passes the 1/3rd octave analysis, and where it does not apply a lesser value depending on "degree of failure" or for a tone that was not always present . For impulses Jon recommended analysis of sound within 30 minute blocks, and reference method evaluation of only the most notable impulses during that period, with the remainder of the impulses being assessed comparatively to that. He issued a note of caution from his experience, where short duration clicks could generate huge impulse corrections where sometimes large crashes produce far lower correction results. Jon emphasised the need to apply context to the measurements, and that increasing the number of objective assessments could help minimise the uncertainty of the assessment if the penalties could alter the assessment outcome.

The final speaker of the morning dealt with the "elephant in the room". Alluded to throughout the day, the spectre of uncertainty was explained by Richard Collman (Acoustic Control Engineers and Consultants). Richard provided an amusing and practical approach to dealing with uncertainty as envisaged by the BS 4142 drafting committee. Richard's view was that uncertainty needed to be understood from basic acoustic principles, in order that it could be minimised during measurement or evaluation. Some uncertainty was unavoidable and would therefore need to be evaluated (either quantified or qualified) though calculation, estimation or guess! The key issue was that uncertainty needed to be placed in context so that the effects on the data or the end result of the assessment could be better understood. He reminded delegates of some of the obvious (and not so obvious) uncertainties – weather, temperature inversions, locations for monitoring, reflections,

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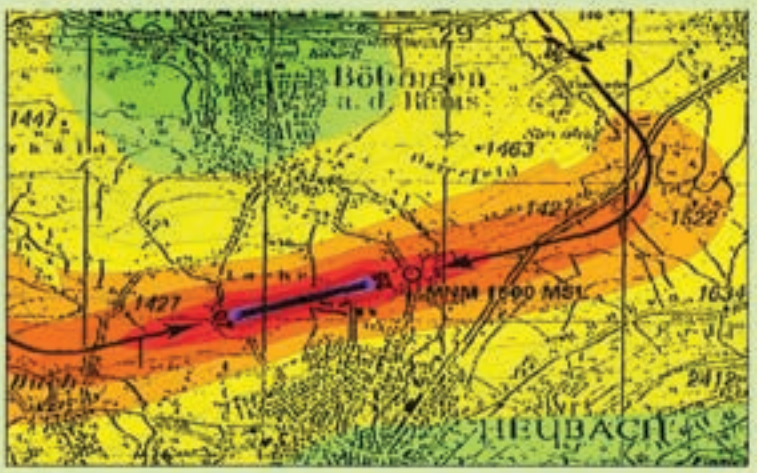

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A light-hearted moment in Mark Dowie's talk

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standing waves, interference patterns, the interaction between specific and ambient sounds in the environment. In particular uncertainties in relation to weather and wind were considered at length and provoked several discussions but the need for robust data to help describe the measurement environment was emphasised. Richard also raised the issue of the use of models to predict sound levels. The accuracy of models was also discussed and some of the potential problems with verification and validation of models highlighted.

After lunch Graham Parry of ACCON UK and Ian Matthews of Red Twin presented case studies.

Graham's example looked at a proposed housing development next to an existing industrial site, focusing on the difference in assessment between the council and the appellant. The case showed a significant variation in result despite both parties agreeing on the acoustic feature corrections and the LA90 level.

Ian's case came from a complaint about an industrial cooling fan with a particular set of acoustics features. The difference between the assessment under the new BS 4142 when compared with the 1997 version was 7dB due to the source incurring both tonal and impulsive corrections. Ian also explained how they were able to reduce the fan noise to an acceptable level.

The final session of the day was a practical one prepared by Mark Dowie and Tony Higgins who presented some acoustic measurements for a small factory unit. Delegates were provided with a scenario where the factory wished to extend operating hours from 6pm to 10pm. Data provided showed hourly LAEQ residual and background data and some typical data for when the site was in operation (ambient). The delegates were asked to work in groups to evaluate the proposal and make recommendations. The case study was well received, and highlighted a number of key areas of concern around determination of background levels, calculating specific levels from ambient, and application of correction factors.

A high point of the day (particularly for one delegate) was the presentation of IOA Best Diploma Student of the Year to Jenefer Taylor (London Borough of Tower Hamlets). Jenefer produced exceptional results both in her examinations and submitted work. Well done Jenefer!

Once again, many thanks are owed to Linda and the team at IOA HQ for all their hard work behind the scenes to facilitate such an enjoyable and stimulating professional meeting particularly as this is the second one in six days!

Noise impact assessment and development constraints

By Colin Grimwood

Around 80 delegates attended an interesting one-day Institute meeting on noise impact assessment held at Austin Court in the heart of the Birmingham canal area. With more miles of canal than Venice and the weather to match (at least on the day) it was a testament to the meeting organiser, Graham Parry (ACCON UK), and to all the presenters and delegates that the meeting room remained full and the questions continued to flow until the close of the proceedings. The topical subject matter attracted a mix of delegates including consultants, local authority officers and even a couple of planning inspectors.

Graham Parry opened the proceedings by welcoming delegates and mentioning some of the policy and guidance documents that are relevant to the consideration of noise in the development control process – not the least of which is the fairly recently published IEMA document *Guidelines for Environmental Noise Impact Assessment* (available from http://www.iema.net/noise) that he had personally helped steer to fruition. Graham also tantalisingly mentioned the work that is currently under way by a joint IOA/ANC/CIEH/RTPI working party to produce Professional Practice Guidance on planning and noise for new residential development.

The opening speaker, Tony Higgins (then Ricardo-AEA now Enviroconsult), continued to set the scene with a comprehensive overview of the current suite of Government guidance and supporting documents. He stated that in his view it was possible to continue with traditional approaches to planning and noise that are designed to protect amenity, and he emphasised that SOAEL should not be allowed to become a design target as the planning system should not operate at the borderline of potential significant adverse effects. He considered that the current system encouraged a "pick 'n' mix" approach to available guidance that risked inconsistent interpretation and decisions. Tony reminded delegates that planning policies and decisions must reflect EU obligations and that this could become relevant if the Environmental Noise Directive was revised to include noise level targets. Questions tackled whether paragraph 123 of the NPPF was working properly particularly with regard to new residential developments being built close to existing industry. Discussion highlighted noise problems being caused by changes of use from B2 to offices and from offices to residential without the need for planning consent. It was agreed that local authorities need to have SPDs that interpret paragraph 123 and set out their local planning and noise policies.

The discussion led nicely into the second presentation from Dani Fiumicelli (Temple Group) on *Acoustic design of sustainable noise sensitive development near existing industrial and commercial sources of noise*. His talk was about the need to balance the needs and rights of residents and industry within the wider legislative and policy context. Dani drew attention to the change to the Planning

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Presentation time

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Practice Guidance on the effect of a new residential development on an existing business that was issued last Christmas Eve and includes the advice that "appropriate mitigation should be considered, including optimising the sound insulation provided by the new (*residential*) development's building envelope". Dani's view was that this did not mean that we have to acoustically seal up every new residential building but that sound insulation should be considered as part of a wider process of good acoustic design. Referring back to the previous presentation, Dani commented that since there were no references to standards or guidance in the national planning policies and guidance it meant that there was "more to discuss, more to debate, more fee"! Dani is not a supporter of using sealed up windows in new residential developments and in his opinion nuisance complaints should not be upheld where a property has been properly designed to give reasonable acoustic and thermal conditions with windows shut – his view is that in such circumstances it would be ordinary reasonable use to shut the windows and use the alternative ventilation that had been provided.

The next speaker was Pam Lowery (HS2 Ltd) who spoke on *Controlling noise and vibration from high speed rail*. Her perspective was slightly different to the previous speakers and she spoke of how the current noise policy framework (including NPSE and NPPF) had helped HS2 to better structure the consideration of noise issues. Indeed it seems that national policy on noise has also been useful in helping to structure the wider HS2 sustainability policy. Pam spoke generally about how HS2 Ltd is seeking to control noise, including by use of best practice at source, and in particular about how HS2 Ltd has developed specific daytime and night-time values for LOAEL and SOAEL for airborne noise during operation, and for airborne noise during the construction phase, as well as for groundborne noise and vibration during the construction and operational phases. Further information is available in the published EIA and in a series of Information Papers (https://www.gov.uk/government/publications/hs2-information-papers-environment). Pam stated that approximately 70 properties had been identified that were expected to exceed the SOAEL for airborne noise during operation of HS2 and she was questioned by members of the audience on the uncertainty surrounding this estimate and whether or not there would be any noise monitoring to confirm compliance.

The next presentation was from Nick Tinsdeall (Birmingham City Council) on *The development of local guidance to reflect the aims of the NPSE and other noise and planning guidance*. He described how Birmingham had developed internal BCC guidance on planning and noise (currently undergoing further revision) that aligns with national policies in order to help environmental protection officers make consistent recommendations to the planning management service. The document includes noise level targets. Although the guidance is classed as an internal document, it is also shared with planning applicants. This approach allows Nick and his colleagues to adapt and revise the local planning and noise guidance without need for formal consultation. Nick described a number of challenges facing his team which included deciding on an appropriate external noise limit for new residential development ("can it be too loud even if OK inside?"), how to treat new residential near existing entertainment premises and how to treat new entertainment premises. He bravely suggested to a room full of consultants that the quality of many acoustic consultant reports left much to be desired and gave examples of reports without maps/plans, reports that did not specify measurement locations or times, and reports that did not contain any data to support the opinions given. The subsequent discussion served to emphasise the limited resources available in local authorities (LAs) to deal with the expected increase in residential development proposals in noisy locations and led to several requests for a copy of the BCC guidance. Nick feels that it is important to note that although this guidance seems to be working in Birmingham it may not be suitable for other locations.

After lunch the chair passed to Richard Perkins (WSP|Parsons Brinckerhoff) for the afternoon session. Delegates were able to recover from their lunch time excesses by listening to Stephen


Pam Lowery

Turner (ST Acoustics) discuss *Why is considering a range of factors so important in a noise assessment*. Stephen began by congratulating Graham Parry on securing the publication of the IEMA Guidelines which Stephen described as "a very worthwhile contribution to the profession". Stephen's presentation highlighted the many factors that have to be taken into account in a noise assessment, expanding upon the advice given in chapter seven of the IEMA document using a number of examples that illustrated the complexity of the subject. "You cannot shove a few numbers into a box, press a button and get the answer – it's not that simple". "If the limit is 65dB, and your assessment comes in at 66dB are you going to force a developer to spend money over a 1dB difference that a resident will probably not perceive anyway?"

The next speaker was Ian Holmes (Highways England) on *Aligning DMRB with Government Noise Policy Objectives*. Highways England formally took over the roles and responsibilities of the Highways Agency on 1 April 2015. It was interesting to observe that, not unlike Pam in the morning session, Ian and Highways England seemed comfortable working within the framework provided by current government noise policy which facilitates a structured and prioritised approach to noise issues. Ian referred delegates to the Roads Investment Strategy (https://www.gov.uk/government/collections/road-investment-strategy) for more information on ambitious plans to tackle the important areas highlighted by the END Noise Action Plans. There is currently designated funding set aside under the RIS for delivering noise management schemes. Ian also spoke about work in progress to update DMRB HD213/11 including a need to reflect government noise policy not just to avoid and mitigate noise but to deliver improvements where possible. Ian spoke of minor tweaks rather than a need for wholesale changes. Current thinking is that example LOAEL and SOAEL threshold values may be provided for residential receptors and that assessors will be given flexibility to set appropriate thresholds for non-residential receptors depending on local circumstances.

The final presentation was by Ed Clarke (Clarke Saunders Associates) on *Designing for good acoustic conditions whilst accepting the need for natural ventilation*. Ed made the case for compromise ("an intermediate state between conflicting alternatives reached by mutual concession"). He suggested that acousticians and regulators should be prepared to allow tolerance/dispensation on acoustic standards for naturally ventilated dwellings and offices because of the wider benefits that will occur. Such an approach is already beginning to emerge in Australia but is not at all common in the UK. Ed stressed that it was necessary to carefully specify ventilation requirements in new residential developments in noisy locations and referred to the two articles by Jack Harvie-Clark and Mark Siddall in *Acoustics Bulletin* (Nov/Dec 2013 and Jan/Feb 2014). Ed spoke of the need for guidance on how to balance acoustic and thermal comfort mentioning that a change of 1 degree Celsius may be equivalent to a change of 4 – 7 dB in terms of occupant comfort and appealed for more research on the topic.

The development of the ETSU-R-97 Good Practice Guide

Irish Branch meeting

By Martin Lester

In recognition for the time and effort that Dr Gerry McCullagh put into the promotion and education of acoustics throughout Northern Ireland and the Republic of Ireland, the Irish Branch of the Institute holds an annual lecture where an industry expert is invited to present a talk on their area of expertise.

The 2014 lecture, the tenth, titled *The development of the ETSU-R-97 Good Practice Guide* (GPG) was presented by Richard Perkins from WSP Parsons Brinckerhoff, lead author and editor of the guide. The branch was also delighted to welcome Gerry's mother Jean (now into her 100th year) and his widow Rita to the lecture.

Richard started with a history lesson as to how the GPG came about as a result of the evolution of interpretation of ETSU-R-97 through public inquiries and appeals. The often controversial ETSU-R-97 limits were specifically excluded from the GPG's terms of reference as these were deemed to be a political decision.

A good range of consultation responses were received from the renewables industry, acoustics consultancies, local government and objectors. Some of these consultation responses were extensive, but all were categorised and fully considered.

Richard provided an overview of each section of the GPG. Without wishing to replicate previous Bulletin articles, Richard made a number of pertinent comments:

- For the majority of sites, there are limited differences between summer and winter background noise levels, but each site needs to be considered on its merit. Richard gave the example of water courses that may run higher and quicker in winter than summer.
- The reliance on SODAR and LIDAR has become more prolific and lenders will now fund on such data.
- The wind speed measurement methods are a hierarchy, with hub height measurement being the most robust.
- Noise limits based on Quiet Waking Hours apply for across the whole of the daytime period
- Night-time noise limits can be set lower than 43 dB LA90, if local development plans permit.
- Cumulative issues are constantly evolving and becoming more prominent, with additional guidance likely come the next review.
- The IOA is likely to consult on the amplitude modulation methodologies within the next couple of months.

Attendees asked a number of pertinent questions based on local issues that had arisen:

- Is it OK for turbines to be curtailed during the day to comply with the tighter daytime limits, only for that curtailment to be removed at night, (i.e. wind farms get louder at night)? At the time ETSU-R-97 was drafted, curtailment technology was not available and hence the authors did not envisage the limits being used in this way i.e. the tighter of the daytime or night-time limits was the limit applied.
- As the IOA GPG had not been out that long, what post completion measurements have been taken to verify the prediction methodology? Richard advised that all post-completion testing that he was aware of demonstrated that the propagation model was robust but that sound power level data can differ to that stated within manufacturer's data.
- There can be confusion with respect to what is meant by "financial involvement" The occupier of the dwelling is required to be financially involved i.e. the owner if he or she is the occupier or the tenant if he or she do now own the property.
- It has been the experience that the rain in water courses as opposed to the action of the rain itself is more relevant to background noise level measurements. Richard agreed that the action of the rain itself is normally less important than its consequences e.g. swollen rivers, wet roads etc.

Left to right: Rita McCullagh, Joan McCullagh and Richard Perkins

The GPG has been endorsed by all Environment Ministers as being "good practice" but only in Northern Ireland was comment provided on flexibility with attaching the example planning condition. Comments from the floor noted that local NI planning department, further to pressures from Environmental Health, now applies similar noise conditions.

Long-term noise monitoring issues and potential solutions

Central Branch report

By Richard Collman

Central Branch made a late start to its 2015 meetings programme in May with an informative presentation by Craig Storey of Cirrus Research on the challenges presented by long-term sound level monitoring.

When applied properly technology can overcome many of the problems, but care must be taken to ensure that appropriate instrumentation is selected and that it is properly used, he told members. However, this still leaves challenges such as ensuring the equipment is still (likely to be) there when you return (or possibly that it has a tracker so you can see where it has disappeared to), that it is reasonably safe from vandalism, or being blown up by the police if they are concerned about a suspicious locked box that has been chained somewhere fairly unobtrusive.

Even with the ability to remotely access, control and download data, a few of the other difficulties include power supplies, access for calibration, and ensuring that the presence of the monitoring equipment does not significantly alter what is being monitored e.g. noise producers noticing the equipment and changing their behaviour.

Craig's talk generated a good discussion which was continued at a nearby Indian restaurant, as is customary for Central Branch meetings, and where it was agreed that he had definitely earned his dinner. Thanks also go to NHBC for hosting yet another Central Branch meeting.

Noise Policy Statement for England: five years on

Southern Branch report

By Reena Mahtani

Stephen Turner, former Head of Noise & Nuisance Technical & Evidence team at Defra, offered branch members a review of the first five years of the Noise Policy Statement for England (NPSE) and its integration with the National Planning Policy Framework (NPPF) of 2012. Stephen has recently returned to consultancy with a new venture, ST Acoustics, following the completion of his contract at Defra.

For most members the NPSE implied the start of an era without the clear guidelines and numbers contained in PPG24. However Stephen's presentation went further into the implications of the NPPF/NPSE and how these have been and will be integrated into other national policies.

Its origin and history was discussed. It was a lengthy process to get where we are now, and some examples of real life application by consultants and local authorities were also included to show the different approaches and flexibility that the current planning framework allows.

Some very interesting questions were posed and as ever the debate continued in a nearby pub after the presentation.

This event took place at Basingstoke & Deane's civic offices as part of the continued effort of making the events in the southern area closer to members. The presentation was not broadcast this time but it should soon be available in the branch's *YouTube* channel. If you would like to keep up to date with our activities, forthcoming events are posted under latest events on the website. If you are not already a member, you can join by logging into the members' section.

Instrumentation Corner

BS 4142:2014 – measurement planning and practice

By Mark Dowie MIOA, Environmental Applications Specialist at Brüel & Kjær

This article is based on a presentation at the Measurement & Instrumentation Group's BS4142 workshop on 19 May. It is a guide to planning and making a measurement for BS 4142:2014 with suggestions on how to report and support your assessment. This article is split into two parts, the second of which will appear in the next issue.

Planning your measurement

An individual's response to sound is subjective and the level of impact depends a number of factors including:

Absolute level, exceedance over background level, time of day, character of sound, local attitude to the premises and nature of the neighbourhood.

BS 4142:1997 was mainly concerned with the exceedance over background sound and the character of the sound. BS 4142:2014 will use similar data for the calculation but requires the consideration of context at all stages of the assessment and therefore all of the above factors must be noted.

In order to perform the rating calculation two sets of Ambient Sound Level data are required. One when the specific sound is present; this could be measured or modelled. The other is when the specific sound is absent; this will give the residual and background levels.

This data should be acquired at least in the reference periods of 15 minutes at night (11pm to 7am) and one hour during the day. You may need several of these measurement periods in order to show that your chosen period is the most relevant for your assessment. More variability in sound level and weather conditions will cause greater uncertainty and require longer measurement periods. A steady level will have less uncertainty and therefore a shorter measurement period may be sufficient.

Before making any measurements consider what you need to measure and why. In order to measure the ambient noise with the specific sound present you should understand how much variation there is from the sound source. It may be possible to discuss the process schedule with the plant operator to determine how much variation there will be. If you cannot determine the level of variation in the source you will need to measure for a longer period to demonstrate that the reference period used for the assessment is the most appropriate. On occasions it might be necessary to measure for a whole week or at different times throughout the year.

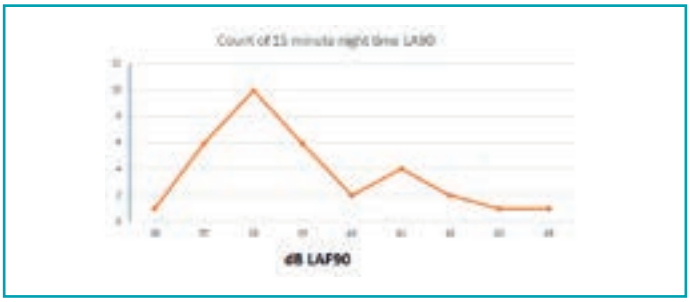
When measuring the residual sound level you should pick a period that is as similar as possible to when the site is operating. This could, for example, be lunch time, just before the morning shift or after the site has closed for the day. This residual period (Lr) will allow you to

correct your ambient level with the site sound present (La) to give you the Specific Sound level LAeq (Ls). Use the following formula:

Ls = 10lg[(10^La/10) – (10^Lr/10)]

This removes the contribution of the residual from the ambient to leave a specific level that can be used for the rest of your calculations.

Background LA90 levels could be acquired at the same time as the residual but in some cases this will not be the most suitable period. You should consider when the complaint is occurring or when proposed change would have most impact. On occasions you will need to measure LA90 periods throughout the day and/or night. With this data it is possible to show the distribution of different LA90 levels and decide which level to use.



The graph above shows that an LA90 of 38dB would be the most reasonable level to use. It is also advisable to note what contributes to the background sound. Transport, foliage, water and dawn chorus can all cause significant variation in the residual acoustic environment.

In some situations it may not be possible to measure in the absence of the specific sound. In this case a proxy measurement location should be found. You should explain why the proxy location is suitable, taking note of the distance from any main roads or significant sound sources.

Measurements should ideally be taken in the nearest residential garden, outside dwellings or on the site of the proposed dwellings. Note the distance to site from the measurement location and take photos. Measure long enough to show that your chosen calculation period is the most suitable; this could be a few hours on one day or multiple periods on several different days. Have an understanding of the typical local weather and try to perform measurements in representative conditions. Avoid periods with heavy rainfall and wind speeds above 5m/s unless you can justify that this is typical weather for the location.

What data do we need?

The essential parameters are LAeq and LA90. The obvious logging period is 15 minutes for night time and one hour during the day but if you can also log LAeq and statistics every second. This could allow exclusion of erroneous data and recalculation to reference periods, depending on your post processing software.

You will be measuring outside so use a wind-shield and turn on the correction in the meter if available.

In addition to this the following will be of use:

- Log fast LAF data for impulsivity - 10, 25, 50, 100 or 125ms - use fastest available (10 & 25ms can be used for the objective method. 50, 100 and 125ms will support your subjective assessment)
- LZeq 1/3 octaves for objective tonal assessment
- Record wind speed and direction, temperature, humidity, rainfall & pressure – synchronise with noise data if possible
- Use audio recording – uncompressed recordings such as wave files could be used for post analysis of tonal characteristics to the reference method. Audio files can also be used to back up your subjective opinion about the character of the noise
- Check you have sufficient space on your meter's memory, one hour of wave file recording (up to 20KHz) with one second logging of the above parameters will be about 340MB.

The second part of this article will look at performing a measurement, what to report and the use of checklists.

New offshore oil surveying method will protect marine environment

A new method to pinpoint offshore oil fields cuts the need for unnecessary drilling and the associated impact to the marine environment.

Developed by Professor Jacques Guigné and Professor Nicolas Pace at the University of Bath, Acoustic Zoom is a novel seismic exploration technique adapted from sonar applications.

The principle differs from that of conventional seismic survey which analyzes the reflecting sound energy returned from the seafloor.

Instead, Acoustic Zoom uses a 16-spoke array set on the ocean floor to measure how the energy is scattered. The array transmissions transfer energy as small calculated bursts released slowly over time.

As the system is stationary, energy is directed in a localized manner at the seabed and not the water column, therefore marine mammals and their habitats are typically not disturbed.

The introduction of Acoustic Zoom addresses the need for producing high resolution images of the geology by fully exploiting the use of acoustics in a manner similar to a radio telescope. A principle first used to search galaxies in the mid1950s and still used today.

"Acoustic Zoom is an 'earth telescope,' a stationary lens from which propagating sounds can be manipulated and made to be directed to 'zoom' into a field with unprecedented imaging qualities, capturing the way the sound energy gets redistributed – attenuated, reflected and scattered – all three forming the final but detailed image of the geology," said Professor Guigné.


Less drilling may be needed to find offshore oil fields

"It also allows a controlled low dose acoustic footprint, gentler on the surrounding environment, limiting the disturbances to fragile marine life. If anything, sea life of all forms has been seen to swim around the system out of curiosity, not out of alarm."

Two ears attuned to high frequencies help us find objects using echoes

The ability that some people have to use echoes to determine the position of an otherwise silent object, in a similar way to bats and dolphins, requires good high-pitch hearing in both ears, according to new research from the University of Southampton.

The study, published in *Hearing Research*, found that locating an object by listening to echoes, without moving the head, requires good hearing at high frequencies and in both ears. This builds on research published in 2013 by the team at the University's Institute of Sound and Vibration Research (ISVR) that demonstrated conclusively that some sighted and blind people could use echoes in this way. What was not clear until now was how important high-frequency hearing in both ears is.

Dr Daniel Rowan, lead author of the study, said: "We know that hearing echoes is very important in daily life for some blind people. Hearing loss, such as associated with getting older, usually reduces hearing at high frequencies in both ears. Some people can develop deafness in one ear. We wanted to get some insight into how much those particular forms of hearing loss might affect users of echoes to locate objects: our results suggest they would struggle."

The researchers conducted a series of experiments with both sighted and blind people. In their most recent experiment, sighted people were asked if an object (in this case a flat MDF board) was to the left or right of them. The experiment used a 'virtual auditory space' technique originally created in ISVR's anechoic chamber, one of the quietest places on Earth, but reproduced for the participants over special earphones. This method allowed the researchers to remove audio and non-audio clues to the location of the object that are unrelated to echoes, such as the sounds and air movement associated with positioning the object.

Sounds were manipulated in various ways, simulating high-frequency hearing loss and single-sided deafness, as well as to check carefully that people were not finding cunning ways to use the echoes with one ear. People could locate the object accurately but only if they had good high-frequency hearing and in both ears.

Dr Rowan added: "Hearing aid services tend to focus on how well a person can hear speech. Our research indicates that those services also need to take into account whether someone needs to hear echoes in their daily life. For example, they might need hearing aids in both ears, despite the emerging trend in some parts of the country to only fit one."

This work is currently being extended to detecting objects and using head movement to improve the localisation of objects. Initial results suggest a similar conclusion. A web-app will be launched later in the year for the public to try out the team's experiments themselves and see if they can 'make like a bat' too.


A reproduction of the experiment conducted in the ISVR's anechoic chamber

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New membrane will reduce aircraft cabin noise


Passengers may be able to enjoy quieter flights

Researchers at North Carolina State University and Massachusetts Institute of Technology in the US have partnered to develop a lightweight membrane for aircraft, which can reduce low-frequency noise that enters the cabin.

Made of 0.25mm thick rubber, the membrane can be used with honeycomb-like materials that form aircraft wings and floor and ceiling of cabins.

The membrane, which covers one side of the honeycomb structure, blocks the sound waves from passing through it and bounces them back.

North Carolina State University mechanical and aerospace engineering assistant professor and senior author of project Yun Jing said: "It's particularly effective against low-frequency noise.

"At low frequencies, sounds below 500Hz, the honeycomb panel with the membrane blocks 100 to 1,000 times more sound energy than the panel without a membrane."

Usually, the honeycomb structures do not block low-frequency noise such as noise of an aircraft engine. Using insulation materials to limit the noise will increase the weight of the aircraft.

The new material adds approximately 6% to the overall weight of the honeycomb panel, researchers said.

Lead author of the paper Ni Sui said: "The membrane is relatively inexpensive to produce, and can be made of any material that does not impact the structural integrity of the honeycomb panel.

"It could make flying much more pleasant for passengers, particularly in helicopters."

Soundscapes offer clues about coral reef community

Eavesdropping on coral reefs reveals patterns in soundscapes that are linked to the reef's physical and biological characteristics, according to new research from the University of Bristol.

Sophie Nedelec and colleagues studied sounds from coral reefs in the Gambier Archipelago, French Polynesia.

They made recordings of ambient noises at 42 reef sites at three different times of day, and compared these with habitat and fish community surveys taken at the same time.

They found that physical characteristics were related to overall sound pressure levels. Reefs were louder when coral cover (including both live and dead coral) was higher, sea state was higher, depth was greater and the bottom was covered by more Porites coral, branched coral and massive coral.

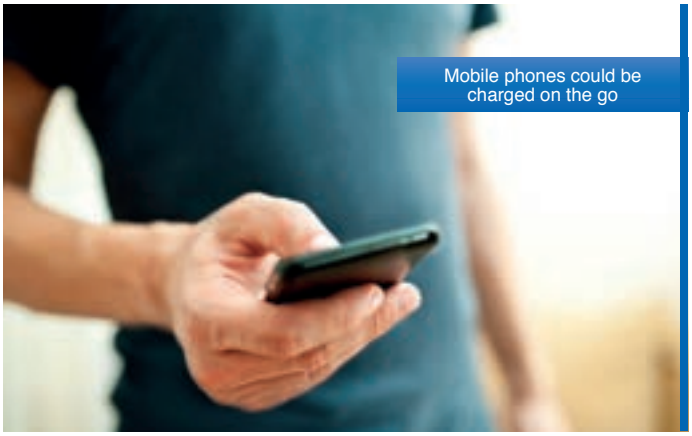
Biological characteristics were more closely related to the number of snaps from snapping shrimp and sound pressure levels at frequencies above 0.63 kHz. These were negatively related to live coral cover and the density and diversity of adult and juvenile fish, but positively related to dead coral cover.

Other than snapping shrimp, sounds recorded included fish vocalisations (produced at low frequencies, around 0.2 kHz), wind and wave noises.

"These results highlight how passive acoustic monitoring could give clues about how habitats under the water might be changing over time," Sophie Nedelec said.


Sound from coral reefs may provide vital data

Paper microphone may help charge your mobile phone


Mobile phones could be charged on the go

Researchers in the US have developed a postage stamp-sized microphone that can harvest acoustic energy to help charge your mobile phone on the go.

Zhong Wang of the Georgia Institute of Technology in Atlanta and his colleagues created their microphone from a thin sheet of paper just a few centimetres across.

They used a laser to zap a grid of microscopic holes in the paper, then coated one side in copper and laid it on top of a thin sheet of Teflon, joining the two sheets at one edge.

Sound waves vibrate the two sheets in different ways, causing them to come in and out of contact. This generates an electric charge, similar to the one made when your rub a balloon on your hair, which can charge a phone slowly.

The paper microphone could also be used as a way to recycle sound energy from the environment, getting free electricity from the "waste" sounds all around us. The charge can also be converted into a range of sound frequencies, allowing the initial sounds to be amplified.

The amount of power the microphone provides depends on its size, but it is around 121 milliwatts per square metre.

"It can be made into any size you like," said Mr Wang, though he admitted a stamp-sized microphone fitted to your phone would only provide a small amount of power rather than fully charging your phone.

Breakthrough in tinnitus research could lead to testable model

By Bert Gambini

A global research effort has made a major breakthrough that provides new insights into how tinnitus, and the often co-occurring hyperacusis might develop and be sustained.

The results of the study, published in *eLife*, suggest the neural network responsible is more expansive than previously thought. The findings could lead to a testable model that helps to identify what region or regions of the brain might be responsible for causing the two conditions.

Having conceptualized a broader, more comprehensive neural network, the researchers hope to eventually test the model by deactivating specific segments of the neural network. By process of elimination they would learn if shutting down one part of that network relieves tinnitus, hyperacusis or both conditions.

Until the mid-1990s, tinnitus was thought to be centred in the ear, but patients who lost their hearing on one side after a surgical tumour removal unrelated to the condition reported still hearing a ringing – in their deaf ear.

"This changed the thinking in the field," said Professor Richard Salvi, director of Center for Hearing and Deafness at the University of Buffalo in the US, and one of the study's authors. "Having severed the neural connection between the ear and the brain, it's impossible for the phantom sound to be generated in the ear. It has to be generated in the brain."

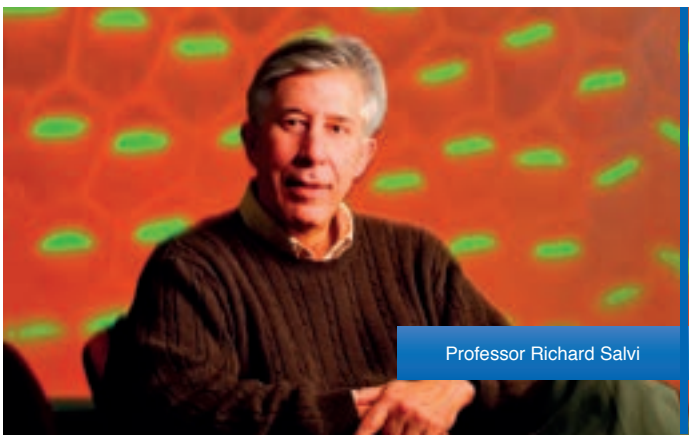
Though it is not known yet exactly where and how tinnitus occurs in the brain, Professor Salvi said their functional MRI studies show the abnormal activity underlying tinnitus and hyperacusis was not confined to a specific brain location, but actually involves a neural network.

Unlike traditional MRIs, which show only structure, functional MRIs show what parts of the structure are active at a given time while functional connectivity MRI reveals how one part of the brain interacts with other regions, much like partners would interact on a dance floor, explained Yu-Chen Chen, a radiologist at Southeast University in Nanjing, China and one of the study's co-authors.

The researchers, who also included a team from Dalhousie University in Nova Scotia, Canada, induced tinnitus in rats by administering the active ingredient in aspirin, which has long been known to produce tinnitus and hyperacusis symptoms in humans.

"Certain brain regions become very active once tinnitus is induced, much more so than it is for an animal with normal hearing," said Professor Salvi. "Even though high-dose aspirin induces a hearing loss and less information is being sent from the ear to the brain as a result, the brain responds with greater activity. It's paradoxical, like a car getting better gas mileage with a less efficient engine."

Tracing the network's course, the investigators identified a major hub within the central auditory pathway, the sound processing centre of the brain. "Other research has shown this activity, but what is novel about the current study is the amygdala pops up. This is the part of the brain that assigns emotion to our perceptions," said Professor Salvi. "Many patients report the onset of tinnitus after experiencing significant stress or anxiety. We think it's not just the hearing loss that's essential. There are other emotional factors working together with the auditory factors."


Professor Richard Salvi

New ultrasound tool set to improve injury treatment

A new tool developed at the National Physical Laboratory (NPL) could help improve the quality of ultrasound treatment for soft tissue injuries such as muscle strains and ligament damage.

Ultrasound is used in physiotherapy to accelerate healing of tissue injuries. Ideally, the sound waves should be applied uniformly to the treatment site, but it is well known that this does not happen in practice. This can affect quality of treatment and even cause damage.

NPL has developed a way to quickly map the intensity and distribution of ultrasound, allowing treatment heads to be used to administer the treatment more effectively. It will alert physiotherapists to sharp "hot-spots", allowing them to move the head to smooth the intensity or reject it where it could cause more harm than good. It also has potential for manufacturers, who could quickly test the effect that changes in design have on the intensity distribution.

During treatment, piezoelectric-based treatment heads convert electrical energy to mechanical energy, creating the vibrations needed to produce the ultrasound waves. These are transmitted into the target tissue with the aid of a thin layer of coupling gel.

The treatment heads actually vibrate in a complex pattern, in part due to the fact that they are highly resonant devices. This leads to variations in acoustic pressure and acoustic intensity over the area being treated, resulting in 'hot-spots', which can cause excessive heating and even damage to the tissue. Without carrying out the complex and time-consuming process of mapping the acoustic field, it is very difficult to tell exactly where the acoustic energy is going.

NPL scientists have come up with a solution to this problem by developing a simple tool to help visualise the distribution and intensity of the acoustic energy. The method works by using crystals that are thermochromic, meaning that they lose their colour when heated up above a specific trigger temperature. Importantly, the effect is reversible; the crystals regain their original colour on cooling.

The tool consists of two-layers. The bottom layer is made up of the thermochromic crystals embedded in a polyurethane rubber matrix which absorbs sound. The top layer is colourless and is used to trap the heat within the tile. The tile heat produced by the acoustic energy is quickly and evenly trapped, and the crystals turn white as they reach the trigger temperature. This then produces a pattern on the tile which represents the temperature distribution generated by the treatment head, which in turn relates to the spatial distribution of the acoustic intensity. The pattern can be clearly visible after only 10 seconds of exposure to the ultrasound.

New Finnish study to investigate the effects of wind turbine noise on people

A new two-year research project on sound produced by wind power plants has been launched by Lappeenranta University of Technology (LUT) in Finland.

In the study the formation and dissemination of sound from wind power generators, and people's experiences of it in Finnish climatic conditions, will be modelled and experimented with.

The aim is to identify annoying features of wind power plants form the point of view of people living near them. To help in identification, a real-time feedback system and statistical models are to be used. A special task of LUT's South Karelia Institute will be to study the psychoacoustics of how people experience sound.

"In practice people's experiences with wind power are very difficult to study," said Pertti Kolari of the South Karelia Institute. "In previous research we have asked people to keep a diary, but it has proven to be an impractical way of collecting information. Weather varies and the wind doesn't always blow, and people cannot always be bothered to keep the diary. Research into how people experience sound requires new, easier tools. But people must not be forgotten, and how people experience sound involves much more than logical argumentation."

In the new study, LUT's research on sound from wind power will be continued, with the aim of ascertaining more deeply what kinds of characteristics and conditions people find annoying in the sound of wind power.

"In practice we already have descriptive material available to us. Concrete information gathering could be implemented in the future using mobile telephones or iPads, and on that basis we would develop new kinds of equipment and technology for taking measurements. The aim is to conduct long, and short-term sound measurements", said project researcher Sari Janhunen from LUT.

According to Ms Janhunen, objective information is needed on the sound emitted by wind power, and especially on how people experience it and how it affects the acceptability of wind power. Janhunen emphasises that people's experiences cannot always be directly transferred from one culture to another. Finland needs more information with respect to sound coming from wind power plants.

"In Finland, for instance, we are accustomed to silence, or we select a silent area for our living space, which probably affects people's attitudes and experiences concerning sound coming from wind power", said Ms Janhunen.

Study will probe turbine noise effects

British and Chinese engineers team up to invent microscopic 'sonic screwdriver'

A team of engineers has created tiny acoustic vortices and used them to grip and spin microscopic particles suspended in water.

The research by academics from the University of Bristol's Department of Mechanical Engineering and Northwestern Polytechnical University in China, is published in *Physical Review Letters*.

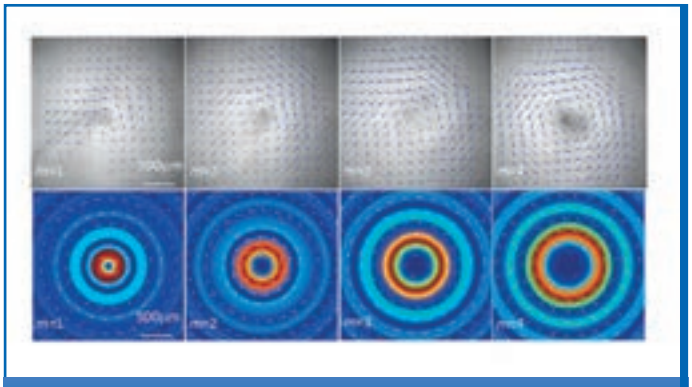
The researchers have shown that acoustic vortices act like tornados of sound, causing microparticles to rotate and drawing them to the vortex core. Like a tornado, what happens to the particles depends strongly on their size.

Bruce Drinkwater, Professor of Ultrasonics in the Department of Mechanical Engineering and one of the authors of the study, said: "We have now shown that these vortices can rotate microparticles, which opens up potential applications such as the creation of microscopic centrifuges for biological cell sorting or small-scale, low-power water purification.

"If the large-scale acoustic vortex devices were thought of as sonic screwdrivers, we have invented the watchmakers' sonic screwdriver."

The research team used a number of tiny ultra-sonic loud-speakers arranged in a circle to create the swirling sound waves. They found that when a mixture of small microparticles (less than 1 micron) and water were introduced they rotated slowly about the vortex core. However, larger microparticles (household flour) were drawn into the core and were seen to spin at high speeds or become stuck in a series of circular rings due to acoustic radiation forces.

Dr ZhenYu Hong, of the Department of Applied Physics at Northwestern Polytechnical University in China, added: "Previously researchers have shown that much larger objects, centimetres in scale, could be rotated with acoustic vortices, proving that they carry rotational momentum."



Microparticles twisting in an acoustic vortex.
Top row shows the experimental observations (0.5 micron particles) and the bottom row the predicted acoustic energy distribution

Electroacoustics – a review of major developments during the past 40 years

By Peter Mapp

The past 40 years have seen huge changes in virtually every aspect of electroacoustics – from measurement to transducer design and application. Forty years ago it would have been completely impossible to predict the now current and everyday electroacoustic technology, this being pre the CD, iPod, ear buds and hand-held real time analyser and STI meter era. Before reviewing some of these major changes in technology, I thought it might be interesting to put the subject of electroacoustics into context by looking back at the subject in the years before the IOA's inception in 1974.

Electroacoustics – pre 1974

The first and probably most influential and momentous electroacoustic invention must be that of the telephone – usually taken to be in 1876 by Bell (ignoring claims by Elisha Gray and previous invention of Reis). The telephone, assisted by Bell Labs, directly led to much of the pioneering work into transducer design, speech intelligibility, and the science of acoustic and audio measurements – subjects still discussed every year at the annual IOA Reproduced Sound (RS) conference. Harvey Fletcher's work at Bell Labs led to the invention of the decibel, equal loudness curves, the anechoic chamber as well as laying down the fundamentals of speech intelligibility. In 1933, Bell Labs were also involved with the capture, transmission and reproduction of stereo sound. (Transmitting a concert given by the orchestra in Philadelphia to New York and then Washington where it was reproduced in three-channel 'stereo').

Rice & Kellogg invented the moving loudspeaker in 1925 in the form that we know it today – though patents for the general concept date back to 1898. Recognisable microphones date back to around 1911, though the invention of the microphone is generally attributed to Hughes in 1878. (Interestingly the term 'microphone' was invented by Wheatstone in 1827 for his acoustic device, now called a stethoscope).

The first telephone-based, electroacoustic research was replaced in the late 1920s and 30s by movie sound requirements, with the first talking picture being released in 1926. Cinema sound research also led to the study of the associated room acoustics and room acoustic and loudspeaker interactions, as well as to the acoustics requirements of recording environments. Wartime audio research was primarily concerned with speech communications and built on and extended the work of Fletcher and Bell Labs, eventually leading to the creation of the Articulation Index, one of the first objective methods of being able to assess the potential intelligibility of a communications channel.

The invention of the transistor and microgroove vinyl LP record in1949 and stereo LP in 1958, together with the invention of the Philips audio cassette in 1963, led to the hi-fi boom of the 1970s and 80s with the first transistor, portable radio coming on the market in 1954. The 1970s saw the 'Quadraphonic Hi-Fi wars' break out with the competing QS and SQ systems mesmerising and confusing the buying public in equal measure. Amibsonics also appeared at around this time but has managed to survive in the background ever since, never realising its full potential. The 1950s and 60s saw a new era of electroacoustic research and development with the invention of the first two-way, line source, column loudspeaker with an 11 ft tall version being used by Parkin and Taylor in St Paul's Cathedral in 1952. Increasing the reverberation time of a space (concert hall) by electronic means was also tried out in the early 1960s with the development by Peter Parkin at BRE of the Assisted Resonance system which was installed in the Royal Festival Hall in 1962 and successfully operated there for more than 30 years. There was no way to predict in 1964, when the electret microphone was invented, that the effect that this device would have on the world, with more than a billion being made every year to fuel the incessant need for mobile phones, hearing aids, computers and other day-to-day electroacoustic devices.

So in 1974, although electroacoustics research had been around for almost a century, the IOA was born at around the start of the next audio and reproduced sound revolution – with digital audio being just around the corner. (The first CD compact disc and player was released just eight years later in 1982 and the first

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1963 Philips Casstette

Transistorised Hearing Aids

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'digital' delay lines in around 1975).The following table charts some of the key electroacoustic events and inventions prior to 1974. The second part of this article looks at a number of electroacoustics topics in turn and charts their progress over the past 40 years. It is completely impossible however to cover all aspects in such a short review.

Early audio history and some key inventions / events	
1827	Wheatstone coins the term microphone
1876	Bell telephone
1878	Hughes contact microphone
1896	Moving coil microphone (Oliver Lodge)
1898	Moving coil loudspeaker Lodge / Siemens
1898	First stereo recording (wax cylinder)
1904	Thermionic valve
1907	Triode valve
1911	Fist commercial moving coil microphone
1915	First valve audio amplifier
1915	First PA system
1916	Condenser microphone
1920s	Ribbon microphone and dynamic microphones
1921	First electronically amplified PA system
1925	Rice & Kellogg moving coil loudspeaker
1925	First loudspeaker with a crossover
1925	First stereo radio broadcast
1926	First talking picture
1926	Tannoy founded
1926	First electric gramophone using 1 watt amplifier moving coil loudspeaker
1930s	Crystal microphone, parabolic reflector and shotgun mics
1933	Fletcher & Munson Equal Loudness Curves
1940	Noise cancelling microphone
1944	First hi-fi records (Decca) 50Hz – 14kHz
1949	Vinyl LP invented
1949	Transistor invented
1949	Hass publishes seminal paper on sound delay
1952	Tape delay machine for sound reinforcement
1953	Active noise control proposed (Olson)
1963	Philips audio cassette
1964	Electret microphone
1965	Introduction of SM58 and SM57 microphones
1969	Dolby noise reduction system
1971	Speech Transmission Index STI invented
1971	Articulation Loss of Consonants concept introduced (modified in 1972 for PA systems)
1972	First 1/3 octave Real Time Analyser

Electroacoustics 1974 –

The RS conferences, held annually since 1984, have not only tracked the changing world of electroacoustics but have played a significant part in it by providing a unique environment for fostering discussion, advancement and debate. RS was born out of an auditorium and electroacoustics conference held in Edinburgh in 1982. A quick scan of that programme reveals many topics that are still being debated at RS conferences and other IOA meetings today. In particular, there were several papers on speech intelligibility including one by Houtgast and Steeneken introducing STI to the UK acoustics fraternity.

Hi-Fi and personal listening

As noted in the introduction, the hi-fi boom occurred during the 1970s to 1990s. During this time the Sony Walkman appeared in 1979, the CD was invented and introduced in 1982 and the portable CD player followed on in 1985. The Digital Audio Tape (DAT) format was introduced in 1986. Although DAT never took off as a domestic medium, it was widely used by audio professionals and acoustics consultants for measurements and recording purposes for more than 20 years. The minidisc appeared in 1999 but never took off being superseded rapidly by the iPod in 2001 and MP3 players which were introduced in1998. Digital data compression, lossless coding and what is or is not audible have remained topics

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Sony Walkman 1979

Sony Discman 1985

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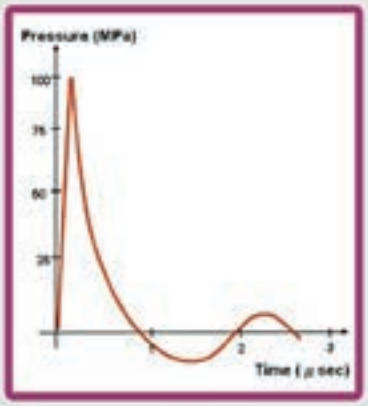
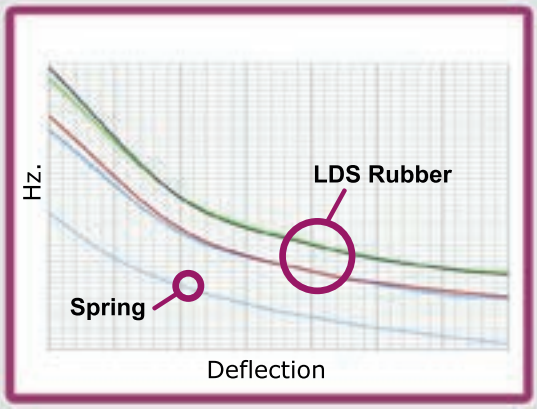
Construction phases of a spring floating floor



Shock Pulse



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Rubber or foam is not effective against shock pulses. Such layers can absorb the higher frequencies but are too dynamically stiff to react and absorb the problematic lower frequencies. These pass through and can easily travel throughout the building. Springs react virtually instantly, allowing each coil to absorb energy –the physical displacement of the shock pulse needs to be absorbed. The higher the deflection spring the more effective coils are available and the lower the frequencies which will be absorbed.

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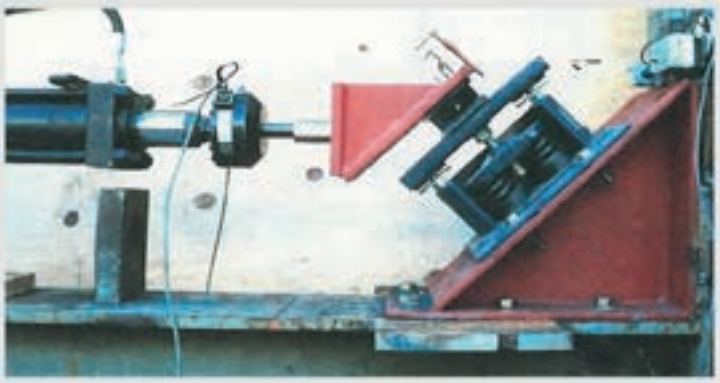

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of debate ever since – particularly in the bar at a number of RS conferences. Whilst loudspeaker technology has significantly evolved since 1974, the basics have not changed and a 1974 vintage domestic loudspeaker is essentially the same as a current model, though how the end product and acoustic result is obtained has indeed undergone quite a revolution. In 1974 crossover design was pretty much a 'black art' and required building several prototype units before a final design was settled on. The same could also be said about driver design and the cabinet. Towards the end of the 1970s, as personal computers become available, programmes were written to crunch the numbers and optimise the 'what if' scenarios. Today, every part of the loudspeaker is computer modelled and optimised before a prototype is ever made. Computers have played a huge part in not only the design and design optimisation of loudspeakers but also in their measurement, enabling for example 3D views of their directional and radiation characteristics as well as their temporal and frequency responses to be made. Scanning laser interferometery, developed during the 1970s and 1980s, enables the motion of a loudspeaker cone and areas of breakup or rocking to be studied in great detail. This area of research was in its infancy towards the end of the 1970s with a novel paper by Celestion loudspeakers and BT Labs being presented at the1982 electroacoustics conference mentioned above. As with many electroacoustic measurement devices, specially built and conceived 'one off' laboratory devices have now become commercially available, standard instrumentation.

Although the fundamental moving coil loudspeaker concept has not changed over the past 40 years, two new forms of loudspeaker have occurred. These are the Distributed Mode Loudspeaker (DML) conceived (by accident) in 1997 and the ultrasonic loudspeaker, which dates to around 2001. Whilst the DML did not take over the loudspeaker market as it was first thought, the technology can be found in a range of applications and is still being developed. The research carried out by NXT into the DML had a number of interesting spin offs and helped in the development of conventional loudspeaker technology. Ultrasonic loudspeakers work by the demodulation of the ultrasonic carrier sound by the air. The beam formed can be highly directional which has enabled the technology to be used to create specific zones of wanted sound.

Soundbars are a relatively recent development, being consumer loudspeakers designed to fit under flat screen TVs, and use a number of techniques to deliver stereo or even multi-channel sound from a single loudspeaker unit. Advanced signal processing techniques enable either steered beams to be created and reflected from the room boundaries or psychoacoustically based Head Related Transfer Function processing may be employed to create perceived multi-channel surround sound images. Wavefield Synthesis systems have also been developed to cater for larger audiences.

Since 1974, domestic stereo (Hi-Fi) systems have developed into 'home theatre' 5.1 or 7.2 channel surround sound systems. The current trend for cinema systems to become more immersive with increasing numbers of channels and formats being developed, particularly to provide height information (e.g. Dolby Atmos 64 channel system) will also trickle down to domestic home theatre systems. This will require more loudspeakers to be employed and special units developed to create the height signals in a more domestically friendly manner by reflecting the sound off the ceiling rather than peppering this with loudspeakers.

Object based broadcasting is set to add to the audio, as well as the visual experience. This could be a boon for the hard of hearing, enabling the background sound and effects to be personally tailored to optimise the listening experience and perceived intelligibility. The 1990s also saw the development and better understanding of deaf aid loop systems (AFILS) for the hard of hearing. This lead to the provision, in nearly all UK cinemas and many theatres and public buildings, of an inductive loop system. Many railway stations and all London Underground stations now have deaf aid loop systems. Research into the acoustic and intelligibility aspects of assistive listening systems is still a current topic.

Considerable investigation into listening environment acoustics has been carried out of the past 40 years. The effects of discrete reflections, reverberation and ideal loudspeaker directivity and frequency response have all been studied and quantified. As a result the imaging and colouration of today's loudspeakers are generally far better than those around in 1974 – though there are exceptions. The difference is that now it is possible to readily measure and quantify the devices. Whereas in 1974, the frequency domain was felt to be the key to good sound reproduction, today, the time domain is known to be equally if not more important. The availability of suitable instrumentation has also played a huge part in the process.

Instrumentation

In 1974, virtually all audio and electroacoustic instrumentation was frequency domain based. Few options were available for obtaining temporal information. The most common and virtually only way was to use a pulse or impulse signal and observe it on an analogue storage oscilloscope or one with a special long persistence screen. Permanent data capture was by means of a Polaroid oscilloscope camera. Digital transient recorders and gating techniques were developed towards the latter half of the 1970s which enabled time / frequency responses to be obtained – though this could be a long and tedious process. Hard wired FFT analysers were becoming available by this time as well as a few research computers (eg PDP 11 mainframes) with specially written software. ISVR at Southampton University had such a system and B&W loudspeakers bought a development of this. KEF loudspeakers pioneered digital loudspeaker measurements and by 1980 had converted almost exclusively to digital measurement FFT techniques for their loudspeakers. Time Delay Spectrometry became commercially available by the mid 1980s and a number of loudspeaker manufacturers employed the newly available TEF measurement system. This was a hardware-based solution with software control and data processing using a CPM operating system. A number of sound system contractors and electroacoustic consultants also bought the TEF and so for the first time frequency and time selective measurements could be readily made outside of the laboratory or dedicated measurement facility. The availability of such equipment quickly led to several new insights into sound system behaviour and performance. The TEF machines, whilst transportable were not as portable as really needed for many applications. In 1977, IVIE produced a handheld, 1/3 octave real time analyser – the 30A. This was a revolutionary piece of equipment for the sound contractor and consultant. The device had a switchable 45, 30 or15 dB led display and with a pink noise signal enabled frequency response of a sound system to be instantaneously viewed and adjustments immediately be seen. The unit had two memories with permanent data capture being by means of a transparent film sheet and wax pencil to trace out the response! In 1979 an ancillary unit was developed that enabled an X-Y plotter to be hooked up and a high resolution permanent plot

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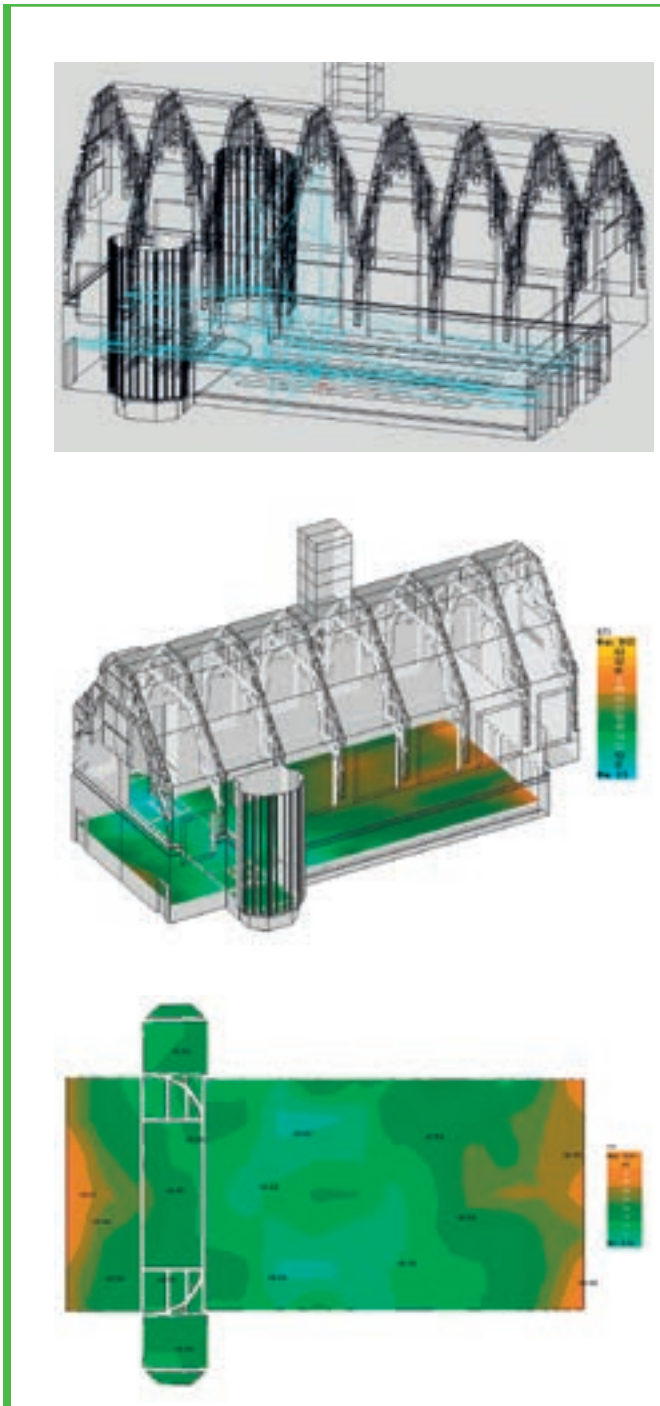
to be made. The unit also included a gating system and so enabled time gated ('windowed') measurements to be made. Distortion measurements were also possible. The unit was way ahead of its time and continued in production for more than 25 years – a unique achievement for a piece of test equipment. The Urei 2010 frequency response plotter and Neutrik Audiograph were also commonly used analogue based audio system test instruments in the 1980s and 90s.

As the power of personal computers and laptops in particular increased, the possibility of using a PC rather than a dedicated computer/ processor became a viable proposition. The TEF analyser adopted this approach and in 1991 a very much more compact and flexible software driven version was launched. The days of dedicated, hard-wired test instrumentation were numbered. Another major development in the audio and acoustics measurement field was the development in 1987 of MLSSA. This used a dedicated measurement card and, at the time, a 286-based computer could run it. The measurement approach employed a maximal length sequence (MLS) and windowed the resultant impulse response to derive the frequency response. The 'temporal' aspect of a system or system in a room therefore dominated what was seen and again further new insights into loudspeaker behaviour and the behaviour of a loudspeaker in a room could be viewed. Unlike the TEF approach, a single measurement obtained all the data required, with post processing being employed to derive the required information or parameter. This made MLSSA and the MLS technique a uniquely powerful tool. As the computing power of computers increased, so did the speed of the post processing. For example, in 1990, using a 286 laptop (with maths co-processor), took several minutes (~10) to compute a Speech Transmission matrix and calculate the resulting STI value. With a 386 computer the time reduced considerably whilst a 486 enabled the user to actually watch the 98 data point table to fill up. A Pentium instantaneously displayed the result. In 1988,a TEF 12 took more than 15 minutes to measure and compute a single STI value. It is a salutatory thought that today smart phone apps are able to carry out these tasks!

On the audio, electronic measurement side, the 1980s also saw the beginnings of a paradigm shift in the way in which measurements were made. The idea of using separate, dedicated items of test equipment to measure a particular parameter, gave way to computer controlled and software based measurement systems.

NTI XL2

Selection of current STIPA meters and Apps



Example of Electroacoustic Computer Model showing ray tracing & STI contour plot

The Audio Precision 'system one' introduced in 1986, for example, became the universal leader in the field and set the standard for many years to come.

One piece of electroacoustic test equipment that must not be left out of this review is the B&K RaSTI meter. This was introduced in 1985 and for the first time enabled simple, on site, STI measurements to be made and PA systems to be audited. In 1991 BS 7443 (the standard for emergency sound systems) was published and became the first standard to introduce speech intelligibility as a design parameter and performance requirement. This led to RaSTI/STI being a requirement in BS5839 the national Fire Alarm Standard and also in BS 7827. The latter document was the British Standard dealing with sound systems in sports grounds following on from the Hillsborough football stadium tragedy in 1989. The Kings Cross fire in 1987 led to a huge change in the way underground stations were operated and life safety systems used and designed, including the public address or voice alarm systems as they became known. Requirements for the intelligibility of the station PA systems were introduced and a step change in their effectiveness occurred – attributable in large part to RaSTI. Speech Intelligibility, in terms of RaSTI was also introduced as a requirement of BS 7594 – the standard for Deaf Aid Loop Systems (AFILS) when it was first published in 1993. Subsequently, all the standards have been updated to employ STI or STIPA instead of RaSTI. Many IOA Electroacoustic Group members have been involved with writing and contributing to these standards.

Speech Intelligibility and PA system design

As noted above, the intelligibility of PA and sound reinforcement systems took on increasing importance – particularly from the mid 1990s onwards. Speech intelligibility has been a stalwart topic at most of the 30 IOA Reproduced Sound conferences. Although STI was conceived in 1971, it was not until the introduction of the computer controlled and software based analysers and the B & K RaSTI meter that it really took off. STI is now the universally recognised method for measuring the potential intelligibility of PA and emergency sound systems. The PA system of every commercial (and military) passenger aircraft has to achieve a minimum STI value. Train and passenger ship PA systems also have set requirements. Perhaps, unbelievably, station PA systems also have a minimum STI standard to achieve, though some are now very good. The PA systems on oil rigs and fire / voice alarm systems in buildings all have to meet intelligibility standards – usually with STI being stated as the measurement / design parameter. In the late 1990s, the shortcomings of RaSTI became better understood and a more sophisticated measure was required. In 2001 STIPA was introduced (at a RS conference). STIPA, whilst employing a sparse modulation transfer function matrix, has the advantage of measuring each of the 7 octave bands over the range 125Hz to 8 kHz instead of the limited 500Hz and 2kHz bands of RaSTI. The correlation with full STI measurements was found to be extremely good and the method was quickly adopted with many audio analysers and sound level meters providing this measurement function.

As personal computers became more powerful, acoustic modelling programmes took advantage of this and were able to become more accurate and sophisticated. Full ray tracing or image-source methods could be employed for example, rather than statistical acoustic approaches and contour plots rather than isolated, individual points could be computed. This, in turn, has led to improved PA and sound system performance as the way in which an area is covered by a given loudspeaker or set of loudspeakers is relatively easy to compute and visualise, enabling better and more informed decisions to be taken. Sound systems can also be auralised – enabling the potential performance of a particular design to be subjectively assessed before it is installed. Pre-installation computer modelling is now mandated by many authorities and organisations so that some assurance that the sound system will perform as required can be given.

Whilst moving coil loudspeakers are extensively used in PA

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and sound reinforcement systems, so too are horns with associated compression drivers. The invention in 1974 of the constant directivity horn was a major breakthrough, enabling better and more uniform coverage to be achieved. The CD horn is now by far the most widely used non-cone loudspeaker device. In order to control the radiated sound, the horn dimensions need to be comparable to the wavelength of interest. This can lead to physically quite large horns and associated architectural objections. Another way of controlling the directivity of the emitted wavefront is to use an array of devices. For many PA and sound system applications, directivity is only required in the vertical plane. This enables tall but relatively slim column or line array loudspeakers to be constructed. Such a format and footprint are far more readily able to fit into the architecture of many spaces. The physics of line array behaviour has been known since the early 1950s, if not before. However, before and during the 80s and 90s much of this seems to have been forgotten as short (i.e. less than 1m) column loudspeakers became the vogue. This, however, began to change in the late 1990s as a new breed of column loudspeaker – the digitally steered line array – was introduced. The advantages of this type of loudspeaker is that narrow, well defined beams can be formed and steered to where they are required. Furthermore, the unit can be (should be) vertically mounted. This latter aspect allows the units to be discreetly accommodated – a non-acoustic factor that dominates and affects many sound system designs. In it interesting to note a comment by the author in a paper at the 1982 Edinburgh electroacoustics conference "unless the electroacoustic consultant has a strong sense of conviction and stubbornness concerning loudspeaker positioning and acoustic treatments of surfaces, many a system will be doomed from the beginning". Sometimes nothing seems to have changed in the past 30 – 40 years of electroacoustics within the IOA!

Conclusion

Forty years ago it would have been impossible to predict many of today's audio technologies. The development of assisted resonance or electroacoustic reverberation systems (electronic architecture as the current systems know tend to be known) could certainly have been perceived as an area that was likely to evolve. There are now at least five commercial systems on the market with most also creating and manipulating early reflections as well as reverberation. This enables far more sophisticated control of the resultant listening to take place – often with different conditions and parameters being set for the performers and their audience.

Mechanically steered, full range music line arrays (often known as 'J arrays' due to their shape) that now form an integral part of most amplified concerts could not have been foreseen yet this is now an everyday technology. Conversely however, the development of digitally steered speech line arrays could have been expected, as electronically steered arrays were already commercially available by the mid 1970s. I suspect that the digital revolution starting with the CD and going on to encompass, MP3 players, Digital Signal Processing (DSP) and mixing as well as sound system control could never have been expected or conceived of back in 1974. The huge role that computers would play in both product and systems design and complex acoustic modelling could not have been foreseen — as 1974 was still very much the era of the typewriter and needle scale voltmeter — with the word processor, Apple computer, Excel, AutoCAD, and Finite Element and three dimensional analysis still many years away. The prospect of being able to wirelessly control a large scale sound system from an iPad or tablet whilst sitting in the front row of the stalls or even from the other side of the world was inconceivable yet this is now what effectively happens every day.

It would therefore be foolish to try to foresee the changes and advances that will occur in the next 40 years. However, over the next 10 years (i.e. up to the IOA 50th anniversary) there is no doubt that as processor power increases and the next generation of audio engineers takes over, the future will be digital and evermore wireless. Whether analogue audio will disappear for ever or re-establish itself as vinyl records are currently doing (who could have foreseen that !) remains to be seen. Multi-channel or as it is now termed "immersive audio" will most likely continue to develop, though whether 64 channel headphones will is perhaps less likely. There will certainly be greater interactivity between the listener with their personal audio and video media as object-based broadcasting develops and becomes more sophisticated. Whether we will still be listening to bits of stiff paper being shoved backwards and forwards thousands of times a second in order to listen to amplified speech and music as we have done for the past 90 years is something to think about – and perhaps a topic for the IOA at the 50th anniversary electroacoustic review.

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Some Electroacoustic milestones & developments since 1974	
1974	Ambisonics
1974	Invention of Constant Directivity (CD) horn
1979	IVIE 30 & 17 hand held RTA
1978	PZM (Pressure Zone Microphone)
1979	Sony Walkman
1982	Compact disc
1983	Fibre optic cable
1983	TEF 10 analyser
1985	RaSTI devised & B+K RaSTI meter introduced
1986	Digital Audio Tape (DAT)
1986	Audio Precision – System 1 introduced
1987	MLSSA analyser
1989	Digitally Steerable Line Arrays
1998	MP3
1989	First digital signal processor
1990	First commercial digital mixer
1990s	Array microphones
1996	Cobranet – digital audio network developed
1997	Distributed mode loudspeaker
1998	First commercial digital amplifier
2001	Ultrasonic loudspeaker
2001	STIPA (Speech Transmission Index for PA systems)
2005	Solid State recorders
2006	Dante Audio Network Protocol
2010	Sound bars
2012	Steerable array microphones
2013	Dolby Atmos – multichannel surround sound system
2014	Digital network microphones

The propagation of low frequency sound through an audience

By Elena Shabalina, d&b audiotechnik

Introduction

Frequent concert or open-air festival visitors might have noticed that at large events subwoofers, the dedicated low frequency loudspeakers, are often placed in a row in front of the stage as an evenly spaced array (Fig. 1). The reason for that is the directivity control that can be achieved by using beamforming techniques. Opposite to the standard left/right set up which creates strong interference throughout the listening area, a carefully designed subwoofer array provides an even sound pressure level distribution across the listening area, and keeps the sound away from the stage and the neighbours.

However, at large outdoor events the audience often stands tightly packed in front of the stage (Fig. 2) and the sound from the subwoofer array propagates partly through the crowd and partly above it. Live sound engineers notice the difference in the tonal balance in an empty venue and with the audience present, but they have different opinions on the topic. Some say the bass becomes louder when the audience is present, some say it's quieter, so we've decided to find out how much of the low frequency energy is actually coming through the crowd. The question is: does it make sense at all to work on the beamforming algorithms for subwoofers if all the sound is absorbed by the audience anyway?

The first thing that comes to mind is "people are soft, so they should absorb sound". And they do absorb quite a lot, especially at high frequencies ([2, 3]).

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Fig. 1 An array of subwoofers in front of the stage

Fig. 2 Tightly packed audience in front of a subwoofer array

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The trouble is that all the measurements were done only above 100Hz. This was partly due to the lack of interest to low frequencies, which were not much needed back then, and partly because the size of a typical reverberation chamber restricts the frequency range.

The obvious way to find out if people absorb anything or not is to place them into a large reverberation chamber with a subwoofer and measure them as regular absorbers according to the ISO 354 ([1]). That might be not the best approach because this measurement method assumes diffuse field, and the field at a concert is not necessarily diffuse. Nevertheless, the diffuse field absorption data might give an insight.

The next step would be to build an analytical model to investigate the problem from the mathematical point of view and then to verify it using computer simulations, scale measurements and live concert measurements.

Part 1 of this article covers the diffuse field absorption measurements of the human body and the mathematical model. Part 2, which will appear in the following issue, will present the results of computer simulations and live measurements.

Diffuse field absorption of the human body

In order to find a correct way to model the sound propagation through an audience, it is important to evaluate the energetic or diffuse field absorption of a single person. If the human body itself absorbs sound energy at low frequencies, it has to be taken into account in the model, resulting, for example, in a complex wave number in the equivalent fluid model. If the absorption is small or zero, it might be left out; in this case only the density of scatterers and the form of the crowd is important.

The frequency range of interest is from 30 Hz to 100 Hz.

The sound absorption of the human body can be measured according to ISO 354 ([1]) in a reverberation chamber. For the current work the total absorption per person is important, the area absorption coefficients were therefore not calculated. Previous works including [2] or [3] present measurement results down to 100 Hz [2] or 80 Hz. Below these frequencies a usual reverberation chamber is not big enough to create a diffuse field; also the lowest frequencies were not of the first interest for concert halls at the time the measurements were made. In the experiment described below, a larger reverberation chamber along with single mode evaluation technique was used to obtain the absorption characteristics of the human body at low frequencies.

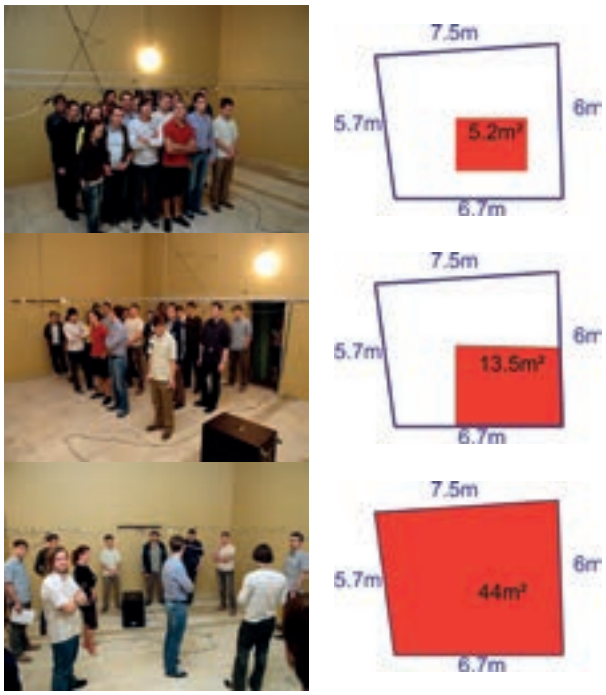

Fig. 3 Measurements setup: three different densities of the audience

Measurement setup

The measurements were conducted in a reverberation chamber of 217 m^3 volume and 220 m^2 surface area. A group of 20 students took part in the experiment which allowed measurement at three values of concentration of the audience: 3.8 pers./m^2, when people stand very close to each other, 1.5 pers./m^2 and 0.5 pers./m^2 . To avoid the influence of the increase of sound pressure level close to the walls, the participants were asked to stay at least 0.5 m away from the walls. The measurement setup is shown in the Fig. 3.

The usual method to measure absorption or absorption coefficients is the diffuse field method according to the ISO 354. Impulse responses were measured using a sweep signal for three loudspeaker positions and four microphone positions for every concentration of the audience, which results in 12 impulse responses for every concentration.

However, the Schroeder frequency of the reverberation chamber is about 163 Hz, so the frequency range of interest is in the range of strong modes.

According to ISO 354, evaluation of the reverberation time and absorption should be done in 1/3 octave frequency bands which are relatively broad at low frequencies. To find out if the calculation in 1/3 octave bands still gives correct results, an alternative method was used to calculate the reverberation time and absorption of the audience.

If modes do not overlap too much, the Q-factor of a single mode can be defined from its -3 dB level. From the difference between the Q-factors of a mode in an empty chamber or in the presence of people their total absorption can be calculated. These values were compared to the results of the diffuse field measurements. A detailed account of the measurements and evaluation can be found in [4].

Results

The absorption for all three densities together is presented in Fig. 4. Table 1 presents the obtained values of the absorption per person.

The absorption measurements of the human body evaluated both according to the ISO 354 and using a modal calculation give similar results in the frequency range from 30 Hz to 100 Hz. The values also do not contradict to those obtained by [2, 3] in the overlapping frequency range of 80 Hz - 100 Hz.

With the characteristic absorption of 0.05 m^2 per person, an audience of 350 listeners (the amount that will be used for BEM-simulation and scale modelling) has a total absorption of 17.5 m^2 which results in an absorption coefficient of 0.06-0.10 for the corresponding listening area. The effect of the absorption is therefore considered small and is not taken into account. However, further investigations might improve the accuracy of the models by including the diffuse field absorption.

	Frequency, Hz						
Density, pers./m^2	31	40	50	63	80	90	100
3.8	0.05	0.03	0.03	0.05	0.06	0.06	0.05
1.5	0.04	0.04	0.05	0.04	0.06	0.05	0.05
0.5	0.03	0.06	0.06	0.05	0.06	0.07	0.07

Table 1. Absorption of human body, pers./m^2

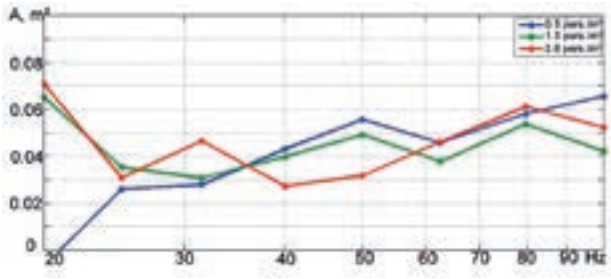

Fig. 4 Absorption per person for the audience density of 0.5 pers./m^2 (blue), 1.5 pers./m^2 (green) and 3.8 pers./m^2 (red)

Analytical model

A convenient way to describe the wave propagation through a complex medium such as an audience is the equivalent fluid model. The idea is to represent the audience as a homogeneous medium with a generally complex speed of sound and a complex density. The speed of sound and the density have to be calculated from the microscopic parameters of the audience: concentration of people and their average dimensions.

This can be done using the model of a porous medium with a rigid frame introduced by [7] and described by [6]. According to the model, three parameters of the medium are required to calculate the speed of sound: porosity, structure factor and flow resistivity. These parameters can be obtained from the simplified representation of an audience as a set of infinitely long, hard upright cylinders (Fig. 5). Assuming the cylinders infinitely long allows to reduce the problem to a one-dimensional wave propagation.

The concentration of the crowd, or the number of people per square metre, and the average cylinder radius are assumed to be known parameters.

For an audience modelled as a set of cylinders, "pores" are the spaces between the cylinders, and the cylinders form a rigid frame.

Porosity h is the ratio between the volume of air (V_{air}) in the pores and the total volume (V_{total}) (eq. 1).

$$h = \frac{V_{air}}{V_{total}} \quad (1)$$

If cylinders are infinitely long, porosity is the ratio between the unoccupied area and the total area (eq. 2).

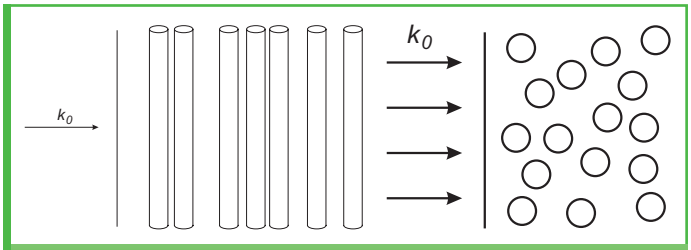

Fig. 5 Plane wave propagation through a set of cylinders

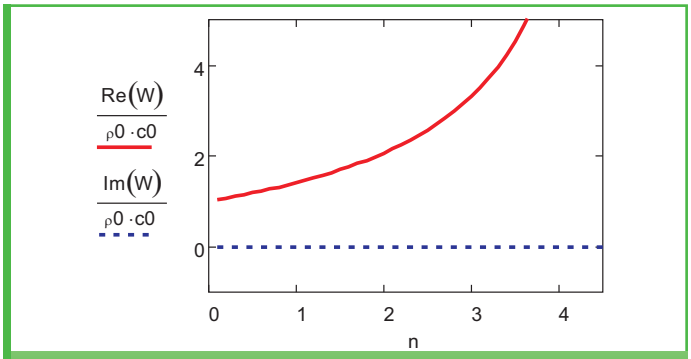

Fig. 6 Real and imaginary part of the relative wave impedance depending on the concentration

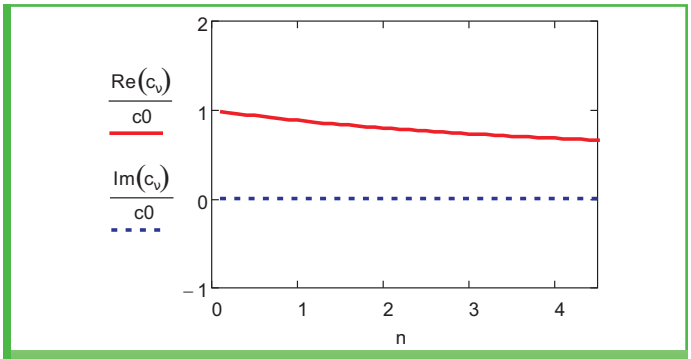

Fig. 7 Real and imaginary part of the speed of sound depending on the concentration

$$h = 1 - v\pi r^2 \quad (2)$$

where v is the concentration of people in the audience and r is the average radius of the cylinders. The average radius of a human body is assumed 25 cm, which results in the maximum concentration value of $v < \frac{1}{\pi r^2} = 5$. Reasonable values of v range from 0 to 4.

The structure factor ξ is the ratio between the actual distance through the pores between two points, and the straight line between them (eq. 3).

$$\xi \quad \xi = 1 + v\pi(\pi - 1) \quad (3)$$

The flow resistivity (σ) takes into account the viscosity of air (η) in the pores (eq. 4):

$$\xi \quad \sigma = \frac{\xi}{h}\frac{8\eta}{d^2} \quad (4)$$

where $\eta = 1.85 * 10^{-5}$ is the viscosity of air and $d = \frac{1}{2v}$ the pore radius.

Using these parameters, we can calculate the speed of sound according to [6]:

$$c_v = \frac{c_0}{\sqrt{\xi - i\frac{\sigma h}{\omega\rho_0}}} \quad (5)$$

Generally the speed of sound in a porous medium is complex. If we take a closer look at the real and imaginary parts of the speed of sound at different concentrations of the audience (Fig. 7), we see that the imaginary part stays constant and close to zero, and the real part decreases with the increase of the concentration. That means, the closer people stand to each other, the slower the wave propagates through them. At the maximum possible concentration of 4 pers./m^2 the speed of sound in the crowd is about 80% of the speed of sound in the air.

For the next step we need the wave impedance of the audience, which can also be calculated according to [6]. Fig. 6 shows the real and imaginary parts of the wave impedance: the imaginary part is small and constant and the real part increases with the increase of concentration.

Waves in an audience of finite depth

The audience usually starts after the security barrier several metres away from the stage and the subwoofer array. The "depth" of the audience is defined either by another row of the barriers, or the crowd density just naturally decreases farther away from the stage. The concentration can decrease slowly, when people stay in small scattered groups at the end of the listening area, or the crowd can end abruptly, if everybody is trying to stand as close to the stage as possible.

For simplicity, let's consider the later situation: everybody is trying to keep as close to the stage as possible, so the crowd has a constant density from the front security barriers, and ends abruptly at a distance L from front. This assumption makes the calculations easier, and the case of the variable density is described in [5].

A crowd of a constant concentration with abrupt boundaries can be represented as a layer of a porous medium with a wave impedance W between two infinite layers of air (Fig. 8)

The wave impedances of the audience and the air can be quite different, as we can see in the Fig. 6. A difference of impedances always creates a reflection of the wave from the impedance boundary with a complex reflection coefficient, which can be calculated, if the wave impedances of the media are known. The wave impedance of the audience we have already calculated in the previous section, and the impedance of the air is known

$$Z1 = Z2 = Z = \rho 0 c 0.$$

The sound wave from the subwoofer array enters the audience, propagates through the audience until its rear boundary where a part of it is reflected from the boundary back into the audience. The sound field within the audience is in this case a sum of the incident wave and the reflected wave:

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$$p(x,t) = Ae^{i\omega t}\left[e^{-ikx} + Re^{ikx}\right] \quad (6)$$

where

$$R = \frac{Z-W}{Z+W} \quad (7)$$

The first component e^{-ikx} represents a wave propagation from the stage towards the end of the audience, and the second component Re^{ikx} is the wave, reflected from the boundary between the audience and the air.

R is a reflection coefficient, which is calculated from the wave impedances of the crowd and the air. The real and imaginary parts of the reflection coefficient are shown in Fig. 9. With the increase of the crowd concentration, the boundary becomes closer to an acoustically soft boundary, such as the boundary from water into air, and the real part of the reflection coefficient approaches -1 - the value for a soft boundary. The imaginary part is, again, very small and constant.

The wave reflected from the boundaries between the audience and the air interferes with the incident wave and creates a standing wave between the front and the rear boundaries ([5]). The distance between maxima and minima of the standing wave

$$\Delta x = \frac{\pi}{2k} = \frac{\pi c_v}{2\omega} \quad (8)$$

depends on the wave number within the layer and, correspondingly, on the concentration of the audience. As the speed of sound within the layer c_v decreases with the increase of concentration (Fig. 7), the distance between maxima also decreases. The difference between the maximum and minimum values of the sound pressure values depends on the reflection factor. At low concentrations, when the space occupied by the audience doesn't differ from the air very much, the reflection factor is close to zero (Fig. 9). In this case no reflection occurs, and, consequently, no interference. As the concentration increases, the reflection factor and the maximum/minimum ratio increase (Fig. 10 and 11). With the increase of concentration the reflection coefficient approaches -1, which corresponds to a soft boundary condition. The amplitude of the corresponding standing wave at 50 Hz, shown in Fig. 11, represents a typical resonance with soft boundary conditions: the sound pressure is minimum at both boundaries, and the ratio between the extrema is maximal.

That means in a tight crowd the difference between the interference maxima and minima at low frequencies are more noticeable than in a sparse one. On the other hand, in a dense crowd people are less likely to wander about and compare sound at different spots.

Summary

Here, in short, are the main results of the study: We have found out that the diffuse field absorption of the human body is from 0.025 to 0.07 m^2 per person in the frequency range from 30 to 100 Hz, which is not much in comparison to high frequencies. Despite that, there is a measurable difference between the sound pressure level distribution in an empty venue and in the presence of an audience, and the sound pressure level decay with the distance tends to be less in the presence of an audience.

At low frequencies an audience forms a medium with its impedance significantly different from the impedance of the air, which leads to the reflection of sound waves from the boundaries back into the audience and therefore the increase of the sound pressure level. The wave impedance of the medium and, correspondingly, the propagation of sound through it, can be calculated using the porous medium theory. Part 2 of this article, which will appear in the following issues will show how close the theory can represent reality.

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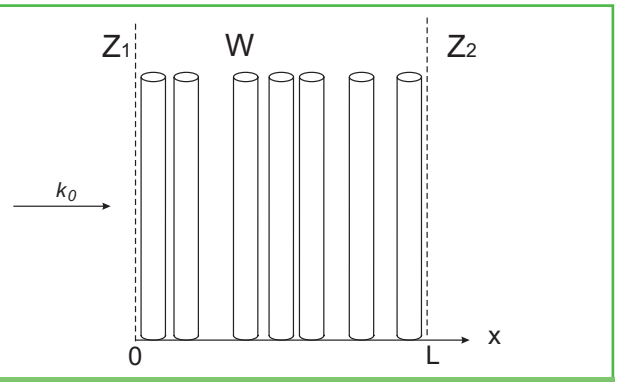

Figure 8: Plane wave propagation through a set of cylinders

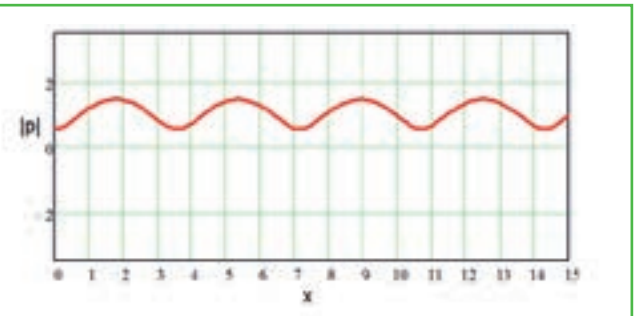

Fig.9 Real and imaginary parts of the reflection coefficient depending on the concentration, frequency – 50 Hz

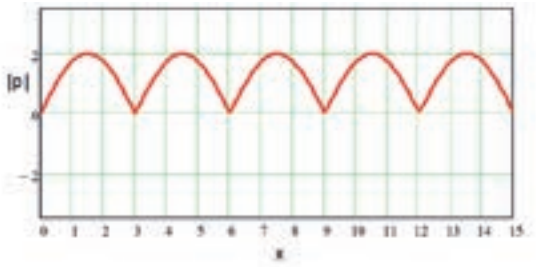

Fig. 10 Amplitude of the standing wave caused by reflections from the boundaries of a layer of audience with the maximum concentration of *v=2.6 pers./m², L=15 m* is the thickness of the layer. Frequency – 50 Hz

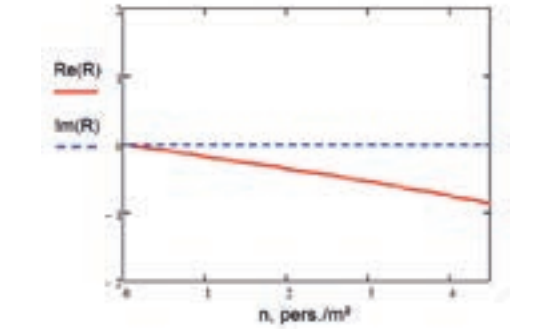

Fig. 11 Amplitude of the standing wave caused by reflections from the boundaries of a layer of audience with the maximum concentration of *v=2.6 pers./m², L=15 m* is the thickness of the layer. Frequency – 50 Hz

An efficient filter-based model for calculating absorption coefficient and directivity of resonator panel absorbers

By Spyros Polychronopoulos

Historical background

A resonator is a cavity with one or more apertures which have the property to resonate in certain frequencies. Our current knowledge regarding its functions is not complete. Thus, a great number of scientists worldwide focus their research on this field. Aristotle makes the first clear reference to a resonator in the 4th century B. [1]. It is probably the first acoustic element used in architectural acoustics. A few centuries later, Vitruvius (1st century AD) refers to resonators that were placed under the seats in ancient Greek and Roman theatres to improve their acoustic quality [2]. Later, in medieval ages resonators were embedded inside the walls of worship spaces for the same purpose [3-6].

Nowadays, the common resonator is known as the Helmholtz resonator, taking its name from the German physicist Hermann von Helmholtz (1821-1894) [7]. The theory of Helmholtz resonators was firstly established by J W S Rayleigh (1842-1919) [8], and half a century later KU Ingard described analytically their function and use as sound absorbers and scattering devices [9].

Introduction/basic theory

The Helmholtz resonator is a lumped element that has the property, due to its shape, to attenuate acoustic energy at its resonant frequency in the far field. The resonant frequency depends upon the geometry of the resonator. Accurate, but rather complicated, formulas can be used to calculate the resonant frequency for a variety of different shaped resonators and be found in bibliography [10-14]. The first approximation for calculating the resonance frequency, which was introduced by Ingard, is given by the following formula [9]:

$$f_0 = \frac{c}{2\pi}\sqrt{\frac{S}{VL}} \qquad (1)$$

Where c (m/s) is the speed of sound, S (m^2) the cross section area of the neck, L (m) is the effective length of the neck (including the end corrections), $L=L'+1.7a$, L' (m) is the real length and V (m^3) the volume of the cavity. The geometric characteristics can be seen in Figure 1.

The operation of a Helmholtz resonator can be identified via its mechanical and electrical equivalent systems and it is shown in the following figure.

Helmholtz resonator as a filter

The acoustic performance of an ideal Helmholtz resonator can be simulated as a second order system, whose discrete time domain impulse response can be modelled by an IIR filter [15], i.e. a filter having both feed-forward and feedback terms. Such a digital filter, for an ideal Delta function input $\delta(n)$, will yield as output its impulse response, and for any input $x(n)$, the output $y(n)$ will be represented as shown in the following block diagram, where n is the sample. Figure 3 shows a block diagram of this IIR filter while Figure 4 shows the impulse response of the filter in time and frequency domain.

Perforated panel as a filter

Modern perforated panels, as shown in Figure 5a, are commonly

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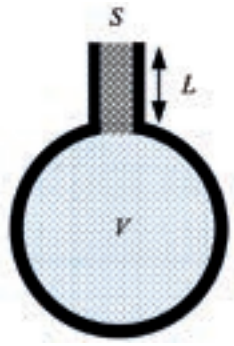

Figure 1. The geometry of a simple Helmholtz resonator

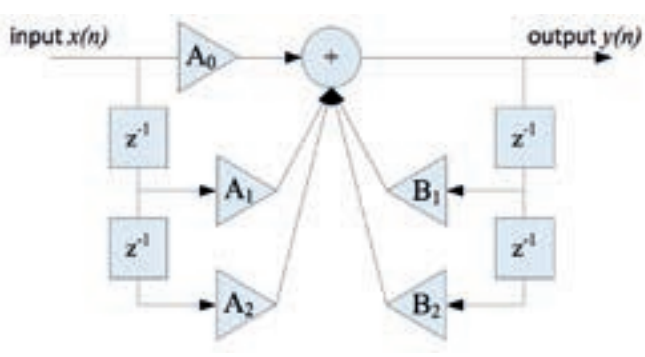

Figure 3. Block diagram of a second order IIR filter

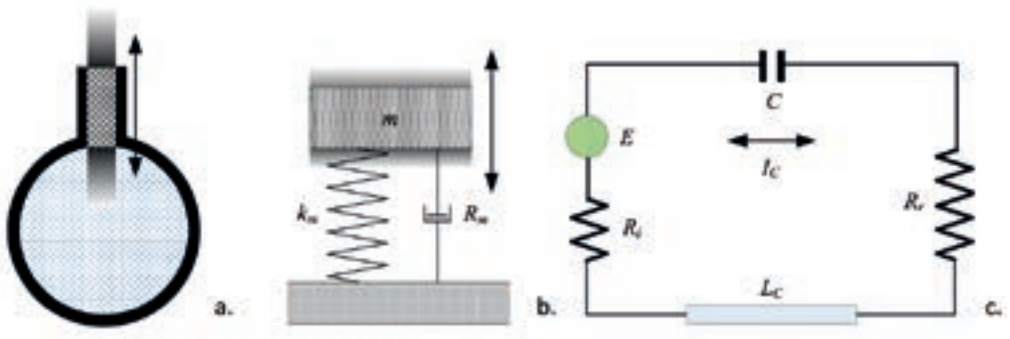

Figure 2. a. Helmholtz resonator in operation, b. Mechanical analogue and c. Electrical analogue

Advertising Feature

British Gypsum raises the standard with class A acoustic ceiling range

British Gypsum is raising the standard in commercial acoustic ceilings with the launch of a new range of high-performance ceiling tiles.

The Eurocoustic range has been developed to assist specifiers in meeting the diverse range of performance requirements found in today's commercial environments. Ideally suited to education, healthcare, office and retail sectors, the Eurocoustic range provides a unique combination of acoustic and physical performance features that meet these requirements.

Acoustic conditions and the control of reverberation have grown to become one of the main considerations in these kinds of interior environments, and specifiers can work to the guidance laid out in documents such as HBN 00:10 and HTM 08-01 for healthcare, and the most recently updated Building Bulletin 93 in education.

However, depending on the room type, intended use and particular client requirements, a number of additional factors are considered alongside the acoustic performance. As an example, aesthetics, durability, and resistance to fire, humidity and cleaning regimes must all be considered.

The Eurocoustic range can help address all of these challenges, offering the highest classification of sound absorption – class A – on all products in the range. Additionally, high light reflectance, A1 reaction to fire, 30 minutes' fire resistance, and up to 100% moisture resistance all come as standard across the range.

Manufactured from high quality basalt stone wool to EN13964, the Eurocoustic range comprises five ceiling tiles, each with these base performances as standard, and additional features such as cleanability and antimicrobial performance on specific tiles.

"Tiles such as Eurocoustic Tonga and Minerval are ideal for where high levels of acoustic performance is the main consideration", says John Newbury, Senior Product Manager at British Gypsum "while Area, Ermes and Clini'Safe are appropriate where a higher level of aesthetics or cleanability are required.

"The cleanability of surfaces is essential in many environments, particularly healthcare and residential care environments, but also where aesthetics are a priority. The Eurocoustic range includes washable and antibacterial grades supporting regular deep-cleaning and sanitisation routines to maintain high standards of hygiene and cleanliness"

"Whichever option a specifier goes for, they've got peace of mind that they are fully backed up by British Gypsum's Specsure lifetime warranty."

Full system details, along with Revit BIM components and acoustic data, are available for download from the British Gypsum White Book System Selector Guide.

For further details please visit **www.british-gypsum.com/eurocoustic**

Eurocoustic TONGA is ideal for reverberation control in office, education and commercial sectors

Eurocoustic ERMES combines class A sound absorption with a high quality aesthetic finish

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Advertising Feature

The Eurocoustic range from British Gypsum: The new standard in acoustic ceilings

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Not only that, Eurocoustic tiles are available in a range of sizes and surface finishes, including washable and antimicrobial grades - all covered by British Gypsum's SpecSure® lifetime system warranty.

For more information call us on **0844 800 1991** or visit www.british-gypsum.com/eurocoustic

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SAINT-GOBAIN

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used to improve the acoustics of internal spaces. This element is an array of Helmholtz resonators installed on a surface. Assuming that each resonator can be simulated as a multidirectional point source, the signals that will reach the receivers' point, when the system is given an input, are shown in Figure 5b.

For the sound reflected from the panel, taking into account the finite distance differences from the source to each resonator in the panel, the specific time delay and the sound pressure attenuation are calculated for each resonator element, so that the input sound that reaches each resonator is attenuated by

$$\frac{p_A}{r_{ABi}}$$

and delayed by n_{ABi} samples, where i is the index number of each Helmholtz resonator, A and B the source and receivers' point respectively and p_A the source sound pressure. In the next step the incoming sound pressure is filtered by the Helmholtz resonator filter and the output sound pressure from each resonator is represented by an omnidirectional wave, emitted to the receiver (green dashed line, Figure 5b).

Due to the summation of N elements for the Helmholtz resonator path, the overall level of the response increases disproportionally with respect to the level of the reflection that would be received due to a normal panel. The calibration factor (c_f), adjusts the peak level of the combined panel and Helmholtz resonators to the level of a non-perforated panel. The complete block diagram of the processing steps followed is shown in Figure 6.

Typical time and frequency domain response results, for a 4x4 Helmholtz resonators' array attached to a panel, are shown in Figure 7. For this example, the resonator's filter parameters were set so the resonance frequency was to be 115Hz, whereas the panel surface with typical absorption coefficient was assumed in order to illustrate more clearly the panel's material effect.

Filter based resonator panel model in diffuse field/calculating the absorption coefficient

The previous section was concerned with the filter-based

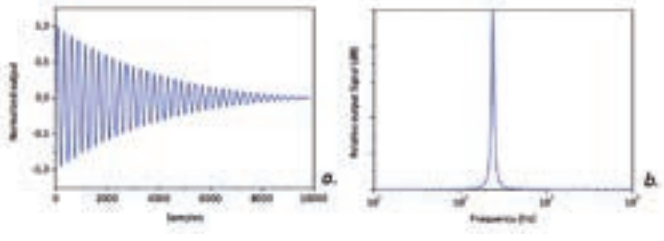

Figure 4. Impulse response of the second order IIR filter: a. in time domain (samples) and b. in frequency domain

Figure 5 a. Perforated panel and 5b. Signal paths from source to receiver for a perforated panel in free field

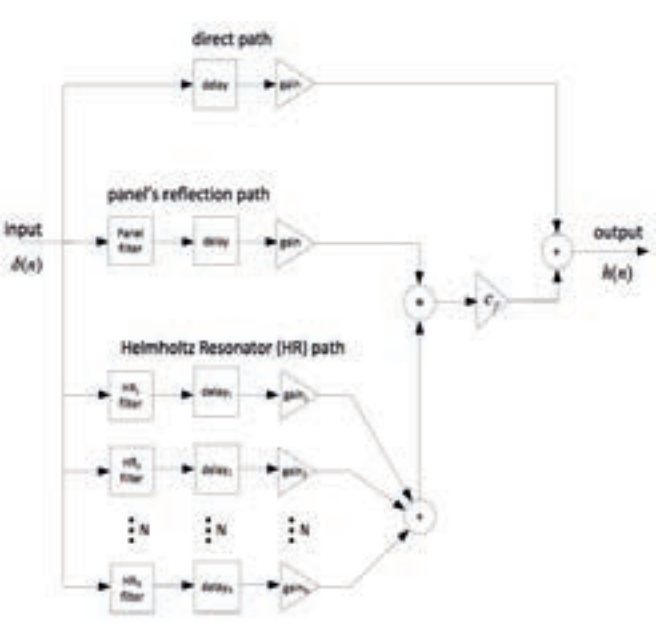

Figure 6. Block diagram for the proposed filter-based model of an absorber panel containing an array of N Helmholtz resonators. The ideal free field model is shown here, whereas for the diffuse field case, the input will be the ideal diffuse field impulse responses and the direct path will be omitted

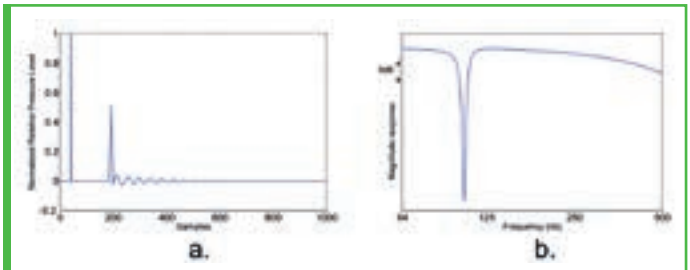

Figure 7. Impulse response at receiver position for a combined 4x4 Helmholtz resonators array and panel due to a delta impulse at source position. a. Impulse response and b. Magnitude frequency response

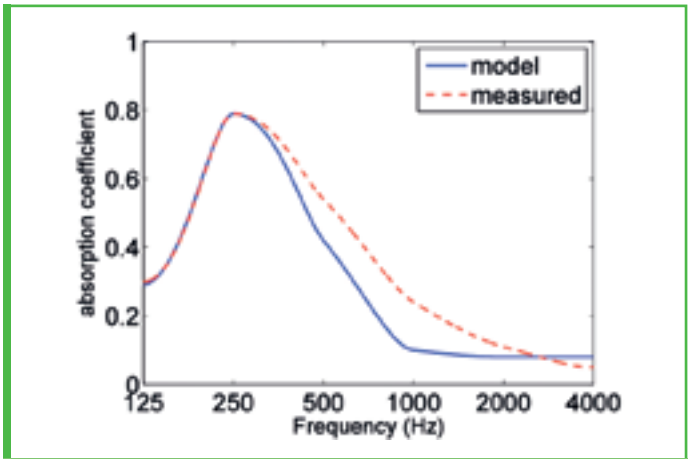

Figure 8. Typical comparative results for absorption coefficient evaluated for 1/3 octave bands of a commercially available resonator absorption panel and the simulated data of the same panel obtained by the proposed method

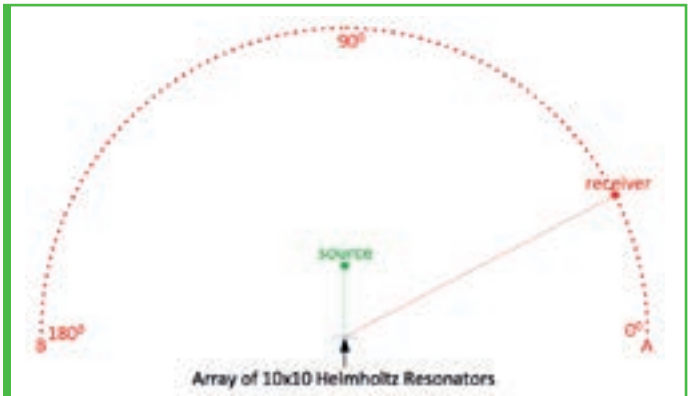

Figure 9. Helmholtz resonators 10x10 array with displaced receiver along an arc

evaluation of the resonator absorber panel's response in the free field. However, the absorbing properties of such panels need to be measured via the reduction of sound energy achieved under ideal diffuse field conditions, as is dictated by ISO 354 [16]. Following the proposed model such a condition will be realized, assuming that the sound input of the simulated panel system is not an ideal Delta function, but instead an ideal diffuse field response. By definition, such an impulse response will be characterized by randomly arriving reflections, decaying exponentially with time. Such diffuse components of room impulse responses may be modelled by exponentially decaying white noise [17].

Hence, by driving the panel filter model via such diffuse field response corresponding to an ideal reverberation chamber, the filtered output will emulate the measured response at a specified receiver position, when the absorber panel is installed. The modelling procedure will also follow the block diagram shown in Figure 6, where in case the input is the ideal diffuse room the output will be the response.

In order to evaluate the absorption properties of panels modelled according to the proposed approach, an ideal diffuse reverberant chamber is simulated. Its impulse response (arriving at the resonator-panel system) is evaluated for arbitrarily chosen value of the reverberation time. Then, any resonator absorption panel of specified parameters (perforation spacing, resonant frequency, panel material and size) is assumed to be placed inside such space, resulting in to a modified response at a receiver position and now having a modified reverberation time due to increased absorption. The simulated tests here attempt to predict the absorption coefficient of the panel system under such ideal diffuse field conditions, as is dictated by the standardized procedure.

The comparative 1/3 octave results, for the measured and estimated absorption coefficient that are shown in Figure 8, indicate a close approximation between measured and simulated data, especially around the resonant frequency region. In this simulation, some discrepancy is observed at higher frequencies due to inexact representation of the specific plain surface absorption of the specific panel. Such discrepancies can be reduced when the exact properties of the panel material are known prior to modelling. For more analytical description and formulas please see [18].

The signals' contribution as a factor of receiver's angle

In order to study the effect of receiver's angle to a Helmholtz resonators array and be able to plot a polar diagram, the arrangement as shown in Figure 9 was modelled. The following figure depicts an array of 10x10 resonators, a displaced receiver along an arc by 1° step and a point source that stays constant. The source emits an ideal impulse (Delta function δ).

In Figure the 10 red line depicts the case of one resonator. It is observed that the directivity is independent of the angular displacement of the receiver as provided theoretically [19]. The light green line stands for resonators distance of d=0.02m, the blue line for resonators distance of d=0.04m and the darker green line for resonators distance of d=0.08m.

By comparing the figures, it is observed that at the resonant frequency the acoustic field is significantly reduced in all cases. It is also shown how the degree of perforation of perforated panels affect the directivity.

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Conclusion

A novel and computational efficient method for evaluating the response of perforated absorption panel with an arbitrary number of Helmholtz resonator elements has been proposed, based on a simplified, parametric filter-based model. The combined response of these resonators and of a panel surface having user-defined reflection properties can be also predicted, leading to the efficient evaluation of the system's impulse and frequency response functions. An extension of the method allows the evaluation of the response of such a system under ideally diffuse acoustic excitation and an efficient estimation of the resulting time, energy and frequency response. From those functions, the reduction of the initial diffuse field reverberation time due to the panel absorption can be evaluated, leading to the estimation of the frequency-dependent absorption coefficient of the simulated panel specimen according to the ISO standard. This was confirmed by a comparative test between simulated results obtained by the proposed method and published measurement data derived from a standardized test of a commercially available perforated panel.

Analytic solutions for systems and applications of complexity such as of the ones covered by the proposed approach, are beyond the capabilities of current computer systems. The proposed method, implemented in Matlab [20], introduces a flexible and practical alternative having far shorter and manageable computation time requirements than any Finite Elements Method (FEM) - based method. The following table shows the typical CPU computation time as function of N resonator elements for the numerical evaluation of resonator panel response using a FEM-based model (using Comsol Multiphysics [21]) and the proposed filter – based model. Note that from the publication date of the paper [18], a more efficient algorithm reduced the computation time even more, as shown in the table below.

	Number of Resonators			
	1	16	64	2500
FEM-based model	4 hours	17 hours	2 days	Not feasible
Filter-based model	5 sec	20 sec	2 min	18 min

Table 1. Typical CPU computation time as function of N resonator elements for the numerical evaluation of resonator panel response using a FEM-based model and the proposed filter – based model.

As discussed previously the proposed method is useful for estimating the distance and angle depended response of any arbitrary-sized perforated panel surface, not only having a given perforation ratio, but also potentially having any non-symmetric distribution of the resonator element array. Besides, the resonator elements may be unequally-sized, potentially leading to novel and optimized solutions for sound absorption.

Spyros Polychronopoulos *was born at Athens in 1980. Even from his youth, he was interested in sound as a physical phenomenon as well as in sound's artistic perspective (music). After his graduation from the Physics Department, he completed his PhD in Polytechnic department of University Of Patras on acoustics and he has published a number of papers. As for the artistic aspect of sound, he released 14 albums and conducted many concerts. He has also organised workshops and gave lectures regarding the new technologies in composition and aesthetics of music. He works at KP Acoustics, London.*

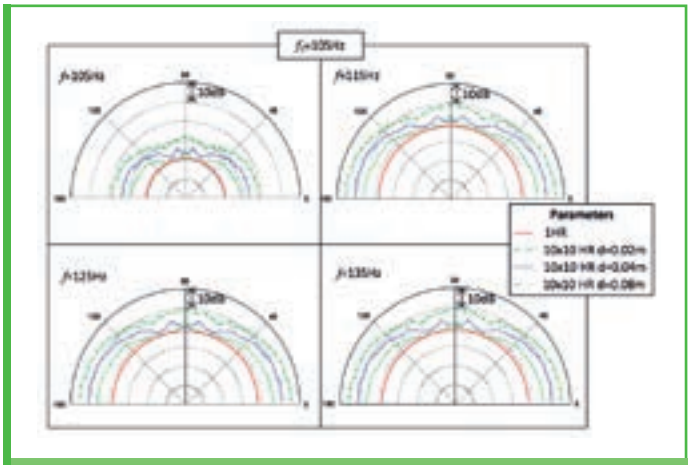

Figure 10. Polar diagram for various distances between the Hemholtz resonators and various frequencies (f=105Hz, f=115Hz, f=125Hz and f=135Hz) for resonance frequency f_0=105Hz

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LG Motion moves to take over Precision Acoustics

Motion control technology specialist LG Motion has acquired a controlling interest in ultrasonic measurement equipment manufacturer Precision Acoustics.

Existing shareholders Dr Andrew Hurrell and Dr Paul Morris maintain their interest in the company, whilst founder member and Managing Director Terri Gill has taken the opportunity to retire.

With 15 employees and annual sales in excess of £1.5 million, Precision Acoustics is a leading manufacturer of ultrasonic measurement equipment with an established worldwide customer base in sectors as diverse as medical equipment manufacture, industrial non-destructive testing, national standards metrology, academia, space and defence research.

The company has more than 25 years' experience in acoustic measurement and material development with an extensive competence for equipment for the MHz ultrasound markets with more than 75 percent exported globally. Its hydrophones, ultrasonic transducers, scanning tanks and other acoustic measurement products are used worldwide.

The continued product development and research implementation will be overseen by Dr Hurrell and Dr Morris.

The move will see Precision Acoustics, its products, offices and identity maintained, with the Dorchester site continuing to operate as a production and development centre for acoustic and ultrasound components.

Gary Livingstone, LG Motion Managing Director, said: "This is an excellent addition for LG Motion, and firmly strengthens our position as a market leader in the production of acoustic scanning tanks and motion technology. The move allows us to offer our customers a wider product portfolio, particularly in our positioning and scanning solutions."

Left to right: Andrew Hurrell, Paul Morris and Gary Livingstone

ISVR in tie-up with Chinese manufacturer to cut train noise

The University of Southampton has signed an agreement with Chinese high-speed train manufacturer CSR Qingdao Sifang (CSR Sifang) to establish a new centre for railway research and development.

The China-UK Rail Transit Technology Joint Research and Development Centre, which also involves Imperial College London and the University of Birmingham, will undertake research to develop new technologies, materials and manufacturing processes for high-speed trains and metros.

The University of Southampton's Institute of Sound and Vibration Research (ISVR) is collaborating with CSR, which has manufactured around half of China's entire high-speed rail fleet, on research and development into biodynamics and ride comfort, vibration and noise reduction, human factors and staff training.

The ISVR established an initial collaboration with CSR two years ago. Two joint projects on cabin active noise control and passenger sound quality are currently ongoing. The main focus of the new project is research into, and the development of, an active noise control seat to improve ride comfort and to reduce noise in the passenger's head area. The research will be conducted using the unique range of test facilities within ISVR's Human Factors Research Unit.

Dr Yi Qiu, Associate Professor in ISVR, said: "The implementation and outcomes of the project will help advance our understanding of the characteristics of passenger ride vibration and acoustics to develop better solutions for reducing vibration and noise to improve ride comfort for high-speed trains."

Professor Paul White, Director of ISVR, added: "We hope this project marks the start of a long and fruitful relationship with CSR Sifang working towards solving some of the engineering challenges associated with high-speed rail travel."

The multi-axis simulator at the Human Factors Research Unit where the research will be carried out

ROCKFON Sonar X edge ceiling tiles installed at school for autistic pupils

ROCKFON Sonar X edge ceiling tiles have been fitted at a London school for autistic children.

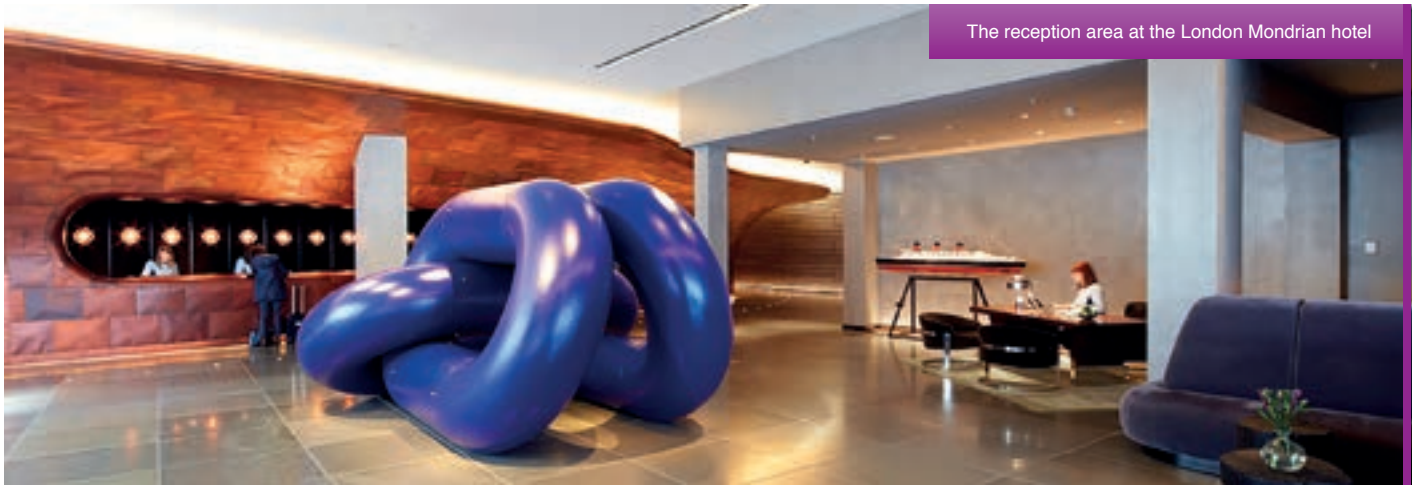
Charlie Graham, of StilSound ceiling installers, fitted the ceilings at London Queensmill School using Chicago Metallic T24 Click 2890 grid system.

"The interior is designed to create a 'low arousal' environment for the children who have complex autism, so they can learn in a calm state," he said.

"To meet this requirement, the Sonar X tiles were installed using a concealed suspension grid to avoid any discernible grid patterns which could become a distraction for the pupils."

New generation ROCKFON Mono Acoustic ceilings have been chosen for the reception, restaurant and bar areas of the new London Mondrian hotel on the south bank of the Thames in the former Sea Containers' HQ.

For more information ring **0800 389 0314**, email **info@rockfon.co.uk** or visit **www.rockfon.co.uk**



The reception area at the London Mondrian hotel

Theatre Projects opens new studio in central Paris

Theatre Projects has opened a studio in the historic Marais district of Paris to which it has recruited two senior acoustic designers, Seb Jouan and Victoria Chavez.

The pair will work with colleagues on international theatre design projects as well as provide standalone acoustic design services to architects designing sophisticated performance and entertainment spaces.

Current projects include the new Yves Saint-Laurent museum in Marrakech, the new Abu Dhabi District Lyric Theatre, the Weltmuseum in Vienna, the Casino de Paris and Folies Bergères in Paris, the next V&A exhibition and a recital hall for the Dublin National Concert Hall.

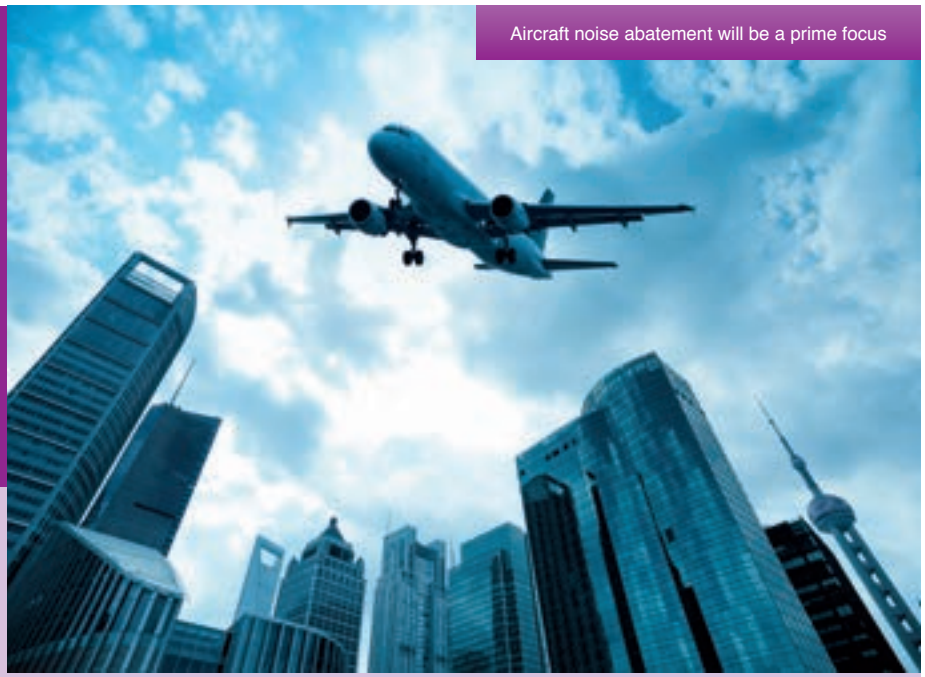
Seb was previously Regional Director of AECOM, where he led the Arts and Culture sector of the global acoustic team and its Middle East acoustic team. He started the Academic Alliance between AECOM and the University of York focusing on auralisation with the AudioLab. He also worked at Arup Acoustics for nearly 15 years, where he started and led in 2006 the acoustic team in Scotland as well as leading the Arts & Culture sector for Arup Scotland. His consulting work there included around 250 projects mostly in the performing arts sector. For Arup, he is also known for his work on the development of the SoundLabs in London and Scotland, for which he also acted as European spokesman.

Before joining Theatre Projects, Victoria worked at Xu Acoustique where she consulted on several cultural projects and led the acoustic team on the renovation of the Cannes Festival and Congress Palace, as well as Levallois Perret Conservatory of Music, and the Opera Building at Suzhou Culture Centre. Aside from her academic studies and consulting work, Victoria has contributed to several journals and conferences, including the 2008 Paris Acoustic Congress where she discussed the absorption of bass frequencies in the new Valladolid Symphony Hall. Victoria speaks English, French, and Spanish fluently.

Started in 1957, Theatre Projects has worked on 1,200 projects in more than 70 countries, ranging from studio theatres to performing arts centres.

Seb Jouan at the studio opening

Brüel & Kjær announce tie-up with US-based BridgeNet



Aircraft noise abatement will be a prime focus

Brüel & Kjær has announced a partnership with California-based BridgeNet International to deliver more products for airport customers in the new ANOMS (Airport Noise and Operations Monitoring System) Business Partner Network. It will expand BridgeNet's global reach and capitalise on the two companies' strengths.

ANOMS currently assists more than 250 airports around the world with noise abatement processes and effective community relations to better manage their impact on neighbouring communities. Incorporated into ANOMS, WebTrak delivers online real-time flight and noise information to the public for improved communication.

The first offering from BridgeNet is Flight 3D, which works with WebTrak to display flight tracks in three dimensions to make it easier for the public to visualize a plane's flight path relative to their location. Webtrak also makes it easier for users to understand airport-related information, such as noise and weather. Further offerings are in development and will be available later this year.

Baker Consultants wins North Sea noise and marine mammal monitoring contract

Baker Consultants Marine has been appointed by GeoSea project to provide underwater noise and marine mammal monitoring and mitigation during the construction phase of the Gode Wind 1 and 2 offshore wind farms in the North Sea.

GeoSea will undertake the foundation installation work for this DONG Energy project, which will see 97 Siemens wind turbines with a total capacity of 582 MW installed 45 kilometres off the German coast.

Passive acoustic monitoring

Baker, whose team is based in the Netherlands during the contract, will provide noise monitoring and noise mitigation advice throughout foundation installation of the 97 monopiles, as well as carrying out harbour porpoise activity monitoring and marine mammal mitigation and reporting on the efficiency of the mitigation strategy.

The wind turbines are expected to be fully commissioned in the second half of 2016 and, in total, the Gode Wind 1 and 2 wind farms will supply CO_2-free power approximately equivalent to the annual electricity consumption of 600,000 German households.

Baker's team will provide a comprehensive service at all stages of project development, from modelling potential impacts to informing the Environmental Impact Assessment and monitoring during construction.

Dr Federica Pace, Baker marine technical director, said: "Building on our successful work as part of DONG Energy's Borkum Riffgrund 1 project, we are delighted to be appointed by GeoSea to carry out noise and marine mammal monitoring and mitigation for the Gode Wind 1 and 2 offshore wind farms."

WSP | Parsons Brinckerhoff integration races ahead

As part of the recent acquisition of Parsons Brinckerhoff by WSP, its two acoustics teams are in the process of integration.

The combined WSP | Parsons Brinckerhoff team has more than 45 acousticians in six offices across the UK ,who are currently involved in projects such as Mall of Egypt, London Bridge Station redevelopment, multiple deep level Crossrail stations, power stations around the world and the East-West Rail Phase 2 project from Bicester to Bedford.

Martin Raisborough, Senior Technical Director at WSP | Parsons Brinckerhoff, said: "The fit of our two teams couldn't be any better. With Parsons Brinckerhoff's strong profile in energy and infrastructure, and WSP's historical track record in predominantly property and real estate, the combined capability and breadth of technical competence is something we are extremely excited about."

The company has also announced a new acoustics presence in East Anglia with the appointment of Toby Lewis and Gary Percival to its team in Cambridge.

Toby has more than 23 years' experience in local authority environmental health, with a significant track record in planning inquiries, expert witness and appeals, along with noise impact assessments for a large variety and scale of development, while Gary brings over five years of experience in predominantly building acoustics. He previously worked for WSP | Parsons Brinckerhoff in Australia.

Dr Jorge De Avillez has also joined the acoustics team. He has significant experience in vibration impact prediction and control and has achieved EngD status, having studied rail-induced vibration at Loughborough University.

Queen's Award for Enterprise for Applied Acoustic Engineering

Applied Acoustic Engineering has won the Queen's Award for Enterprise in the international trade category, for a second time. The award is in recognition of its outstanding achievement in boosting export revenues over three years of continuous growth.

"This is wonderful news for us," said Managing Director Adam Darling, "I'm pleased for everyone in the company because the recognition of a Queen's Award is about as good as it gets in business.

"We have competitors all over the world, so it's great to know that what we do in terms of engineering excellence, customer service and fast response technical support really pays off. It's a true team effort."

Applied Acoustics, which is based in Great Yarmouth, designs and manufactures underwater acoustic positioning, tracking and survey equipment sold mainly to the commercial offshore energy market but increasingly sales have been secured with oceanographic research institutions and naval defence industries.

The company exported to more than 61 different countries over the past three years, including significant orders received from Japan, USA and Germany. New agency agreements have been established in Turkey, Mexico, Brazil and Australia.

Atkins acoustics team is celebrating a half-century of project delivery

Atkins Acoustics Noise and Vibration is celebrating 50 years' of project delivery this year.

Led by Dr Inan Ekici, Atkins has 25 qualified acousticians working in environmental, transport, industrial and architectural acoustics as well as in public address and voice alarm system design.

Although it has many external clients, staff frequently work as part of Atkins' project teams, UK staff being based in Birmingham, Bristol, Cambridge, Epsom, Glasgow, London and Warrington and additional staff in Copenhagen.

In 1965, Atkins worked on the six-storey Albany Court building directly above St. James's Park underground station in London. A structural bearing was devised based on one Atkins developed in the 1950s that consisted of rubber sheets sandwiched between steel plates. Analysis by Roy Waller, the original Head of Acoustics, showed the rubber to be flexible enough to absorb vibration while the steel provided rigidity and strength. Atkins positioned such bearings in the building's foundations, thus attenuating the vibration reaching the main structure. This was the first building in the UK to be isolated from vibration in this revolutionary way, pioneering a system that is now frequently used in the industry.

Research undertaken by Atkins in the late 1980s formed part of technical advice in the Government's planning documents *Minerals Planning Guidance: The Control of Noise from Surface Mineral Workings* (MPG 11, 1993) and its Scottish counterpart *Planning Advice Note: Controlling the Environmental Effects of Surface Mineral Workings* (PAN 50, October 1996). Later work supported policy changes which resulted in the publication of *Minerals Policy Statement 2: Controlling and Mitigating the Environmental Effects of Minerals Extraction in England* (MPS 2, 2005).

In the early 1990s, in connection with the Channel Tunnel Rail Link, Atkins' measurements and noise modelling led to it giving evidence to the Commons Select Committee, which found in favour of its client and resulted in more extensive noise mitigation measures being provided.

Atkins developed in-house environmental noise modelling software from the 1970s onwards and in 2003 used it to produce what was then the largest and most detailed noise map in the UK, showing predicted road traffic noise levels over 1,600 square km of London.

More recently the team provided comprehensive acoustics advice for all Jeddah International Airport's buildings, including controlling noise from building services, mapping of environmental noise from air, road and rail traffic as well as ground operations and designing public address and voice alarm systems.

For the London 2012 Olympics Atkins provided design advice as part of a wide scope of work across the site. Other current infrastructure projects include the M25 motorway (on which the noise team has worked from original design in 1970s through to the current widening), Crossrail and HS2.

New centre for acoustic products development

A centre for polyurethane development is to be built by TMAT to create "the next evolution of acoustic products and solutions".

Jason Lippitt, Managing Director, said: "This is the kind of ambitious development we were all excited by the prospect of when Blachford Acoustics Group purchased TMAT in December 2014.

"We want to create the kind of environment and facility that will help our talented chemists thrive and develop game-changing acoustic solutions for global OEMs (original equipment manufacturers)."

The new centre, which will be at TMAT's Chesterfield headquarters, is expected to be completed within the next year.

TMAT is to build a new research and development centre

How loud is the silence of the lambs?

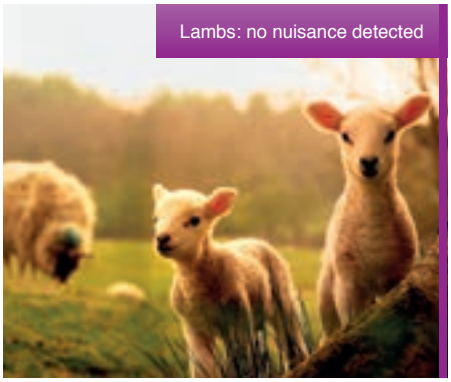
Noise consultant Louise Alderson has recently finished one of her most unusual assignments – monitoring the noise made by new-born lambs and their mothers.

Officials from a local authority in Cumbria called for a report in order to check if the animals' bleating would disturb residents on a proposed housing development on fields near the farm.

Louise used the Cirrus Environmental Invictus to take 2 x 24 hours surveys at different times of the lambing cycle. "Measured levels determined that there was no significant adverse impact," she said.

"The highest hourly ambient level over the 24-hour period was 53 dB LAeq but that was actually caused by helicopters overhead, the highest we got from the lambs was in the 40s."

She added: "You find these days that developers are being asked for more and more studies or evidence over issues such as environmental noise, particularly in rural locations. Some would seem almost comical but it is becoming more the norm to meet planning requirements and developers have to comply."



Lambs: no nuisance detected

Obituary

Dr Paul Fox (1966-2015): well-liked acoustician and signal processor who won admiration across Europe

Dr Paul Fox (1966-2015)

Dr Paul Fox, who passed away shortly before his 49th birthday, was an extremely well liked acoustician and signal processor who worked at several key institutions across Europe, *writes Tim Leighton*.

He was born on 11 May 1966. After schooling at Oakmeeds School, Burgess Hill, then Haywards Heath Sixth Form College, he was awarded a BA Hons and an MA (both in engineering science) at the University of Oxford in 1987 and 1995 respectively. He then moved to the University of Reading and in 1995 was awarded a PhD in cybernetics with the thesis title *A state space approach to multivariable deconvolution*. Sponsored by a Marie Curie award from the EU, he carried out research into limited diffraction beams for medical ultrasound at the Department of Informatics, University of Oslo, Norway (1998-2000). An accomplished linguist, he used his French, Spanish, Italian, German and English to work at the Technical University of Denmark, the University of Toledo, the University of Warwick and the University of Sydney.

Paul is extremely fondly remembered at the Institute of Sound and Vibration Research (University of Southampton) where he worked as a lecturer from 2005 to 2010. He showed great empathy in supporting students and colleagues, and was the first to volunteer when, for example, unexpected issues (such as staff illness) meant that a colleague, student or contract could be helped by his taking on extra load, often working evenings and weekends to help someone out. There was huge admiration and respect for the quality of his work, his dedication, and his loyalty and empathy.

After leaving Southampton Paul worked in Italy, at what is now the Centre for Maritime Research and Experimentation in La Spezia and after that he set up a consultancy in the private sector, first in Italy and then in Brighton. However, failing health made it increasingly difficult for him to work, and on 25 April he suffered a fatal brain haemorrhage.

Paul's tragic death has shocked the many colleagues, former students, and friends from around Europe, Australia and the USA, many of whom have expressed the enormous respect they have for the man, his work, his dedication to others and to completing the job, and above all his humanity.

Matt Simpson comes aboard at Baker Consultants

Matt Simpson

Matt Simpson has joined Baker Consultants as Senior Underwater Noise Consultant, where he will be applying his underwater acoustic experience to a range of marine projects, starting with Gode Wind offshore wind farm in the North Sea (see page 55).

Matt brings with him considerable experience and knowledge from his past roles: most recently as owner and principal consultant of Saith Acoustic Solutions, where he provided noise and vibration consultancy to the building, industrial and environmental sectors; and before that as a post graduate researcher in underwater acoustics and ultrasonics at the University of Southampton, where he previously studied acoustics with oceanography.

Federica Pace, Marine Technical Director at Baker Consultants, said: "We are delighted to welcome Matt to our team, as we continue to strengthen our expertise in bioacoustics."

Obituary

David Buchan (1969-2015): much-respected member of the Scottish building acoustics community

David Buchan (1969-2015)

With a background in construction David started his career in acoustics when he joined the A Proctor Group in April, 1996, *writes Chris Steel*. Initially he was the company's technical sales representative for the East of Scotland but he quickly developed an interest in acoustics into a specialism and excelled in the specification, detailing and sale of acoustic products.

In 2001 David took over as the Acoustic Associate for Proctors where he ran their acoustic test laboratory as well as being the acoustic technical advisor for the company. It was during this time that he undertook his Diploma in Acoustics and Noise Control at the IOA's Edinburgh centre as his work began to concentrate more on product development and testing. David's warm-hearted and reassuring personality made him a well-liked and well-respected member of the building acoustics community in Scotland and in the wider UK construction industry where he was always a welcome visitor on site or at design meetings. He also became a well-known face at many IOA events where he regularly manned the Proctor's stand giving advice on products and performance and regularly attending IOA Scottish Branch events.

He was elected an Associate Member of the Institute in 2004 and a Corporate Member in 2007. Despite his fame for often being a bit late – David once turned up late for a time management course – he was always very generous with his time and remained committed to his role in acoustics despite on-going health issues.

David will be greatly missed by all those who knew him and our sympathies are with his wife, Elayne, and their family.

Acoustics, Information, and Communication: Memorial volume in honor of Manfred R. Schroeder

Published by Springer and ASA Press.
Price £153 (hard cover), £122 (eBook)
ISBN 978-3-319-05660-9

Editors: Ning Xiang and Gerhard M Sessler

Review by Mike Barron

Many people, like myself, must have found Manfred Schroeder (1926 – 2009) an intriguing character. Prodigiously gifted and intelligent, he directed a renowned university department in Germany, while devoting his summers to working in the hot house atmosphere of Bell Labs in New Jersey. He was blessed with a highly original mind and a rich sense of humour. This book is a worthy memorial to his life and work. It takes the form of chapters by people who worked with him, followed by an autobiography which he wrote in the latter part of his life.

The major part of this book consists of 13 chapters on his various interests. Schroeder was fundamentally an applied mathematician but he chose to limit himself to acoustics. A remarkable feature was the breadth of topics with which he became involved. In most cases he made seminal contributions, as witnessed in my own field of room acoustics where he has left Schroeder decays (a preferred analysis technique for reverberation time derived from the room impulse response) and Schroeder diffusers (based on number-sequence theory). A particular pleasure of my early years was to discover a new paper by Schroeder, in which a new proposition was presented in a matter of a mere five pages or so; this could often revolutionise one's understanding of acoustic behaviour!

Many of his insights came from applying results from one field to another. He was sent a copy of a new book on the physics of vibration and was interested in a short chapter on Barker codes and maximum length sequences (p.271 in the book). He asked one of the book's authors whether he had thought about the spatial equivalent of these time sequences (he had not!). Schroeder had immediately realised that such structures could solve the problem of diffuse sound reflection.

The basic structure of the chapters is to provide a short history of Schroeder's contribution to the topic, including in some cases an account of the joint work by the author(s) with Schroeder, followed by subsequent developments. There are many riches to be found here, not least a demonstration of the breadth of Schroeder's interests. The following lists the topics covered, with the relevant authors (in several cases the chapter heading is not used as it is ambiguous).

Spatial audio and room acoustics (Joshua Atkins and James West), ray-tracing in acoustics(Asbjørn Krokstad, Peter Svennson and Svein Strøm), analysis of room acoustic decays (Ning Xiang), crossover time within room impulse responses (Guillaume Defrance and Jean-Dominique Polack), are impulse responses Guassian noises? (Jean-Dominique Polack), number-theoretic sequences in audio and acoustics (Ning Xiang, Bosun Xie and Trevor Cox), mathematics and perceptual acoustics (Armin Kohlrausch and Steven van de Par), neurally based acoustic and visual design (Yoichi Ando and Peter Cariani), Schroeder diffusers (Peter D'Antonio), reverberation theory and speech coding (Bishnu Atal), the electret microphone and beyond (Gerhard Sessler), acoustical impedance (Roland Kruse and Volker Mellert), underwater acoustics (Dieter Guicking).

At least as intriguing is the "autobiography" of Manfred Schroeder which occupies the final third of the book. It is no work of literature but offers a factual account of the more significant moments in his life and people with whom he worked; it makes for fascinating reading. Schroeder was born in Westfalia, the son of a mining engineer. It was soon apparent that he placed his interest in solving maths problems well ahead of any interest in playing ball games with his peers. He recalls quite a few schoolboy pranks: as a 15 year old he had built a radio transmitter for a system to listen into teachers' conversations in the school staff room, but one day he looked out of the window and saw an army radio direction finder parked in the courtyard; this was in 1941! Already in 1943 at the age of 17 he was engaged on war work, manning an anti-aircraft battery. A chance observation led to him being assigned to radar work, which dominated the rest of his time during the war. He ended up in 1945 on the North Sea coast of Holland, which luckily saw no fighting.

Though at heart a mathematician, he chose to study physics at Göttingen University where the "father of uncertainty", Werner Heisenberg, was a professor. He soon decided not to pursue quantum mechanics but rather to start with basic physics. When confronted by an experiment to measure the speed of light using a long electrical cable, he suggested a better method would be to connect the two ends of the cable via an amplifier and measure the frequency of oscillation, a method which worked like a charm. This brought him to the attention of the institute director, Erwin Meyer, who offered him a position as a graduate student on the spot! When it came to his doctorate, he was working with microwaves. However his supervisor, Meyer, was much more concerned with acoustics; the compromise title of his thesis became *The distribution of resonances in large rooms: experiments with microwaves*.

In 1954 Schroeder was offered a post at the hot house that was Bell Telephone Labs in New Jersey – "a dream place to start one's career". Bell Telephones offered positions to high flying scientists, who could study whatever they chose. They were well paid but the deal was that they did not personally benefit from patents they had initiated. This regime was highly productive; both the transistor and laser were invented at the Labs. Schroeder was responsible for 45 patents overall. Schroeder initially chose "speech" as his research area, a topic he continued on for the next 50 years. An overriding aim was to improve communication which involved developing such techniques as linear predictive coding; this is now fundamental to mobile phone operation. Much of the work was driven by the new possibilities offered by computers and early digital signal processing. Already by 1958 Schroeder had been made Head of the acoustics research department at Bell, to be followed by further promotion.

After 14 years working at Bell Telephone Labs, becoming a US citizen in the process, he was offered the position of professor at his old Göttingen university department, the Drittes Physikalisches Institut (Third Institute of Physics). He was, however, reluctant to sever his links with Bell and managed to arrange to do research with Bell when he was not teaching in Göttingen. So began a remarkable era from 1969 until 1991 when the stimulus of each environment fed off that of the other. The results were many impressive PhDs, alumni who are now professors themselves and ground-breaking research papers.

Reading this book will be particularly rewarding for those with interests in the more theoretical sides of acoustics, as well as for those who knew or are intrigued by one of the giants of 20th century acoustics.

Cirrus Research moves into vibration monitoring sector

Cirrus Research has moved into the vibration detection sector with the launch of its new Revo vibration meter.

It meets relevant industry standards such as ISO 5349 and European Directive 2002/44/EC as well as the ISO 8041:2005. It is also capable of measuring four channels simultaneously.

The instrument can also be used to measure whole body vibration to ISO 2631, as well as vibration on passenger and merchant ships to ISO 6954.

It typically comes as part of a complete measurement kit, which includes the accessories required to carry out hand-arm vibration measurements and handle mounts for the Triaxial Accelerometer. An extended range of accessories is also available, which allows it to be used in a wide range of additional applications.

In addition to the measurement of vibration for human exposure, the Revo can also measure three channels of FFT data. This is used to analyse vibration in machinery, vehicles and other vibrating structures.

The Revo can store up to 10,000 measurements, as well as up to 1,000 FFT measurements.

Marketing Manager Thomas Shelton said: "We have found that vibration monitoring was becoming more and more linked to our sector, so it was a natural progression to add vibration products to our portfolio."

The Revo vibration meter

Automatic calculation of noise barrier efficiency

Brüel & Kjær's Predictor-LimA noise mapping and prediction software can now automatically calculate noise barrier efficiency to identify inadequate barrier performance.

In addition, by modelling how well a noise barrier performs along the transmission loss spectrum, acoustic experts can more easily identify the most effective noise barrier for a specific location, it says,

"Efficiency calculations have always been critical to determine which walls and Sound Transmission Class (STC) rating is required – we've just made calculating noise barrier efficiency a whole lot easier," said Predictor-LimA Product Manager Doug Manvell.

"This new capability also provides a distinct advantage to experts seeking to demonstrate the need for a higher transmission loss barrier."

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


Noise barrier efficiency can be calculated automatically

Major updates for Norsonic acoustic camera

Norsonic has released new software for its acoustic camera, the Nor848a, which is available in different size arrays. The camera dish comes in 0.4m, 1.0 and 1.6m diameter sizes.

The camera works on a supplied Macbook computer and connects via a single LAN cable, with no conditioning boxes or additional power supplies required. It is lightweight and runs on 12v batteries so can be used for field applications.

It includes an "acoustic eraser" which enables the user to blank sections of the image from the calculations. This is useful where a dominating source is masking lower level sources, which may still be of interest.

The Norsonic acoustic camera in action

For more details go to **www.norsonic.com** The camera is available for sale and hire from **www.campbell-associates.co.uk** Tel: **01371 871030**

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Committee meetings 2015

DAY	DATE	TIME	MEETING
Thursday	16 July	10.30	Meetings
Thursday	30 July	10.30	Diploma Moderators Meeting
Thursday	13 August	10.30	Membership
Tuesday	8 September	10.30	Executive
Tuesday	**15 September**	**10.30**	**Council**
Monday	28 September	11.00	Research Co-ordination
Wednesday	7 October	10.30	Engineering Division
Thursday	22 October	11.00	Publications
Tuesday	27 October	10.30	Diploma Tutors and Examiners
Wednesday	28 October	TBA	CCWPNA Examiners
Wednesday	28 October	TBA	CCWPNA Committee
Wednesday	28 October	TBA	CCENM Examiners
Wednesday	28 October	TBA	CCENM Committee
Wednesday	28 October	TBA	CCBAM
Thursday	29 October	10.30	Membership
Wednesday	4 November	1.30	Education
Tuesday	10 November	10.30	ASBA Examiners
Tuesday	10 November	1.30	ASBA Committee
Tuesday	17 November	10.30	Executive
Thursday	19 November	11.30	Meetings
Tuesday	**1 December**	**10.30**	**Council**

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

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