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ACOUSTICS BULLETIN

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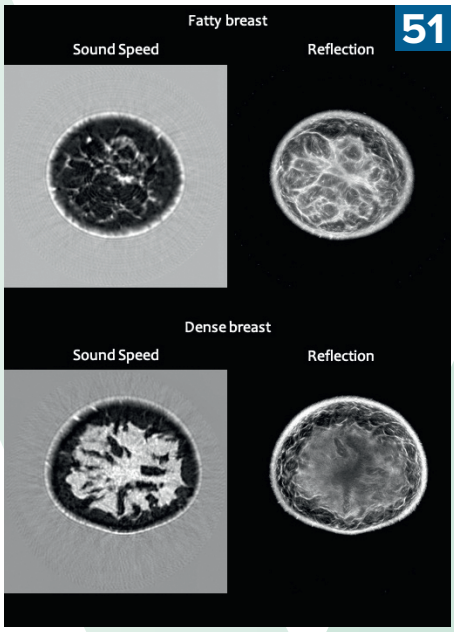

The Institute of Acoustics is the UK's professional body for those working in acoustics, noise and vibration. It was formed in 1974 from the amalgamation of the Acoustics Group of the Institute of Physics and the British acoustical Society. The Institute of Acoustics is a nominated body of the Engineering 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, electroacoustic, 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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Dear Members

Is structure-borne sound still the unheard acoustics? This question was asked by my colleague, Andy Moorhouse from Salford University, and me in 1995 in an article in the Acoustics Bulletin (Vol 20 (6), pages 21 to 26). While there has been much research since then, it still remains somewhat of a closed book to consultants who are more assured when dealing with airborne noise problems.

Why is airborne sound generation and propagation generally well understood by consultants? The answer is that source strength is characterised by the sound power level and there is a menu of standard methods for its measurement: e.g. in anechoic or reverberant chambers. The power obtained is assumed to be the same no matter where the source is located: outdoors, within rooms, inside ventilation ducts, etc. This is because the source surface vibration is almost always unaltered by its environment and radiates into the air, which has a constant impedance. (There are exceptions; such as when sources are tightly enclosed). Sound power level is all that is required, which then is combined with distance effects, ground, air and surface absorptions, screening, enclosure etc. to calculate the resultant sound pressure level.

What about structure-borne sound sources? A vibrating source will transmit vibrations into structures connected to it. A washing machine transmits vibrations into the supporting floor; the rotating drum transmits vibrations into the machine frame and mounts; the motor transmits vibrations to the drum, frame and mounts, and so on. Many so-called airborne noise problems are structure-borne in origin.

Mobility

How should such sources be measured and how can the data obtained be used by consultants to calculate the resultant sound pressure level for any installed situation? One could resiliently support the source and measure the vibration (free) velocities at the mount points when the machine is in operation. However, additional data is required on the structural characteristics at the contacts. This is conventionally given as the mechanical impedance, but its inverse, the mobility offers a useful alternative. Mobility (ease of motion) is the response velocity of a structure to an applied force. Examples of high mobility sources are fan units on thin steel support plates and plastic circulation pumps. Examples of low mobility sources are IC engines and heavy electric motors.

To add to the complexity of the problem, estimates also are required of the mobility of the supporting structure (the receiver) to which the source is connected. Examples of low mobility receivers in buildings are concrete floors and masonry walls. Examples of high mobility receivers are timber joist floors and plaster stud walls.

And there lies the problem: for airborne noise problems, only one source quantity is required; for structure-borne problems, two source quantities are required plus one receiver quantity.

Consultancies have developed empirical methods of predicting likely effects of installed machines and the performance requirements of isolators of course, but they do not always work.

UKAN vibro-acoustics course

For a full description, I suggest that while the free velocities of the machines must be measured, the source and receiver mobilities can be calculated using simple expressions. This is to be the core of one-day courses in vibro-acoustics, funded by the UK Acoustics Network (UKAN) as part of its programme of upskilling early career researchers and practitioners. There are other UKAN topics, such as big data and on machine learning, but I thought you might be interested in a topic I know something about.

Barry Gibbs, President IOA

Engineering Division

By Blane Judd, Engineering Manager

It continues to be a busy period for the Engineering Division providing support for members who wish to join the growing number of engineers professionally registered with the Engineering Council.

Professional registration at CEng or IEng continues to grow in recognition as a way to demonstrate to society and the rest of the engineering community that you operate at the level of professional competence and ethics expected in today's society.

The team here at the Institute of Acoustics work hard to provide the necessary levels of support to assist members like you, through the process. We are lucky to have a dedicated group of volunteers on the Engineering Committee who are willing to give candidates a steer on draft submissions. The Engineering Council are currently reviewing the current UK SPEC and we expect it to be launched next year. As more information on this emerges, we will keep you informed.

Late last year we were assessed by the Engineering Council for the renewal of our license to issue CEng and IEng, which we were granted for another five years (the maximum obtainable).

EngTech registration

We continue to work through the process of applying for a license to offer EngTech registration. This is a level of professional registration for those who can demonstrate that they:

- apply safe systems of work;
- contribute to either the design, development, manufacture, commissioning, decommissioning, operation or maintenance of products, equipment, processes or services;
- provide supervisory or technical responsibility;
- have effective interpersonal skills in communicating technical matters; and
- possess a commitment to professional engineering values.

Technician members of the IOA are most likely to be eligible to gain this level of professional recognition, so we need a group of volunteers to work with us as we put the necessary systems and processes in place to gain this license.

If you would like to be part of this group, please send us an email with 'EngTech' in the subject line and a brief career history to **acosuticsengineering@ioa.org.uk**

Next interviews

Our next round of interviews will take place in March 2020 and we have already identified the next people to go through the process. We hold a number of interview events through the year, depending on the number of candidates we have coming forward for registration. The team, ably supported by Emma, is working with a number of

candidates to prepare their paperwork in time for the next set of interviews later in the year. We can offer face-to-face interviews here at head office as well as at UK sites or by video link.

If you are interested in taking the next step to becoming a professionally registered engineer, contact us on **acousticsengineering@ioa.org.uk.**

Routes to qualification

The requirements for academic qualifications for CEng and IEng changed in 1999. Pre-1999 an Honours Degree at 2:2 or above was required for CEng or a Higher Diploma/Certificate for IEng. Post-1999 this changed and for CEng a Master's Degree was required or an Ordinary Degree for IEng.

There are two routes:

- Standard route, if you have the appropriate EC-accredited qualification in acoustics; and the
- Individual route, which requires further preparatory work from you before submitting evidence of your competence.

Remember, we are here to help you get through the process and advice and support is offered to every candidate.

Peer review process

The election process is overseen by the Institute's Engineering Division Committee, which is made up of volunteers from the membership, to whom we are extremely grateful. They represent the 300 or so members holding EC registration. They provide the essential peer review process that affirms that you are at the appropriate level for recognition as an Engineering Council Registered Professional Engineer.

For the individual route, the Institute accepts a number of courses in relevant subjects such as audio technology, from certain academic centres, as being equivalent to accredited courses for the purposes of EC registration, without the need for further assessment.

The Institute recognises the IOA Diploma course and the several Master's courses linked to it as providing evidence if you are looking to gain CEng registration. You could also offer a PhD qualification, depending upon the content of the associated taught element. We can also offer support for registration via a 'technical report' route, if you do not have the relevant qualifications to help demonstrate that you are working as a professional engineer in acoustics.

The opportunity is there and we are here to support you through it.

Successful candidates' profiles

Niall Smith CEng

I started my career as an environmental consultant before unexpectedly being asked to provide support in terms of noise monitoring for a construction and demolition project. That was an introduction to the world of acoustics!

I have been working for Aker Solutions as a noise and vibration control engineer in the oil and gas industry for some years now, I am the lead engineer/project manager of the noise control element for numerous oil and gas projects ranging in value from low millions to multi-billion-pound developments.

This role involves being the focal point for all noise-related activities, early involvement in the concept selection, specifying requirements for equipment, reviewing various options for equipment noise control, travelling offshore and modelling scenarios.

I have always been part of multidiscipline team with communication required to other team members' this also includes giving noise training and other presentations to team members. Some of my team are based in Norway and this means that I manage video conferencing for some meetings and presentations.

The next natural step in my career was to apply for Chartered Engineer status via the IOA. Blane Judd and the rest of the team at the IOA provided superb mentoring, advice and reassurance during the entire application process.

When interview day came around, I was nervous but confident as I knew how much time and effort I had invested preparing for the interview. I was interviewed by two engineers who asked a wide range of questions spanning my career to date, including all the evidence included in my professional review interview report.

Overall, it was a rewarding experience and I thoroughly recommend it to every engineer working within the acoustics industry. The IOA will give you all the support you need and will guide you through every step.

I feel very privileged to be a Chartered Engineer.

Approved Membership Applications

The Membership Committee reviewed 109 application forms on 16th January 2020 and 99 have recently been approved by the Council following the recommendations of the Membership Committee. Of the total, 39 were new members, 38 were IOA Diploma students, two members were reinstated and the remaining 32 had upgraded their membership.

MIOA

Helene Aasen	Dimitrios Kostovasilis
Stratton Barrett	Chi Pang Lee
Siu Leung Chan	Richard MacKenzie
Sei Him Cheong	Robert Martin
Sebastian Chesney	Julian Martinez
Joseph Conaghan	Rhodri Owen
Taylor Cooper	Luke Pickering
David Denham	Samuel Shapley
Elif Dirim	Yale Sherlock
Daniel Flood	Matt Stroud
Aaron Gutterridge	Kai Chung Tam
Timothy Hegan	Naomi Tansey
Joe Hornby	Zoe Vernon
Simon Jennings	Christopher Wright
Stephen Kearney	William Wright

AMIOA

James Abbass	Stephen Howells
David Al Mouallem	Cian Jones
Islah Ali-MacLachlan	Simon Joynes
Mohammed Alorayed	Hannah Karban
Cristian Anton	Samantha Lewis
Will Bailey	Jessy Liew
William Bladon	Robin Lloyd
Robin Bolt	Laura McLeod
Laura Broadley	Nicholas Messer
Andrew Bryan	Dan Moore
Hugo Caldwell	Jack Park
Rockwell Charles	Dennis Parks
Chris Clayden	Glen Plunkett
Christopher Conroy	Ipek Polat
David Courtney	Harry Rees
Holly Cowperthwaite	Michael Richardson
Adam Dixon	Karl Roberts
Jean du Marais	Irene Rodriquez
Rob Eadon	Tom Ryan
Samuel Elwood	Kathryn Salter
Ilaria Fichera	Rebecca Shaw
Adam Ford	Thomas Sohal
Stefan Fox Marshall	Daniel Sweeney
Rebecca Gabriel	Kaelyn Tan
Jashan Goodary	Eoghan Tyrrell
Jakub Hajko	Davide Vinci
Courtney Hawkins	Samuel Ward
Joshua Heenan	Sean Whelan
Andrew Hill	George Xanthoulis
Matthew Hill	Umut Yurdakul

Tech IOA

Fergal Denman	Seyedali Mirnajafizadeh
Matthew Lambert	Ryan Murphy
Keith McClung	Jago O'Sullivan

Affiliate

Jonathan Dance	Oshoke Ikpekha
Mason Ford	George O'Connor
Adam Freeman	Thomas Rusby
Ben Gray	Jack Tunstall
Matt Higgins	Alexander Wilson

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2020 Conference programme

Hear for Tomorrow
8th April 2020
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London

ACOUSTICS 2020
14th-15th May 2020
IOA Annual Conference, Exhibition and Awards
Chester

ICUA 2020
6th-10th July
Organised by the Underwater Acoustics Group
Southampton

Reproduced Sound 2020
17th-19th November 2020
Organised by the Electroacoustic Group
Bristol

For up-to-date information visit www.ioa.org.uk

International events for 2020

International Conference on Voice Physiology and Biomechanics (ICVPB)
16th – 20th March, Grenoble, *France*
icvpb2020.sciencesconf.org/

Forum Acusticum 2020
20th – 24th April, Lyon, *France*
Fa2020.universite-lyon.fr

The Nordic Baltic conference (BNAM 2020) will be held in
3rd –- 6th May, Oslo, *Norway*
www.bnam2020.org

179th Meeting of the Acoustical Society of America
11th – 15th May, *Chicago*
www.acousticalsociety.org

XXXVI Symposium on Hydroacoustics
26th – 28th May, Leba, *Poland*
euracoustics.org/

Quiet Drones. A Symposium on Noise from UASs/UAVs
26th – 27th May, Paris, *France*
www.quietdrones.org

13th ICBEN Congress on Noise as a Public Health Problem
15th – 18th June, *Sweden*
www.icben2020.se
11th International Styrian Noise, Vibration and Harshness (ISNVH) Congress
17th – 19th June, Graz, Austria
www.isnvh.at/

International Conference on Underwater Acoustics 2020 (ICUA 2020)
6th – 10th July, *Leonardo Royal*
Grand Harbour Hotel, Southampton
www.icua2020.org

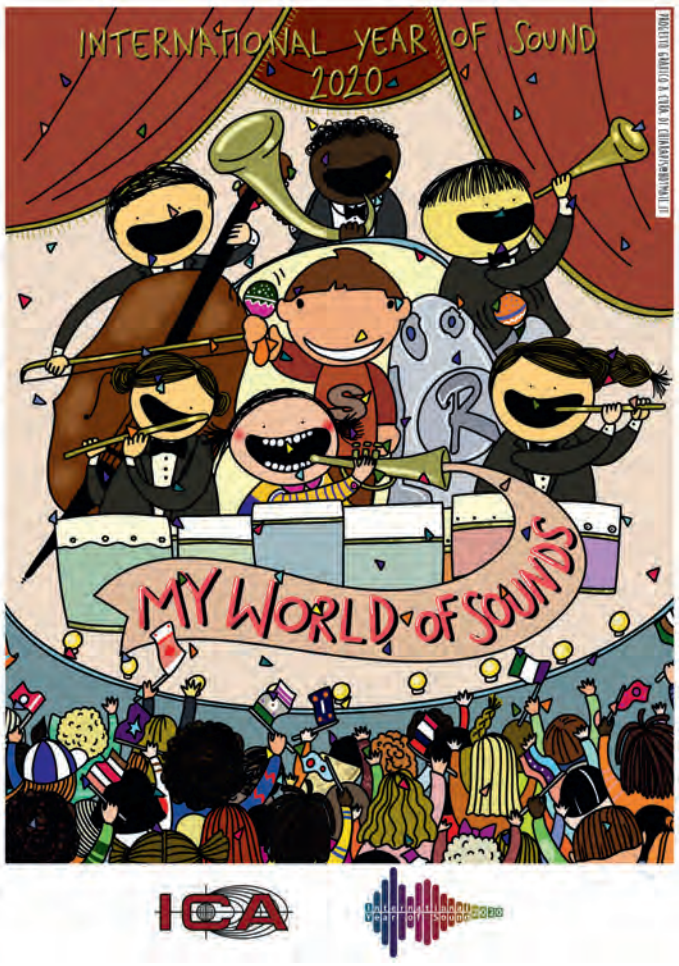
Czech Republic 27th International Congress on Sound and Vibration (ICSV27)
12th – 16th July, *Prague*
www.iiav.org

ICSV2020, International Congress on Sound and Vibration
12-16 July, Prague, Czech Republic
111.icsv27.org

49th International Congress and Exposition on Noise Control Engineering (INTER-NOISE 2020)
23rd – 26th August,
Seoul, Korea
www.i-ince.org

12° Iberoamerican Congress on Acoustics (FIA 2020)
20th – 23rd September,
Florianopolis, Brazil
fia2020.com.br/

180th Meeting of the Acoustical Society of America
9th – 13th November,
Cancun, Mexico
www.acousticalsociety.org



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IOA STEM activity

The Big Bang UK Young Scientists and Engineers Competition

The Big Bang Fair is the UK's largest celebration of science, technology, engineering and maths (STEM) for young people. The event at Birmingham's NEC attracts more than 80,000 visitors, mostly school age children, over four days in March.

The Big Bang Competition is open to 11-18-year olds to enter science, technology, engineering and maths projects. The 1,000+ projects entered are shortlisted in the run-up to the Fair, where the best 200 or so are invited to showcase their work. These projects are then judged for a series of awards including the coveted title of GSK UK Young Scientist and GSK UK Young Engineer of the Year.

Projects entered can be on any topic, and range from novel inventions to improve the lives of disabled people, polished design and technology products, research into alternatives to plastics and finding renewable energy sources, to apps and AI. There is always a good range of acoustics projects in science and engineering categories, with young people showing skills for building design, DSP, coding and so on.

In 2019, the top award of GSK UK Young Engineer went to an acoustic project; Music Splash. Grace Lord, Aalia Sellar and Brendan Miralles, students aged 14 and 15 from Loughborough Schools Foundation, developed a music teacher in a phone/tablet app that uses machine learning to analyse a music performance and provides feedback to help musicians improve their technique.

Above: The Big Bang Fair is the UK's largest celebration of science, technology, engineering and maths (STEM) for young people

Below: (L-R) GSK UK Young Engineers, Grace Lord, Brendan Miralles and Aalia Sellar from Loughborough Schools Foundation

You can read about what the students all went on to do here: **https://www.thebigbangfair.co.uk/news/blog/following-this-years-competition-winners-on-their-engineering-adventures/**. They also attended the China Adolescence Science and Technology Innovation Contest (CASTIC), an international competition in Macau, and won a silver medal.

Judges

Over the past few years, Nick Treby (Spectrum Acoustic Consultants) has been one of the judges/moderators, and he will be joined this year by Helen Sheldon (RBA) and Vicky Stewart (Atkins). Judges support all levels of the programme (regional heats, online judging and finals) throughout the year.

Every year, the high standard of project work that young people achieve either working individually or in a small group is astonishing to see. The children are able to speak enthusiastically about their project, and soon forget their nervousness at being judged when asked a question about the source of their idea, or how they solved tricky problems. Even where projects are not prize-winners, judges are able to inspire and motivate the students, helping them to feel comfortable and enjoy themselves, assess projects against agreed criteria (such as project concept, process, outcomes and personal skills) and provide them with invaluable positive feedback to further develop their work.

There are many cases where a non-prize-winner one year has acted upon their feedback and returned as a prize-winner the next.

How you can get involved

There are plenty of ways to get involved in The Big Bang Fair and Competition — every year the organisers need companies, activity providers and education institutions to share their enthusiasm, insight and expertise to help young people discover the wealth of careers opportunities available in science and engineering. **https://www.thebigbangfair.co.uk/get-involved/become-a-sponsor/**

And volunteers are always needed – such as judges and 'careers captains' or people interested in helping out with activities and research: **https://www.thebigbangfair.co.uk/get-involved/volunteer-with-us/**

The Big Bang Fair is the UK's largest celebration of science, technology, engineering and maths (STEM) for young people

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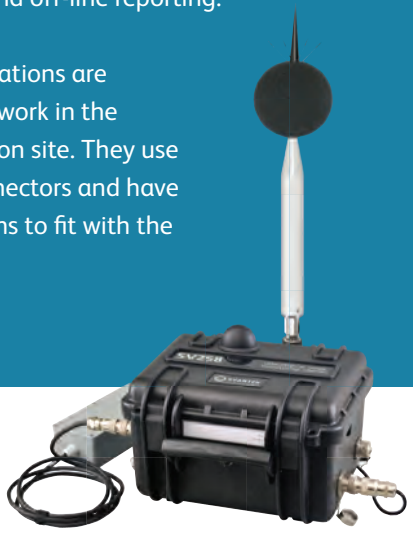

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Building Acoustics Group meeting report - open plan office acoustics

By Building Acoustics Group member, Andrew Parkin, partner and global head of acoustics at Cundall

On 5th December 2019, around 100 people gathered at Austin Court in Birmingham to spend a day considering the acoustics of open plan offices. A number of papers were given by practitioners in the field and good discussion was held in break times, at the end of each paper and in the panel discussion at the end of the day.

Andrew Parkin welcomed everyone on behalf of the IOA Building Acoustics Group and the first paper was given by Paige Hodsman of Saint Gobain Ecophon, on the subject of 'Interior design, psychoacoustics and ways of working'.

This set the scene for the day, explaining how our current ways of working have developed over the past 100 years or so, and that office design actually came out of factory working — developing along with technology.

Good acoustics in the workplace are key to attraction and retention of talent, as poor acoustics lead to working conditions that can make carrying out the simplest of tasks difficult; poor acoustics can also lead to increased absenteeism and mental health issues. Workers like to have a sense of control over their environment and therefore a choice of working styles and spaces is a key to good design. Modern trends in biophilic design are bringing interesting challenges and opportunities for acoustics practitioners with the use of natural materials and soundscaping.

Challenges and limitations of open plan working

Ian Rees of Adrian James Acoustics followed with a paper on 'Acoustic modelling of open plan working – challenges and limitations'. He discussed the use of modelling software (specifically CATT Acoustic) as a tool for predicting acoustic conditions within open plan offices. When there are no partitions or dividing spaces then the propagation of sound and how it is affected by the room is the key consideration.

The move away from suspended ceilings brings challenges in modelling as discrete rafts and baffles can be complex acoustic objects which can over-complicate models if considered in high levels of detail.

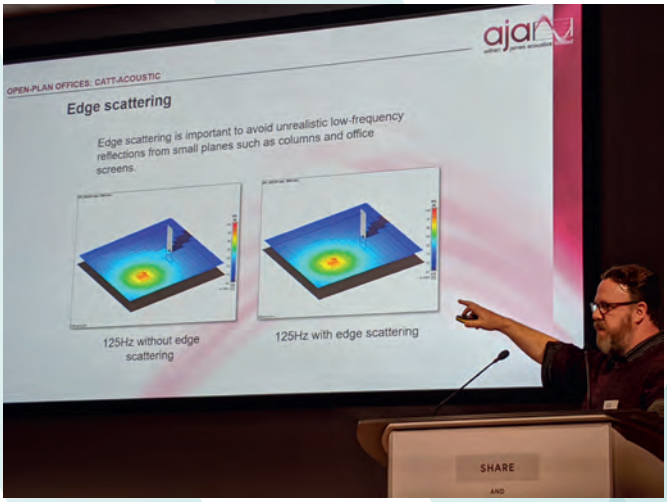
Scattering also plays a significant part in the propagation of sound, not just at suspended absorbers but at desk screens, VDUs and furniture etc. Ian provided useful tips and tricks for practical modelling of rafts and baffles.

Below: The recent Building Acoustics Group meeting at Austin Court, Birmingham

ISO 3382-3

Richard King and Ben Southgate of Sandy Brown Associates gave a paper on 'Modelling, designing and commissioning offices using ISO 3382-3'. ISO 3382-3 has been in circulation for many years but has only recently been adopted in the UK as a design tool. Its parameters are varied and complex, making prediction and modelling difficult. Some descriptors such as Distraction Distance (r_D) can be shown graphically to demonstrate how office users may be impacted by people speaking.

Auralisation and other advanced simulation techniques can be used to demonstrate to clients and stakeholders how effective partitions between offices will be. Uncertainty in testing to ISO 3382-3 was discussed, also discussed was the fact that STI rates higher objectively when using directional sound sources.



Soundscaping

Matthew Hyden and Momo Hoshijima of Cundall presented a paper on 'Soundscaping and speech masking'. Soundscaping as a concept and tool has been around for many years in the office market, but the use of natural sounds and soundscapes for the purposes of speech masking is an emerging subject.

When non-anonymous sounds (e.g. sea, birdsong, water, rain and wind etc.) are used, then visual cues are important to consider, both in terms of room finishes and displays. Research carried out in Cundall's London office found that soundscapes where there is the least variation in level and spectral content are the least noticeable and, therefore, result in the least distraction. Where there are noticeable features to soundscape, this can cause distraction and annoyance which could cancel out the benefit otherwise gained by the soundscape.

The Mailbox case study

Next was James Healy from WSP who delivered a case study of the recent re-fit of WSP's Birmingham office. WSP moved into The Mailbox, a former Royal Mail sorting office with 5.6m high soffits. No ceiling or other absorption is provided except for locally by means of furniture but James explained how the conditions did not adversely impact on their activity-based working.

Ambient noise levels during a typical day are between 50 and 55 dBA when occupied; the constantly high noise level provides self-masking of speech without invoking the Lombard effect. Phone booths, working pods and meeting rooms are available for private discussions and tasks requiring high levels of concentration.

Subjective response by office workers

Jack Harvie-Clark of Apex Acoustics gave a paper on 'Open plan offices beyond ISO 3382-3: designing for acoustic satisfaction'. Jack looked at rating methods outlined in ISO 3382-3 and compared them with reported subjective response by office workers, illustrating little correlation between the parameters and worker satisfaction. Jack discussed a case study that demonstrated how office workers report highest levels of satisfaction when they have a choice over their working environment, e.g. in an activity-based working environment. Jack suggested that workers may be less sensitive to noise in an activity-based working environment, with the benefit of control over their place of work.

Alternative design descriptors

Next was Angus Deuchars of Arup who presented on 'Towards designing open plan office for predictable perceptual outcomes'. Similar to the WSP offices, the Solihull Arup campus has no sound absorption from room finishes. Typical daily average noise levels are 52 dBA with occupancy between 50 and 70%. Subjectively, the working environment is acceptable and does not adversely impact on worker's ability to do their job. Angus commented that most of the research behind ISO 3382-3 stems from Scandinavian studies which focus on annoyance – Scandinavian methods of working do not necessarily correlate with those in the UK. Rather than focusing on any noise being bad, Angus discussed the use of 'vibrancy' and 'relative calm' as design descriptors and to assist in workplace planning.

The forthcoming ISO 22955

The final paper was presented by Andy Parkin of Cundall on a 'Review of forthcoming ISO 22955'. For the past three years, an international panel has been writing a new ISO on Acoustic Quality of Open Office Spaces; the document is now a completed draft and is with ISO for final sign-off.

The document is based on a French standard but has been adapted to make it more universally applicable; regional variations are significant though, both in terms of working style and expectations, which have resulted in significant compromise. The new ISO will give guidance on how to design open plan offices for various stages (e.g. Shell & Core, Cat A and Cat B) and types (e.g. autonomous working, activity-based etc.) and introduces new metrics such as $D_{A,S}$ which is an in-situ level difference between source and receiver locations, in addition to values assigned to metrics from ISO 3382-3. Subject to final sign off, this document should be published in late 2020. It will be interesting to see how this document is adopted in each market, especially considering the significant variance in design and operational requirements in different countries.

At the end of the papers all the speakers took part in a panel discussion, where various points raised throughout the day were discussed. Hot topics such as speech masking were also discussed; the UK market is becoming more disposed to these systems, whereas some European countries remain sceptical.

Above left: Paige Hodsman of Saint Gobain Ecophon

Above right: Ian Rees of Adrian James Acoustics

Environmental Noise Group Annual Report 2019

In October 2018 the World Health Organization published its Environmental Noise Guidelines for the European Region. The guidelines, in part, replace the 1999 Community Noise Guidelines and augment the Night Noise Guidelines 2009.

A conference was held in January 2019 with invited speakers to provide insight into how the guidelines were developed and what they mean, followed by debate on the strength of the evidence base and their possible implications in the assessment and management of environmental noise in the UK in years to come. 140 delegates attended and the key points discussed were published in the March/April 2019 issue of Acoustics Bulletin.

The Environmental Noise Group held a well-attended session at the annual conference in Milton Keynes in May 2019. More than 100 members attended the environment noise sessions, which focused on the WHO Guidelines, tranquillity assessment, planning, aviation noise policy and low frequency noise.

At the Annual General Meeting, Robert Miller left the committee and we would like to thank him for his enthusiastic contribution as young members' representative. Robert is replaced by Toby Walton of RBA Acoustics.

Committee members

Steve Mitchell, chair
Nicole Porter, secretary
Tony Clayton, member
Dani Fiumicelli, member
Colin Grimwood, member
Claire Parsons, member
David Waddington, member
Somayya Yaqub, member
Toby Walton, member (young persons' representative)

World Health Organization

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Sound Masking is also known as sound conditioning or white noise systems

2019 A B Wood medal awarded to Julien Bonnel

For his innovative approach to signal processing of broadband acoustic data in ocean environments, the IOA is delighted to present Julien Bonnel with the 2019 A B Wood Medal.

The A B Wood medal and attendant prize is awarded in alternate years to acousticians based in the UK/Europe (even years) and in the USA/Canada (odd years). It is aimed at younger researchers, those who are aged under 40, whose work is associated with the sea. Following his graduation from Manchester University in 1912, Albert Beaumont Wood became one of the first two research scientists at the Admiralty to work on antisubmarine defence. He designed the first directional hydrophone and was well known for the many contributions he made to the science of underwater acoustics and for the help he gave to younger colleagues. The A B Wood Medal was instituted after Albert's death by his many friends on both sides of the Atlantic and was administered by the Institute of Physics until the formation of the Institute of Acoustics.

Citation

A common requirement in ocean acoustic applications is for robust signal processing algorithms that take into account the complex ocean environment, which is variable in space and time. Julien Bonnel's research has provided the most innovative approach to signal processing of broadband acoustic data in the last decade: time and frequency warping.

Warping is a non-linear signal re-sampling method, based on a physical model of the shallow water sound channel, which compensates for dispersion in the propagating modes. The technique extracts the propagating modes from broadband signals in shallow water at significantly shorter ranges than previously possible, using data from only a single hydrophone.

The technique he has developed has applications in two important areas, geo-acoustic inversion in shallow water environments and passive detection and localisation of marine mammals. An example of the latter is the localisation based on whale vocalisations, to enable estimation of the animal's depth in the water. The method has been successfully applied to obtaining the range and depth of Bowhead Whales in the Chuchki Sea and North Atlantic Right Whales in the Bay of Fundy.

Above: Julien delivering his A B Wood Medal and prize lecture

Below: Julien receives his award from Victor Sparrow, President of the Acoustical Society of America

Julien continues his research in geo-acoustic inversion to develop methods for extracting modal wavenumbers from short horizontal arrays. Of significant general interest is his work on re-formulating the modal filtering technique for sound channels with different dispersion characteristics.

Julien Bonnel is a most promising early-career research scientist who has introduced innovative methods that have led to significant advances in ocean acoustics. The research community has benefitted from the use of his methods and he has done this within a few years of completing his PhD. Importantly, he continues to produce innovative research to improve the methods that he has already developed.

The deadline for nominations for the 2021 award is 1st October 2020 **https:/ /www.ioa.org.uk/about-us/awards N.Mistry@soton.ac.uk**

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Every delegate at the launch will receive a copy of the book and further copies will be available on the day, at a discounted price.

If you cannot attend the launch you can order a copy, via the ANC website, from April 2020.

To find out more about joining ANC go to www.theanc.co.uk/membership

ANC ACOUSTICS & NOISE CONSULTANTS

REPRODUCED SOUND 2019

Creating engagement in sound

By Adam Hill

The 35th annual Reproduced Sound conference, organised by the IOA's Electro-Acoustics Group (EAG), took place in Bristol from 19th to 21st November, 2019. The conference represents the cutting edge of modern audio and acoustics in an informal environment that allows consultants, manufacturers, contractors, end users, academics and students to mingle and share insights and information.

Organisation of the conference was led by EAG chair, Keith Holland (ISVR, University of Southampton), supported by the 10 committee members and the IOA's Linda Canty. A full audio-visual system was provided by EAG committee member, John Taylor (d&b audiotechnik), along with a number of his associates. d&b audiotechnik have generously supported Reproduced Sound in this manner for a number of years, to the great benefit of the conference.

Above: The conference dinner was held aboard Brunel's S.S. Great Britain

The conference primarily took place at the Bristol Hotel (Reproduced Sound's second year at this location), with visits to Brunel's S.S. Great Britain and Colston Hall. The delegates numbered nearly 100, representing a good balance between industry and academia. P22

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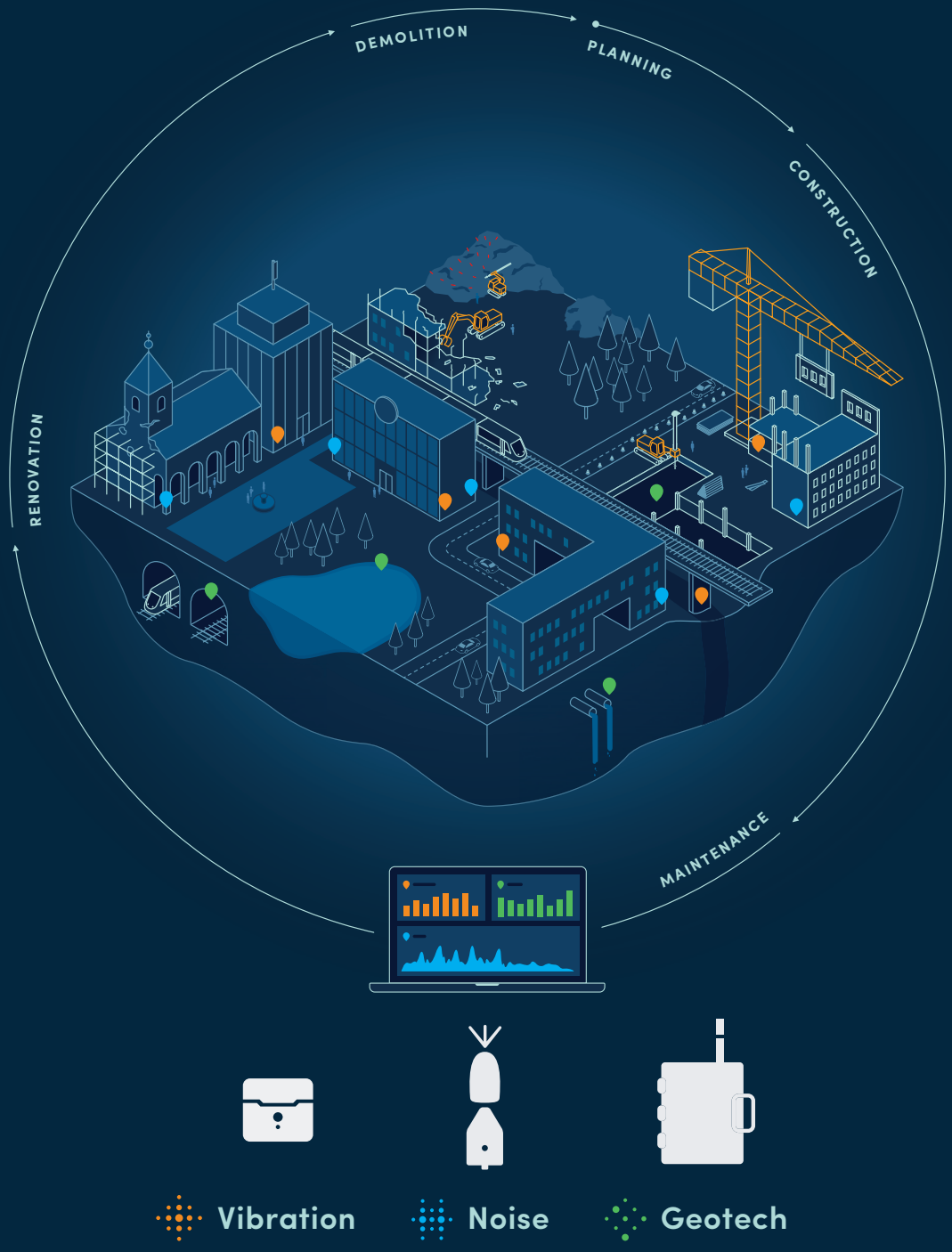

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Pre-conference activities

Although the conference wasn't set to officially open until the following morning, Reproduced Sound often includes a special event the evening before the conference, consisting of a more informal talk and demonstration from a member of industry or academia.

This year, the evening session was hosted by Funktion One, led by company founder, Tony Andrews. Tony opened the evening by talking about Funktion One's design philosophy, their view is that speakers should sound good from their inherent design, not heavily relying on corrective equalisation.

The audience was able to listen to a number of tracks through each of the Funktion One systems that were set up in the room. This began with a compact system consisting of two 5" full range speakers and an 8" subwoofer. The subwoofer performed well for its size, producing bass that could be felt as well as heard. The audience was encouraged to walk around the room as the speakers were auditioned.

The demonstration then moved on to audition a 10" two-way stereo pair of loudspeakers with an 18" subwoofer, followed by a recently developed, full-range horn-loaded system. Before playing the new system, Tony alluded to the importance of speaker efficiency as part of the design process – a topic later covered in one of the conference papers presented by Funktion One engineer, James Hipperson. Finally, there was a demonstration of two large-format horn-loaded loudspeakers with a single 24" horn-loaded subwoofer. This had no problem shaking the room.

The event was well attended and had the usual convivial Reproduced Sound atmosphere, providing a great opening to the conference.

Below: Prof. Francis Rumsey addresses the conference after receiving the Peter Barnett Memorial Award.

Conference – day one

The first formal day of the conference was kicked off by EAG chairman, Keith Holland, welcoming delegates and giving them a general background and history of the event, including its organising committee from the EAG. Keith noted that he was particularly pleased to see a good balance between familiar and new Reproduced Sound attendees. This certainly bodes well for the future of this conference.

Peter Barnett Memorial Award – Professor Francis Rumsey

Keith handed over the floor over to IOA president, Professor Barry Gibbs, for the presentation of the Peter Barnett Memorial Award. This award, which is made annually, recognises advancements and technical excellence in the fields of electro-acoustics, speech intelligibility, and education in acoustics and electro-acoustics. The recipient of this year's award was Professor Francis Rumsey for his significant contributions to knowledge and education surrounding the areas of sound quality, spatial audio and psychoacoustics.

After the award presentation, Francis delivered a captivating talk entitled 'Psychoacoustic quality evaluation in the context of interactive sound and virtual reality'. Francis focused his talk on sound quality in regard to emerging virtual/augmented/cross reality formats, stressing that audio quality must be evaluated in respect to how it impacts on the overall (often interactive, multi-modal) experience. P24

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Ultimately, we need to shift from a focus on quality, to a focus on quality of experience (QoE) when dealing with multi-modal immersive media platforms.

Numerous issues exist with audio quality evaluation, where in many cases the experimenters are evaluating characteristics that normal people don't find important. It has been found that in some cases it is most instructive to let test participants decide what's important (although this may lead to more difficult results analysis). It's also important to note that what listeners do in these evaluations is often more important than what they say.

Ultimately, we need to shift from a focus on quality, to a focus on quality of experience (QoE) when dealing with multi-modal immersive media platforms. In such situations it has been found that audio adequacy is often more important than audio fidelity, which is quite different from the approach taken by most audio professionals.

Overall, Francis pointed towards a collection of current and future research spanning many different disciplines that is showing promise of resolving current issues with psychoacoustic quality evaluations. Francis' talk was followed by questions and comments from the audience, sparking an engaging discussion, which flowed nicely into the first refreshments break of the day. (A full report of Francis' award was published in the January/ February 2020 issue of Acoustics Bulletin).

Session 1 – Room acoustics and measurement (Chair – Paul Malpas)

Acoustic and audio survey of English churches

The first paper of the day was given by Peter Mapp on a recent survey he had conducted on small English churches. The survey was carried out due to the lack of data on such churches, which are commonly found in most small towns and villages. Inspecting data from the 11 churches measured, it was clear that the RT60 characteristics weren't comparable to those of large churches.

In most cases, there were few serious problems identified in terms of the acoustics of the churches (generally around 6-10m^3/seat, which is within recommendations, with nave widths of 10-15m). In some cases, surprisingly high STI values were measured in the back row of seating without any sound reinforcement. Problems arose when the sound systems were turned on, where in many cases, the sound reinforcement made intelligibility worse (although it made the STI more even throughout the venue). Additionally, issues were P26

Below: The 35th annual Reproduced Sound conference was held at the Bristol Hotel

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identified with most assistive listening loop systems tested (generally too low in level with significant mains hum present). Session chair, Paul Malpas, thanked Peter for his "inspiring" talk.

Acoustic design criteria for higher education learning environments
Next on the schedule was a paper given by Sebastian Duran from Solent University. Sebastian spoke about a study that looked into the audio and acoustic performance of five teaching rooms. In most cases, the room measurements were shown to comply with BB93 (although this standard doesn't directly apply to higher education) in terms of STI, sound level and background noise, but nonetheless, were deemed problematic by staff and students (64% of the staff surveyed reported vocal fatigue from teaching in these rooms). While the research pointed to further work required, some general recommendations were suggested, focusing on the need to specify design criteria in relationship to the room volume and use.

Condenser microphones and factors that affect their sound
The final paper of the session was delivered by Hans Riekehof-Böhmer from Schoeps. Hans' presentation was instructive on what influences microphone performance, with an emphasis on practical environments. He stressed the importance of room acoustics and background noise, as well as how essential it is to get the on- and off-axis frequency responses of a microphone to be in agreement (which is easier with small diaphragm microphones). This was highlighted with an instructive comparison of integrated polar responses, which were derived from diffuse field responses of the microphones under test. Supercardioid microphones showed a flat response, indicating they would perform well in most acoustic environments.

Overall, Hans emphasised that a full set of technical information is required to make proper comparisons between microphones, which some manufacturers don't make available. He also noted that non-audio/acoustic-related factors have been shown to influence the perceived sound quality of a microphone (brown microphones sound the best, green sound the worst). This specific point caused a very lively discussion in the audience after the paper and carried on into lunch.

non-audio/acoustic-related factors have been shown to influence the perceived sound quality of a microphone (brown microphones sound the best, green sound the worst).

Diversity (chair – Mark Bailey)
Prior to the first paper session of the afternoon, Mark Bailey led a discussion on diversity, where the IOA has set out the aim to increase diversity across its membership and for the electroacoustic community in general. Mark (and the rest of the audience) noted that this is a difficult challenge and one which cannot be solved by a single event or organisation. The general consensus was that the key was to provide equality of opportunity, with care taken to avoid unconscious biases whenever possible. It was suggested that reasonable targets should be set (possibly over 10 years) to help the sector move in the right direction. The feeling in the room was that everyone present was supportive of this initiative and would value greater diversification in the workplace.

Session 2 – Signal processing and audio coding (Chair – Glenn Leembruggen)

Optimal source distribution for multiple listener virtual sound imaging
The first paper of the afternoon was presented by Philip Couturier from ISVR, University of Southampton. The primary challenge of this project was to identify the best possible discrete source distribution, based on an approximation of the optimal source distribution for multiple listeners. Philip presented results from simulations using three to five listening location for various loudspeaker layouts. The results indicated that the optimisation routine showed promise, although there were currently no considerations for room acoustics or head shadowing, which may influence the performance of the system. While some audience members expressed concerns about the practicality of such a system, Philip highlighted the next steps for this research project, which focus on improving the accuracy of the algorithm, making practical implementations more feasible.

HRTF model comparison in inverse filter design for crosstalk cancellation
Jacob Hollebon, also from ISVR, University of Southampton, delivered the next paper, which looked into identifying the best-performing HRTF model for use in crosstalk cancellation. Three types of models were investigated here:

- in-situ;
- free field monopole; and
- rigid sphere.

The in-situ would give perfectly accurate results, with the other two providing imperfect solutions. Since in-situ isn't necessarily practical for everyday use, it was essential to determine if either of the other two models were sufficient for these purposes. The results were best demonstrated with a live auralisation presented to the audience over headphones. All three models were auditioned without the audience being aware which was which. After listening to the three samples, the delegates were polled to determine the favourite. There was a 50/50 split in the audience. Half preferred the in-situ HRTF (which wasn't surprising), while the other half preferred the rigid sphere model, thus giving strong indication that this model may be sufficient for practical applications of crosstalk cancellation. P28

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Introduction to sparse, or compressive, sampling for audio and acoustics

The third paper of this session was presented by Professor Jamie Angus from the University of Salford. Jamie's paper was in the format of a tutorial, looking into the possibilities of sampling an audio signal below twice the Nyquist frequency, where she stressed that Shannon's sampling theory has terms and conditions and it isn't the only possible method for signal sampling. The key for this so-called sparse sampling is the density of the audio signals. Sparsity of the signal leads to predictability. The term 'innovation' was used to represent the surprise factor of an audio signal, where the rate of innovation defines the required sampling rate. Essentially, the question is what is the minimum number of samples required to explain an observation. Jamie noted that such an approach is regularly used for sampling of images. The key here is to use incoherent sampling, rather than regular sampling, along with a reconstruction optimiser.

Extended-band audio coding exploiting spectral-domain sampling-rate conversion with embedded ultrasonic data

The final paper of the session was delivered by Professor Malcolm Hawksford from the University of Essex. Malcolm described a new audio coding technique that he developed which does away with the need for an anti-aliasing filter and allows for spectral content above the Nyquist frequency to be embedded in the digital signal. To achieve this, spectral matching was utilised over short audio frames (16-32 samples). 16 bits of the digital signal are dedicated to the audio content below Nyquist (so that the coded audio will be compatible with standard PCM coding for CDs) with an additional eight bits used for the ultrasonic content (which can be scrambled to act as dither within a DAC). Malcolm showed how down sampling using this approach is virtually immune to aliasing distortion due to this spectral matching approach.

Below: Prof. Malcolm Hawksford explains a novel form of audio coding.

Session 3 – Assisted listening (Chair – Robin Cross)

Assistive listening systems in theatres

Ian Rees from Adrian James Acoustics kicked off the next session on assisted listening with a paper looking into the use of assistive listening systems in theatres. Ian highlighted the widespread issue with such systems at present, where it has been found that many people requiring assisted listening systems attend theatre less than they would like due to frustrations stemming from poor sound quality. There are a number of factors contributing to the poor quality sound coming from these systems. Problems stem from inappropriate mixes from the sound desk, poorly positioned microphones, and lack of audience microphones (making users of these systems feel isolated). A simple way to start making these systems more useable is to actually listen to the system (it is surprising to learn how rarely this actually happens). Ian's presentation sparked a lively discussion from the audience, where various points were made on the practical issues faced with assisted listening systems and some suggestions for possible improvements. The audience agreed, though, that the situation at present is dire.

Quality evaluation of microphones used for lecture capture in universities

The second paper of the session focused on the common issue of poor speech intelligibility on university lecture recordings. The paper was presented by Rodrigo Sanchez-Pizani from London South Bank University. Rodrigo presented the results of tests he and his team carried out looking into how various microphone types and placements impact the quality of lecture recordings. The tests gave unclear results, indicating that there is more to learn in this area. One practical issue that was brought up was that it's currently very difficult to automatically judge sound quality on recordings manually, as most universities generate roughly 36,000 hours of lecture recordings every week. This may open the door for an AI-based solution. There were a number of suggestions from the audience, most coming from university lecturers who have struggled with this issue for a number of years.

Accessible broadcast audio customisation

Lauren Ward from the University of Salford presented the final paper of the session, which was focused on improving accessibility of broadcast audio. Lauren began by highlighting that audio audibility must be acceptable to the average viewers, while accessibility must be acceptable to all viewers. The key to improving accessibility for all appears to be in providing control to each individual user. This ties in nicely with current innovations in broadcast audio surrounding object-based audio. This allows an individual user to create their own personalised mix of the various elements in a programme, putting them back in control rather than someone in a studio deciding what they should hear. While there is still P30

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a large amount of work to do, Lauren's experiments have shown that the vast majority of listeners given this control found their viewing experience much more enjoyable. With the predicted rate of hearing impairment in the population looking to accelerate in the coming years/decades, this is an important area to focus on in the world of broadcast audio (and beyond).

Conference reception and dinner

After a short break, the conference resumed aboard Brunel's S.S. Great Britain, which, at one point, was the world's longest passenger ship and the first ship to be constructed of iron that included a screw propeller. The delegates were allowed to explore the ship before a very interesting presentation given by one of the museum staff members about the history of the ship.

Following the presentation, delegates moved down to the first-class dining saloon for the conference dinner. Afterwards, IOA President Barry Gibbs presented Adam Hill from the University of Derby with the IOA Young Persons' Award for Innovation in Acoustical Engineering, sponsored by Cirrus Research (Martin Ellison and Clarke Roberts from Cirrus were on hand for the award presentation). The award was presented to Adam in recognition of his research so far in his career which has aimed to achieve the 'democracy of sound,' giving everyone within a given space the same high-quality listening experience. (A full report of Adam's award was published in the January/February 2020 issue of Acoustics Bulletin).

Following the award presentation, EAG chair, Keith Holland, formally thanked everyone who made this year's Reproduced Sound possible including: the EAG committee members, specifically John Taylor and d&b audiotechnik for the top-notch audio-visual support, Linda Canty, the staff at the Bristol Hotel and aboard the S.S. Great Britain, and all of the delegates for continuing to support the conference by coming back every year.

Above: Lauren Ward explains her research into broadcast audio accessibility.

Below: Conference dinner aboard the S.S. Great Britain.

After-dinner talk – Jim Griffiths, Vanguardia

Keith then introduced the after-dinner speaker, Jim Griffiths from Vanguardia. Jim delivered a captivating talk on his career spent managing sound for concerts, festivals and sporting events. He gave a detailed historical overview of how the landscape of the industry has changed over the 40 years that he has been active in the field, highlighting the common challenges he faces at high-profile events in densely populated areas, all punctuated with humorous anecdotes from his experience. Jim also highlighted current developments on both the technological and policy sides of the industry and how these have the potential to positively impact this area of audio and acoustics.

CONFERENCE – DAY TWO

Session 4 – Events and installations (Chair – Mark Bailey)

Keynote: The Royal Albert Hall – sound of the future

This keynote paper was jointly presented by Steve Jones (d&b audiotechnik), Stephen Stringer (Sandy Brown Associates) and Ollie Jeffery (Royal Albert Hall). Ollie started with the venue's perspective, noting that the RAH goal is to achieve a "life enriching, unforgettable experience".

He acknowledged that there had been audio/acoustics issues that had resulted in a poor experience and audience complaints. The goal was not only to address these issues but to go further and to become a "world leader in the quality of sound".

Stephen then gave the consultant's view, outlining some of the past changes to the hall, including acoustical treatments such P32

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as the famous 'mushrooms'. Time was taken to speak with stewards on the ground as they were the ones directly hearing complaints if they happened. Out of 382 shows, there were 176 complaints. Almost all of these were for amplified events. In terms of where these were reported, 50% of these (a significant amount) were in the upper levels. Reported issues were speech intelligibility, the sound being muffled and/or unbalanced. The plans for the venue were known to have discrepancies from the actual dimensions. One reported reason was that during construction, the weight of the roof was so significant that it had caused the entire building to twist. In order to obtain a more accurate picture, a laser scan was undertaken.

Steve Jones then gave a perspective from a sound system designer. He covered how d&b had assessed the configuration of the system. Given the dimensions of the building, it was preferable to have speakers slightly lower to give the FOH engineer and audience a good experience. However, this meant that the arrays needed to be angled up, introducing challenges in reaching the upper levels without causing unwanted reflections.

For the array, an LCR solution was decided upon for coverage and flexibility in cinematic use along with a cardioid sub array to avoid unwanted LF build-up. Finally, some delays were added – with great challenges due to the locations of the 'mushrooms' not being recorded on the plans and challenges in obtaining permission to drill through Grade I listed plaster.

Ollie came back to note that while they expected 50% of rock shows to use the system, so far 100% had been happy to do so. He acknowledged that although sound was subjective, the audience response had been positive and that the number of complaints had reduced dramatically. He felt they had achieved their vision.

Effects of low frequency sound on the human condition

The second paper of this session was about an art installation at the Tate Modern and was presented by Richard Grove and Joe McCall of BDP. The installation, entitled '10,148,451', includes a 40kW sub-bass array. Its intention is to "plug straight into the algorithms of fear and anger" of its audience. As part of their evaluation of this exhibit, they measured the system in various locations. This mapped response showed that while some people in the exhibition walked right up to the speaker, it was actually loudest in some other areas of the room, due to room-modes. A short demo was played for the audience to hear – and feel – and indeed the sounds were discomforting but thankfully, no one showed clear signs of fear or anger. An investigation of what the duration of such exposure might change was noted as something for further work and research.

Sound level monitoring and management at large scale music festivals

Next in this session was Adam Hill from the University of Derby, presenting a case study he conducted at a recent music festival in Chicago. This primarily considered sound exposure to audience members, while highlighting the varying regulations across the world. The goal is to do this while maintaining a high-quality listening experience for the audience. Much of the issue is in the LF range – and these levels are quite extreme. At rock concerts, people may be within touching distance of subwoofers capable of 140 dB peak output. At these levels, hearing defenders are largely useless. Adam is part of an AES group working on this, looking to develop a set of recommendations to address these issues of audience sound exposure, where the work is now also being fed into a World Health Organization initiative.

The results of the study showed that if a limit was set, and the mixing engineer could see a level meter, then most engineers mixed to that limit. Other results showed that larger audiences influenced the engineer to mix louder and that a touring engineer would mix louder than one working for the owner of the sound system.

Above left: Steve Jones explains the design of the new Royal Albert Hall system.

Above right: Peter Mapp questions whether there's a better metric for measuring speech intelligibility.

Acoustic design for sport venues and arenas

Oliver Creedy from Vanguardia presented the final paper of the session, about the recently completed Tottenham Hotspur stadium, discussing the requirements for acoustics and sound reinforcement. For Tottenham Hotspur, the brief was that "the atmosphere must be intimidating" and so adding a lot of absorption for the sound reinforcement was not seen as a viable option. Balancing the need for audio performance and speech intelligibility in environments where the RT60 may be around six seconds or more is a notable P34

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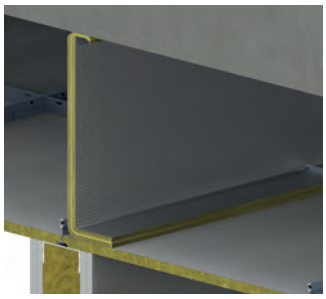

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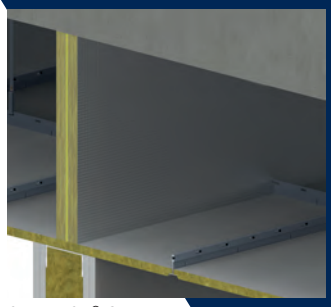

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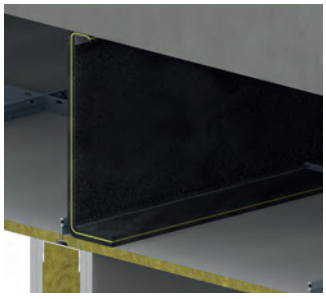

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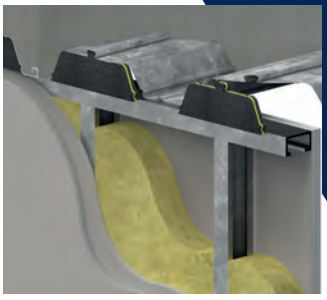

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challenge. Oliver presented some approaches with specific placement of absorption, designed to tackle key reflections rather than RT60 overall. Some auralisations were played to demonstrate the point made.

Session 5 – STI and intelligibility (Chair – Adam Hill)

What would we do if we didn't have STI?

Peter Mapp began the next paper session on speech intelligibility and STI by calling into question whether it would be possible to come up with a new and improved metric to quantify speech intelligibility, expressing that STI should be viewed as a blunt instrument (i.e. it's not very precise).

Peter began by highlighting a number of possible metrics as well as specific acoustic characteristics of a measured signal which are important for intelligibility. He called into question whether 'intelligibility' is the correct term for what we are trying to achieve, suggesting ease of listening, ease or recall, or ease of attention as more accurate descriptors. The term 'engagement' seemed to be appropriate, especially considering Francis Rumsey's talk the day before. All things considered; Peter suggested that we may not be measuring the right thing in this area. Perhaps some form of artificial intelligence including automatic speech recognition would be an appropriate solution? Overall, Peter left the topic open for discussion, but the message was clear — that we shouldn't accept STI as the best solution for quantifying speech intelligibility. The presentation was followed by a lively discussion amongst the delegates.

Another look at the relationship between frequency response and STI

The day didn't get much better for STI, as Glenn Leembruggen from Acoustic Directions presented his paper looking into the effect of frequency response on the metric. Glenn made the point that a number of problems exist with STI when used in noisy and reverberant environments. This was demonstrated by mathematically applying worst-case frequency responses to existing road tunnel measurements. The different frequency responses didn't significantly alter STI, showing that the metric doesn't adequately consider frequency response, despite this acoustic characteristic being essential for speech intelligibility. This is likely down to the fact that the spectrum of the STI test signal doesn't match the spectrum of individual words in speech. Glenn concluded by echoing Peter Mapp's point from the previous paper, that STI is a blunt instrument and we need to consider alternative approaches for the accurate and efficient quantification of speech intelligibility.

Session 6 – Modelling and auralisation (Chair – Bob Walker)

Modern auralisation routines as design tools

The first paper after lunch was from Wolfgang Ahnert from ADA Acoustic Media Consultants, which looked into the implementation and uses of auralisation within acoustic modelling software. Wolfgang began with a thorough historical overview, spanning physical models through to modern day computer models. In terms of auralisation, it is essential to include head tracking and HRTFs, otherwise the results won't provide a useful tool for acousticians. Wolfgang then went on to demonstrate an example implementation of auralisation within EASE 5, which now includes that capability of using B-format files and is compatible with virtual reality. While Wolfgang highlighted the current tools available in this area, he stressed that care must be taken to not misuse them. He strongly discouraged auralisation "competitions" during the tender process, pointing out that there can't be such a thing as a perfect comparison in this area.

A simple model for horn coverage angle

Next in the session was Keith Holland from ISVR, University of Southampton, talking about his approach to creating an efficient and compact model of horn coverage angle. To achieve this, Keith took the audience through how it was P36

Below: EAG Chair, Keith Holland, takes a question from the audience.

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necessary to separately handle the low-, mid- and high-frequency bands. For the mid-frequency range, it was shown that constant directivity can be observed, with more complicated radiation characteristics outside of this band. Measurements of symmetrical horns helped to validate this model, but Keith mentioned that further work was necessary to include the effects of diffraction in the model.

He also noted that Reproduced Sound is one of the rare audio/acoustics conferences that actually has high quality audio.

Transparency of binaural auralisation using very high order circular harmonics

The last paper of the modelling and auralisation session was delivered as a joint presentation by Mark Dring and Bruce Wiggins from the University of Derby. The focus of their work was to identify the point when increasing the ambisonics order results in no further perceptual improvement to the reproduced sound within an auralisation. At present, the current standard used is third order. The experiments in this work were based on modelled binaural room impulse responses and investigated ambisonics orders from 1-31. The results clearly indicate that there is no perceptual difference above 20th order ambisonics, pointing towards a reduced set of BRIRs needed to accurately model an acoustic space for the purpose of auralisation. Further work requires checking these findings with real room measurements to see if the trends are upheld.

Electroacoustics Group AGM

Prior to the final paper session of the conference, was the annual general meeting of the Electro-Acoustics Group (EAG). This meeting was chaired by Keith Holland and was attended by 27 delegates, including eight EAG committee members. Keith delivered the chairman's report, describing all activities of the group over the past year, the central focus being the organisation of this conference. Following the election of officers and confirmation of committee members, IOA President Elect, Stephen Turner, thanked the committee for the great conference and highlighted outreach activities being done at local schools to raise awareness of these fields of work. He also noted that Reproduced Sound is one of the rare audio/acoustics conferences that actually has high quality audio. He expressed an interest in the EAG to disseminate any tips and tricks to other IOA groups. It was noted that the superior audio at the conference is thanks to the ongoing support from John Taylor and d&b audiotechnik. P38

Below: Nighttime view of Bristol from the conference venue.

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Session 7 – Loudspeakers (Chair – John Taylor)

Non-minimum phase behaviour of loudspeaker at low frequencies

The final session of the conference began with a paper from Keith Holland from ISVR, University of Southampton, where the question of why non-minimum phase behaviour is observed in loudspeakers when no such behaviour is predicted by their lumped sum models. This was investigated by creating an extended model of a ported loudspeaker that included the observation point. Using this model, it became clear that the signal from the port arrives at the observation point before the signal from the drive unit. In the measurement, this is observed as an echo which is louder than the direct sound from the drive-unit. This was the cause of the non-minimum phase characteristics, which made it clear why it wasn't turning up in conventional models. To overcome this issue, Keith stressed that the position of the drive-unit and the port must be included in lumped parameter models.

Energy efficiency in sound reinforcement

Fittingly, the final paper of the conference was from the company that started the conference, Funktion One. The paper was presented by James Hipperson where he highlighted the current movement in the live event industry to limit its carbon footprint. Loudspeaker technology is generally one of the worst offenders in terms of efficiency, where we regularly put in kilowatts of electrical power into loudspeakers in order to generate watts of acoustic power. There are ways to increase a direct radiating loudspeaker's efficiency, such as maximizing Thiele-Small parameters: β, l, S, and d, capturing back-EMF when using Class-D amplifiers or, quite-simply, using a horn.

James showed a recent example from his work where 24 horn-loaded subwoofers were driven at concert levels while the three amplifiers only drew 9A, representing a significant increase in efficiency over what a direct-radiator equipped system could supply. James concluded by emphasising that we must strive to increase efficiency of all technology, loudspeakers included, which is why he (and Funktion One) believe horn-loaded loudspeakers are the way forward.

Above: Conference delegates on the visit to Colston Hall.

Below: A full audio-visual system was provided by EAG committee member, John Taylor (d&b audiotechnik)

Conference close

EAG chair, Keith Holland, closed the formal proceedings of Reproduced Sound 2019, by thanking all those who were involved with the organisation and running of the event as well as the delegates for attending.

Post-conference activities

Another tradition of the Reproduced Sound conference is to arrange for an off-site visit to a local venue, museum or university after the formal proceedings of the conference have concluded. This year's visit was to Colston Hall in Bristol.

Despite it not being possible to view the auditorium because it was covered with scaffolding, the evening was highly enjoyable to those who attended. Nick Craney from Colston Hall opened the proceedings with a short history of the hall and an explanation that sound quality has been prioritised over architectural considerations.

Joe Stansfield from theatre consultant, Charcoal Blue, talked about the electroacoustic considerations and the issues of future-proofing the infrastructure. The evening was rounded off by Bob Essert from acoustic consultancy, Sound Space Vision, who explained his design for the auditorium acoustics. Numerous pictures of the hall, past and present, were shown followed by a lively question and answer session.

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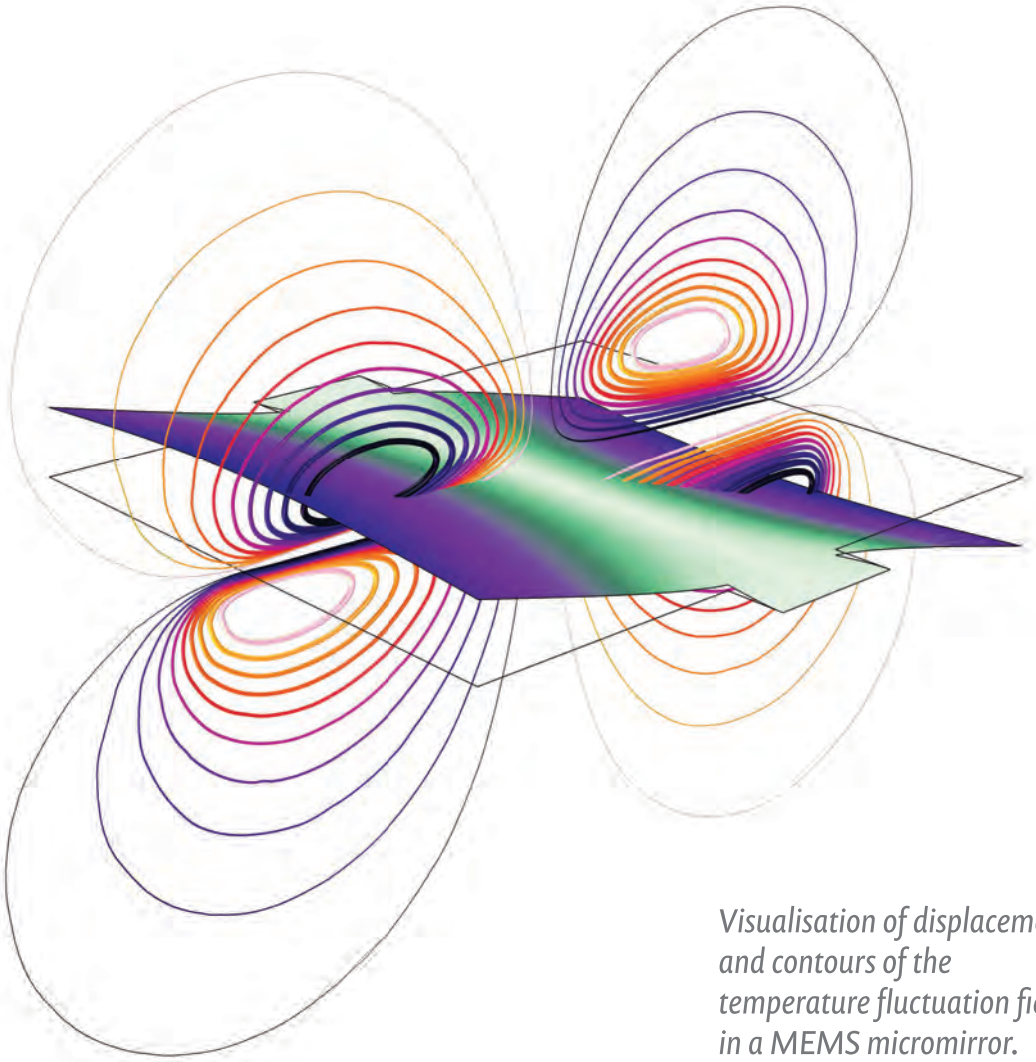

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Instrumentation aspects of CONSTRUCTION ENVIRONMENTAL MANAGEMENT PLANS

By Matt Robinson, BSc MIOA Development & Customer Support (Director) at EEMC Limited

"Here's one we made earlier". This is a phrase not only uttered by over-enthused children's television presenters, but often heard when plans for the management of noise, vibration and dust on construction sites are discussed. It is common for the critical aspects of these documents and their value to be misunderstood by contractors and the cost for production can often be a difficult sell for consultants.

The aim of the effective management of noise, vibration and dust (NVD) generated during construction and demolition activities is to minimise the potential impact of the works on people and property to an acceptable level, by implementing the best practicable means to do so. The contractor should allow sufficient scope in methodology to meet this requirement and undertake the works in a practicable, timely and cost-effective manner.

Main: Annex G of BS5228 Part 1 provides guidance on noise monitoring and the instrumentation criteria

Required actions

The standards for the management of noise, vibration and dust are set by the Local Authority in planning conditions or within a Code of Construction Practice (CoCP). Depending on the size, location, and the proposed demolition or construction methods there may be a number of required actions. The requirements for documentation can also vary significantly between Local Authorities – while most require a Section 61 application for noise and vibration under the Control of Pollution Act 1974, others may also require additional documentation which come in an array of acronyms: C/SEMP, NDVMP, DAQMP, CMP, DEMP, SoPWMP...

All these documents include elements of noise, dust and vibration management but may also cover the wider environmental management concerns such as waste management, ecology and fauna. P42

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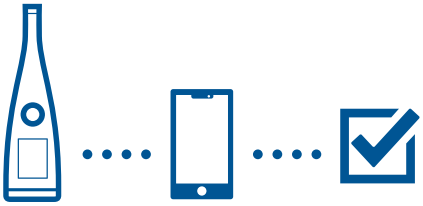

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Bespoke solutions

Despite the array of acronyms, the goal of these documents is to provide bespoke solutions to the management of environmental impacts, including noise, vibration and dust, for each individual site. Individual projects will have differing construction methodologies which could involve the identification of a diverse number of sensitive receptors. As such, it is imperative that management methods need to be tailored to each unique site.

It is particularly important that site monitoring requirements are determined for each site within the management plans. Monitoring requirement should detail the type, quantity and locations of the monitoring instruments and form a key part of the total management system for each site. Through implementation of monitoring, a contractor can illustrate compliance with management plans, often with remote Local Authority oversight. Furthermore, monitoring can provide additional assurance to adjacent occupiers.

Noise and vibration construction criteria are set using the guidance set out in BS5228 Parts 1 and 2. For some sites it may also be necessary to consider the impact of vibration using BS6472-1, where the human exposure is a key concern.

Below left: Site monitoring requirements should be determined for each site within the management plans

Below right: Real-time monitoring instrumentation, when installed, managed and maintained appropriately can be a significant asset to any development

Often, a Local Authority's guidance document, or CoCP will suggest the most appropriate methods to use.

Noise change

For noise, BS5228 Part 1 Annex E provides guidance on the significance of noise effects. For non-commercial receptors of construction noise this is based upon noise change, rather than fixed limits and two methods are offered. Both methods require knowledge of the ambient noise environment. This can be established with baseline noise measurements, or potentially from a noise assessment undertaken at planning stage.

Once the ambient noise climate is known the threshold of significance can be determined:

1) **The ABC Method:** Ambient noise data is rounded to the nearest 5dB and threshold values are provided based on the level of ambient noise. This method is only applicable to residential receptors;
2) **The 5dB(A) Change Method:** Significance is determined if the total noise (pre-construction ambient plus site noise) exceeds pre-construction by 5dB or more, subject to lower cut-off values. This method is applicable to residential and some sensitive receptors (hotels, religious institutions and schools etc.)

For commercial and office receptors the 75dB(A) limit at the nearest window is often taken as the threshold of significance. The fixed nature of BS5228-1 can be partly to blame for some of the 'copy and paste' approach that is often taken by some contractors. It is important to note, however, that Annex E provides informative guidance on levels of significance, not noise limits.

Noise modelling on major sites

For major sites, a noise modelling exercise, either using spreadsheet or CAD based methods can be undertaken, using the standardised machine noise data and assessment methods from BS5228-1, to show the potential noise levels incident on nearby receptors. Using this data, along with the thresholds of significance, proposed noise limits can be proposed and agreed with the Local Authority.

Annex G of BS5228 Part 1 provides guidance on noise monitoring and the instrumentation criteria. Despite a trend in other sectors, the acoustics (and wider environmental) industry is working hard to avoid a race to the bottom, especially in regard to instrument quality – Class 1 (IEC 61672-1: 2013) instruments are preferred, but Class 2 instruments are the minimum requirement. P44

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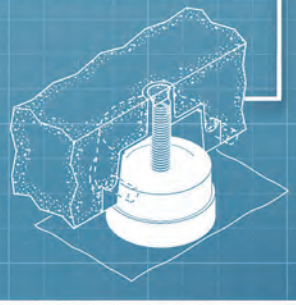

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Typically, Class 1 instruments are installed on the majority of significant sites – and it remains key to consultants, environmental health professionals and contractors that the monitoring data measured is of the highest quality.

Short-term attended or standalone monitoring systems can be used to monitor construction projects and are used particularly in the rail sector. While attended monitoring is useful for short-term and specific events, the benefits of continuous, automated real-time monitoring over the whole development period in providing an uninterrupted time history are being increasingly understood.

Monitoring

Continuous, automated real-time monitoring allows web-based upload of data from site-based instruments with viewing and reporting of measured data available on computers or mobile devices. While short-term attended or standalone systems can be used, the modern expectation of 24/7 connectivity is becoming expected. Modern monitoring systems that can provide SMS and email-based alarms are widely used and can be issued to both site teams and the Local Authority in the event of trigger levels being exceeded. Long-term, continuous measurement also allows reporting of the complete time history for construction event, with many noise monitors providing audio clips when trigger levels are exceeded. This makes identification of exceedance events more straightforward and can be used as evidence to stakeholders to show measured levels were not a result of site activity.

Real-time monitoring instrumentation, when installed, managed and maintained appropriately can be a significant asset to any development. It allows site teams to be proactive in their management of noise, vibration and dust and respond to any issues that may arise before they become a problem. It also provides an opportunity for accountability to stakeholders, as the site team is alerted to levels of noise and vibration that occur and are empowered to take actions to reduce the impact with the best practicable means (BPM).

Below: Consultants are set to play a key and ever-increasing role in construction management

Vital specialist input

Lack of specialist input can be particularly damaging to a project when it comes to monitoring. Without expert and experienced guidance, poor choices relating to the quantity, specification and proposed location of monitoring can be made. These need to be made with care, based on the potential for impact and in liaison with the Local Authority. Care also needs to be taken to ensure the chosen locations; while being appropriate and representative of receptors, they also need to be located somewhere where it is possible to safely install, maintain and provide power to the instrument.

Consultants need to promote the management of noise and vibration at an early stage in a project. Efforts made at the start of the project can nurture a good working relationship with stakeholders and the Local Authority — management of the impact of construction noise is a 'hearts and minds' exercise, where the appropriate monitoring instrumentation is a key tool that provides accountability and reduces the likelihood of significant impacts.

Pre-project planning

Many main contractors have made significant efforts to develop their approach to environmental management, including their own internal specialist teams. Increasingly, the need for impartial technical advice is a key component of the pre-project planning for large contractors and specialist acoustic support is a major contributor to this process.

While few people are overjoyed to experience construction undertaken nearby, if managed and communicated well, the impacts can be reduced — alleviating concerns, preventing notices and delay which, in turn, decreases the overall project costs. Consultants are set to play a key and ever-increasing role in construction management.

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Midlands Branch

Now you're talking: Human conversation from the Neanderthals to artificial intelligence

At our November meeting we were treated to a talk by Professor Trevor Cox, Professor of Acoustic Engineering at the University of Salford.

Trevor's presentation was on how speech arose in humans, how our voices age and how integral they are to our identities. He shared a quite different view of 'voice', exploring what our voices can reveal about us, for example, how voice may indicate social class – how do you say "scone"? Does it rhyme with 'stone' or 'gone'? He knitted together subjects as diverse as the accents in babies' cries; speech therapy for people transitioning gender; foreign accent syndrome and the bizarre mystery of the changing female voice. It seems that women's voices have gradually deepened over the past 50 years.

Trevor then spoke about how technology has changed the nature of speech since Thomas Edison recorded then played a reading of 'Mary had a little lamb' on a phonograph in 1877. He examined how our listening experience has changed through the use of recording, amplifying and tampering with voices. For example, singers today do not have to project their voices to fill entire opera houses; a microphone allows them to reach their audiences with intimate emotion.

The final part of his presentation looked at how artificial intelligence is changing our relationship with speaking and listening and the future... 'Photoshop for voice' has already been demonstrated, leading to a future with #FakeSpeech.

Thank you, Trevor, for presenting a most insightful and engaging talk. Thank you also to Wolverhampton University for hosting the event.

Designing soundscape in urban public open spaces

By Mike Breslin

Professor Jian Kang of University College London (UCL) gave an engaging and thought-provoking presentation entitled 'Designing Soundscape in Urban Public Spaces' on Wednesday 4th December 2019, at the University of Derby.

Professor Kang is head of the Acoustics Group at UCL and currently heads up an international team that is developing indices for assessing soundscape. The team has analysed soundscape interviews conducted with around 10,000 people mostly in urban spaces. The analysis suggests that the suitability of a soundscape is dependent on a number of factors including the type(s) of noise source, the acoustic effects of the space upon noise from the sources, the characteristics of users of the area and other non-acoustic environmental factors.

The analysis found no correlation between sound pressure level and acoustic comfort below 65 dB L_{Aeq}. Peoples' responses to active sounds (people or machines for instance) differ from the responses to passive sounds such as water or foliage. People generally prefer passive sounds, but the degree of preference is affected by age, educational background and cultural differences.

Moving water was identified as a potentially useful source of passive noise. The effects of passive noise from moving water can be enhanced by varying the flow rate and/or controlling the volumes and drop heights to tailor the frequency content of the sound produced.

Music is a special case of active sound. People are interested by the performers of live music (the type of music being performed seems to be relatively unimportant) but response to recorded music is dependent upon the type of music and the level. Similarly, some cultures respond more positively than others to being surrounded by speech.

Response to both active and passive sounds is affected by the acoustics of the space, including the degree and type (specular or diffuse) of reflection and reverberation.

Non-aural environmental factors also affect response to the noise. People seeing (or not seeing) the active or passive sources of noise, for instance, affects the way they react to them.

Professor Kang and his team clearly face an immense challenge to identify a relatively simple way of quantifying the interactive factors which make a good soundscape for the targeted users of a space. When questioned about the difficulty arising from a soundscape being positive for a specific type of user (in terms of age, culture, educational background for instance) and negative for a different social group, he responded with the idea that in future soundscapes could perhaps be adaptive in response to the occupants of the space at a specific time.

The IOA Midlands Branch is grateful to Professor Jian Kang for an interesting and illuminating presentation and to John Pritchard at the University of Derby, who hosted this well-attended evening meeting.

Overheating in homes – ventilation and cooling strategies

In January, Allan Derbyshire and Gary Swift from Zehnder Group UK Limited (Greenwood Airvac), gave a presentation to the Midlands Branch on ventilation and cooling strategies for overheating in homes.

Urbanisation, density planning restrictions and the development of more challenging sites has seen a significant rise in the number of overheating issues in buildings over the past few years. Where new homes are required to meet high quality and insulation levels, the need for effective ventilation and cooling strategies are now crucial to comfort and well-being and to meet planning guidance and regulations.

The presentation explored reasons for overheating, thermal modelling examples and the benefits of using ventilation and cooling to combat overheating in homes and the implications on acoustic integrity to the building envelope.

Our thanks go out to Zehnder Group for presenting to the Midlands Branch and to Rob Bungay for hosting the event at WSP in Birmingham.

Yorkshire and North East Branch

Open-plan offices: advances in acoustic design, by Jack Harvie-Clark of Apex Acoustics

In January 2020 the Yorkshire and North-East Branch held their first meeting in Newcastle in many years; the meeting place was kindly offered by AECOM. The Branch covers a very large area, from south Yorkshire up to Northumberland and in recent years, the majority of Branch meetings were held in Sheffield, leaving a vast number of the northern acousticians out of reach (unless they were prepared to travel over two hours each way to make the meeting). Not surprisingly, the January event was fully booked and well attended: people travelled from Edinburgh, Glasgow, Leeds and across Yorkshire.

The meeting was dedicated to open-plan office acoustics – the topic is critical not only for acoustic consultants and interior designers, but also to many of those who work in open-plan offices and experience daily problems with noise brought about by this modern working style.

Jack Harvie-Clark started his presentation with an overview of the problem with acoustics, speech and noise in open-plan offices. He also reviewed guidance and standards that have been developed in various countries to tackle the issue.

The first part of Jack`s talk was dedicated to ISO 3382 Acoustics – Measurement of room acoustic parameter – Part 3: Open plan offices, published in 2012 and since then implemented in many countries, including the UK. Although the standard introduces the crucial parameters, such as $D_{2,S}$ (spatial decay rate of speech), distraction distance, privacy distance and others, Jack demonstrated that they have little correlation with the acoustic satisfaction measured in various types of offices.

Next, Jack presented an overview of ISO/DIS 22955 Acoustics – Acoustic quality of open office spaces, currently under development by an ISO standardisation committee of which he is a member. The new standard is inspired by the French Standard NF-S31-1999 and takes the same approach, starting with the acoustic requirements of the users. ISO/DIS 22955 proposes acoustic criteria for different types of space, where these predominate across the floor plate, in terms of the ISO 3382-3 indicators.

The final part of the talk was dedicated to the introduction of a new approach – the Apex Method. This method can be informed by the Liveliness parameter. The Apex Method is well suited to assess acoustic conditions within activity-based working (ABW) offices. The Liveliness parameter can be used to characterise suitable acoustic environments for different types of activities; it is measured by recording the sound in five minute samples at an unoccupied workstation. The semantic description of the Liveliness parameter is correlated with an objective measure, based on five minute sample periods. The objective measure is a combination of the A-weighted sound level, $L_{Aeq,5min}$, and the fluctuation strength. The fluctuation strength is measured as the difference between the statistical level of A-weighted sound that exceeds five percent of the time, $L_{A5,\ 5\ min}$, and the LAeq,5min. In contrast to ISO 3382-3, the background level is the occupied sound level, rather than the level in the unoccupied office. Examples of applications of the new Apex Method to design various open-plan offices were also demonstrated. These aimed to achieve acoustic satisfaction in various types of work-situations.

North West Branch

After being in the role for three years, Adam Thomas is standing down from the post of North West Branch chair and Mark Hinds has taken his place. Naomi Tansey is leaving the area for a new job in the midlands, so David Terry replaced her as secretary.

Latest noise complaints statistics for England

The Chartered Institute of Environmental Health (CIEH) published the results of its noise survey in February. It provides the only source of information on the vital contribution made by Environmental Health Practitioners (EHPs) working to resolve noise complaints in England.

Data from the CIEH survey is being used by Public Health England for the Public Health Outcomes Framework, which establishes an important link between noise and health outcomes.

Key figures for England (figures represent 143 local authorities, 45% of local authorities in England):

- 143,054 noise complaints were recorded by these local authorities, 61 complaints for every 10,000 people;
- 2,543 notices were served by these local authorities, one notice for every 10,000 people;
- there were 101 noise-related prosecutions; and
- overall, local authorities allocated 0.2 full time equivalent (FTE) professionals to deal with noise complaints per 10,000 population.

Greater London had the highest number of noise complaints, 183 for every 10,000 people, more than double the national average. Local authorities in Greater London also served the most notices, four for every 10,000 people. South West England had the lowest number of noise complaints, roughly half of the national average, at 35 for every 10,000 people.

Residential noise accounted for the largest proportion of noise complaints. This was the case across all regions in England, except in the South East, where noise from construction, commercial and leisure premises were greater sources of complaints.

Other sources of noise complaints recorded by local authorities include noise from the street, vehicles, machinery and equipment, dogs, agriculture, alarms, military, traffic, aircrafts and railways.

Compared with the last time CIEH collected noise data (2015/16) the 2018/19 data shows a 9% increase in the number of noise complaints in the 65 local authorities which participated in the survey in both years.

Noise is the single largest issue of complaint made to local authorities in the UK, and according to the World Health Organization, noise is a disease burden that is second in magnitude only to that from air pollution.

Anne Godfrey, CIEH Chief Executive, said: "These figures remind us that noise continues to be a major issue of complaint made to local authorities across England.

"Noise has profound impacts on people's health, wellbeing and quality of life. Environmental health practitioners are on the frontline of resolving noise complaints and deserve recognition for their important contribution to supporting and protecting the nation's public health."

Download the report at **https://www.ioa.org.uk/news/cieh-releases-latest-noise-complaints-statistics-england**

Equipment stolen

Two pieces of equipment have been stolen recently from a site in Tottehnam:

1. Noise logger: Svantek SV212 BO monitoring station Svantek 958 sound and vibration analyser (serial number 28483); and
2. Vibration monitor: Profound Vibra+ 'Live PPV vibration monitoring station (serial number VIB03511).

If you have any information that might help recovery, please email Louis Barber at **lbarber@srltsl.com**

The IOA has set up a buying and selling equipment group on Facebook. You can also post details of stolen equipment so that others are aware.

Go to **https://www.facebook.com/ioauk/** and to: **www.facebook.com/groups/ioakit** to buy and sell equipment

'My world of sounds' international school competition

To mark the International Year of Sound, the International Commission of Acoustics (ICA) has launched 'My world of sounds', a competition for students.

Coordinated by an ICA IYS2020 steering committee, the competition is strictly connected to the melody 'We are the sounds of our world' and its refrain, which can be downloaded here **https://sound2020.org/society/student-competition/)**

There are two categories:

1. Students at primary and middle schools (from five to 12 years old); and
2. Students at secondary schools (from 13 to 18 years old).

Entries should reach the IYS2020 national representative by 30th April 2020 and winners will be announced at the end of August.

For full details, competition rules and materials go to **https://www.ioa.org.uk/my-world-sounds-international-school-competition**

You can email the IOA directly if you have any questions **ioa@ioa.org.uk**

Robotic gripper uses acoustic levitation for contact-free manipulation

Researchers at ETH Zürich have developed a robotic manipulator that can pick up and manipulate small objects without actually touching them. Using ultrasonic waves, the new manipulator created by ETH Pioneer Fellow, Marcel Schuck, could be used for handling tiny, fragile items, including precision watch parts.

Ideally, the best manipulator is one that won't touch an object and Schuck devised one that doesn't make contact with anything other than sound waves. The prototype for this device is a lab-bench robotic arm and the 'hand' is a pair of 3D-printed semi-spheres.

The principle, acoustic levitation, has been known for eight decades and involves ultrasonic waves creating a pressure field that can't be seen or heard by humans but is strong enough to lift small objects. If a number of these pressure fields or points are used, they overlay one another, allowing the object to be manipulated.

Schuck's manipulator has an array of very small speakers installed inside the two semi-spheres. With software written by ETH doctoral student, Marc Röthlisberger, the pressure points can be controlled – it's hoped that eventually such control can be performed in real-time. In this way, an object can be suspended, moved, or otherwise manipulated without being touched and with great precision and at low cost.

Schuck's ultimate ambition is to find practical applications for no-touch robotics, especially in the microchip or the watchmaking industry. "Toothed gearwheels, for example, are first coated with lubricant, and then the thickness of this lubricant layer is measured," he says. "Even the faintest touch could damage the thin film of lubricant." Microchip production is another potential application for the technology.

World first treatment with 'acoustic cluster therapy' to improve chemotherapy delivery

The first patient has been treated with an innovative new technology that uses microscopic clusters of bubbles and liquid droplets to enhance the delivery of chemotherapy drugs to tumours.

The clusters of microdroplets and microbubbles are injected along with the patient's chemotherapy and the technology, called acoustic cluster therapy, uses a standard ultrasound scan to convert the clusters into an activated form within the tumour.

Once activated, with further ultrasound the clusters help to 'pump' the drug into the tumour, greatly increasing the amount of drug which reaches the cancer cells. This new treatment, which is now being trialled by The Institute of Cancer Research, London, and The Royal Marsden NHS Foundation Trust, promises to improve the effectiveness of the chemotherapy by better targeting it to the cancer site, and could potentially be explored with reduced doses of drug in order to reduce the severity of side effects.

Acoustic cluster therapy was invented by the Norwegian company, Phoenix Solutions. It was further developed with proof-of-concept studies by scientists at The Institute of Cancer Research (ICR) and the Norwegian University of Science and Technology (NTNU), Trondheim.

TfL to trial new electric bus sound to improve road safety

An innovative new bus sound is being trialled on London's latest electric bus route.

Transport for London (TfL) has developed the sound, which is played through speakers inside the front of the bus, to ensure that all road users are aware of electric and hybrid buses when they are moving at slow speeds. Without this sound, these vehicles are almost silent, which could pose a safety risk. The trial on the 100 bus route comes ahead of an artificial sound becoming a regulatory requirement for all new 'quiet' running vehicles in 2021.

The sound has been developed with input from Guide Dogs for the Blind, London Travelwatch and other key accessibility, walking and cycling groups. It will play until the bus reaches 12mph, when it is reversing and when it is stationary. When travelling above 12mph, the bus will make enough noise that an alert is unnecessary. The pitch of the sound will vary with the speed of the vehicle, helping people know where the bus is and which direction it is traveling.

The sound will be trialled at varying volumes over a six-month period and feedback from road users, residents, passengers and drivers will be collected to help develop the most effective system.

Identifying tranquil and quiet areas in Limerick using Hush City

Limerick City and County Council has invited its citizens to identify and assess tranquil and quiet areas in Limerick City and surrounding areas using the free Hush City app.

The app was developed through an initiative led by Dr Antonella Radicchi of the TU Berlin Institute for Urban and Regional Planning and it allows the sequential collection of georeferenced and timestamped mixed data over a short timeframe (approximately three/five minutes), which is linked in real time to an open access digital map.

The mixed data consists of audio recordings, sound pressure levels, pictures of the place the sounds are recorded and user feedback. User feedback is collected by means of a questionnaire designed to explore what affects our perception of quietness, such as correlation of acoustic environment, emotional responses, perceived quietness, positive and negative sounds and accessibility etc. This data can be shared using the Hush City map (**https://map.opensourcesoundscapes.org/view-area)**.

Data from the app will help the Council see which tranquil and quiet areas are important to the citizens of Limerick, then potentially allow the Council to focus further technical investigation when applying for official designation of quiet areas by the Department of Communications, Climate Action and the Environment.

Download the Hush City at: **http://www.opensourcesoundscapes.org/hush-city/**

AA Sussex team news

David Kendall has joined Acoustic Associates Sussex Limited (AASL). He has a degree in music technology and a wide range of experience including studio production and live performance. Having just gained his air tightness testing qualification, David is also busy with sound insulation testing and other acoustics work, and he is just about to start his masters in acoustics at London South Bank.

Martyn Chambers, who joined the company in 2017, has also seen great success in 2019, with the award of the IOA Diploma in Acoustics from Solent University, where he is currently undertaking his masters in acoustics.

Peter Attwood, MD, said: "It has always been a priority to enable our staff to maximise their potential and we encourage advanced study."

George Orton and Scott Castle, both senior consultants at AASL have been appointed as Directors.

Staff of Acoustic Associates Sussex Limited

New verification scheme launch will allay industry concerns

FIS is the not-for-profit representative body for the finishes and interiors sector in the UK. It exists to support its members, improve safety, minimise risk, enhance productivity and drive innovation in the sector.

With the acoustic performance of products so important and in a bid to curb growing incidents of 'passing off', a new Acoustic Verification Scheme has been created by FIS in response to confusion and concerns related to the comparability of acoustic airborne sound insulation tests claims. This will allow designers, architects and contractors to specify products, safe in the knowledge they will provide the acoustics performance claimed, eliminating any misinformation and misleading information.

As part of the FIS acoustic verification scheme in which independent acoustic consultant, Cundall, verifies acoustic test data, FIS was then able to verify all of the test evidence being put forward and highlighted companies who had not tested operable walls as they should have done. In other words, it highlighted those who were testing an operable wall as a fixed partition. During that process, some companies withdrew from the scheme.

Andrew Parkin, partner, global head of acoustics at Cundall, said: "The FIS Verification Scheme seeks to review claimed performance, for both tests and assessments, against agreed Terms of Reference. Those systems found to be in accordance with these TOR will then give designers confidence that in-situ performance can be readily predicted."

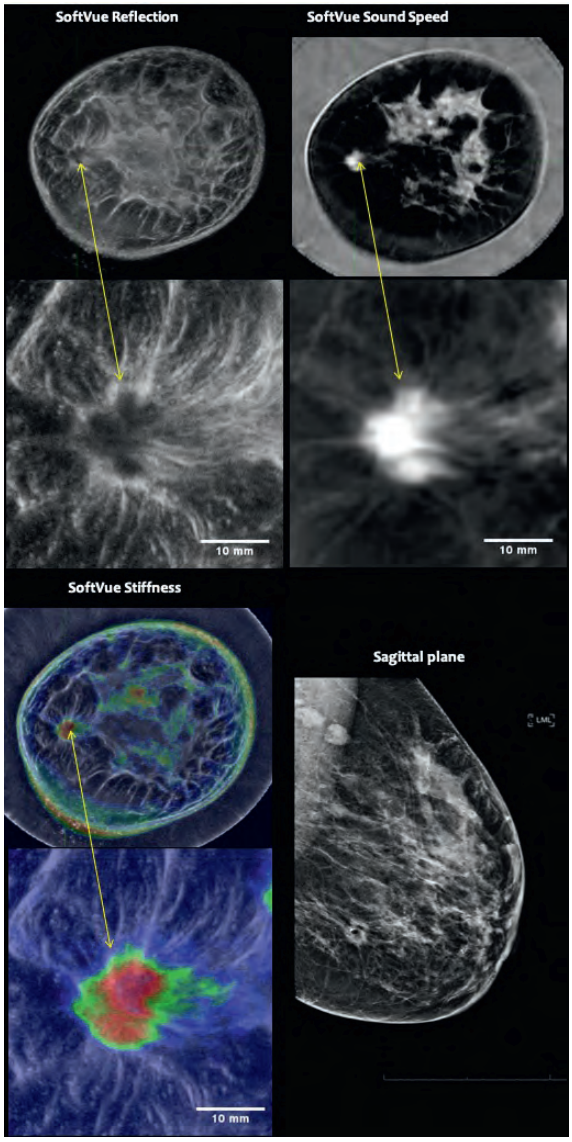
FIS CEO, Iain McIlwee, said: "The test verification framework we have created will provide consistency and enable the comparison of products and systems on a 'like-for-like' basis. This is the first time anything like this has been done."

Ultrasound Tomography (UST): a potential new breast screening modality?

By Preena Patel, Morgan Roberts and Ben Cox

The diagnostic imaging gap

As of 2016, breast cancer is the most commonly diagnosed cancer amongst women in the UK and globally, it is the second most common cause of cancer-related death[1]. The current breast cancer screening programme of mammography involves compression of the breast to produce X-ray projection images from two orthogonal planes, which can reveal suspicious lesions [2, 3]. However, in women with dense breasts, the shadow of a breast tumour can easily be hidden within the complicated background structure of the glandular tissues and hence its sensitivity in these women decreases significantly[4]. This is particularly noteworthy, as women with dense breasts are at higher risk of breast cancer[4] and because there is no clinical biomarker of breast density until a mammogram has been done, there is no way to predict whether a woman has dense breasts or not.



Below: Figure 1: Reflection, sound speed and stiffness images of a human breast using the SoftVue System (Image courtesy of Dr Neb Duric)

Other weaknesses of mammography include the pain associated with breast compression, the psychological trauma of over-diagnosis, and the use of ionising radiation[2]. For these reasons, despite the reduction in mortality shown due to screening, there is still controversy as to whether breast screening does more harm than good and most breast imaging experts would agree there is scope for improvement[2]. Nevertheless, whilst mammography is imperfect, it currently remains the most practical and cost-effective approach for breast cancer screening. However, the above drawbacks continue to drive the development of alternative screening modalities.

Magnetic resonance imaging (MRI) has been demonstrated to have superior sensitivity compared to mammography in younger, high-risk women[5]. However, it is probably not cost-effective for breast screening in large populations. A cheaper alternative of 'Fast MRI' is being explored, however a significant proportion of individuals do not tolerate MRI scans due to claustrophobia (approximately 15%) [3]. Diffuse optical imaging techniques are currently limited by the fact that light scatters significantly while propagating through the breast, thus the spatial resolution is too low to detect small, early tumours[6]. Several photoacoustic tomography systems (whole breast and hand-held) in many stages of development are also showing promising results[18].

Conventional ultrasound (US) imaging of the breast is currently used in the diagnostic pathway if a suspicious lesion is identified on a mammogram[1]. It aids differentiation of soft tissue masses and cysts. As US does not use ionising radiation, it provides scope for screening younger patients, on a larger scale, more often. However, few studies have demonstrated that ultrasound imaging by itself can match the sensitivity of mammography[3]. In addition to this, it is time consuming and requires an experienced practitioner, which subsequently increases the cost above that of a screening tool. To overcome this, automated breast ultrasound systems (ABUS) have been developed. They can generate reproducible qualitative images of the whole breast using a mechanical scanning device which holds the transducer and produces a stack of images of the screened area[7]. In these devices, scanning is accomplished by mechanically moving the probe over the breast in a way similar to that used for hand-held US[7]. The main advantages of these systems include a reduction in variability in examination performance due to less operator dependence, and reduced physician time. These systems have received FDA approval for breast screening in the USA and large multi-centre clinical trials are currently ongoing[7]. P52

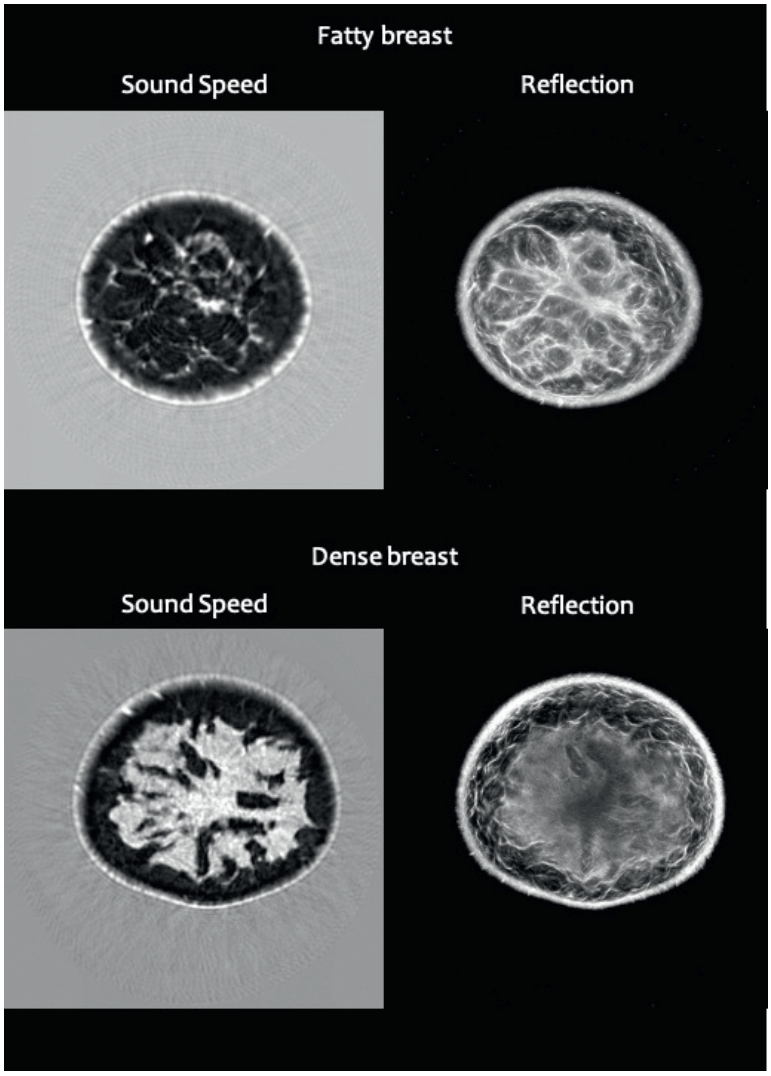
Ultrasound tomography (UST), like ABUS, is an operator independent ultrasound imaging technique. However, it can produce quantitative images[8]. The quantitative nature of these images allows for objective (rather than subjective) interpretation of images, development of diagnostic standards/cut-offs, and scope for additional research into correlations between images and pathology. Additionally, in UST, several slices of the 3D breast volume are produced[8] such that the effect of overlying and underlying anatomical tissue can be effectively removed when viewing individual slices. The detrimental problem of superposition in mammography of dense breasts can hence be avoided.

In 1974, Greenleaf et al. recognised the potential advantages of using a non-ionising tomographic method that removes operator dependence and gives quantitative images, and they introduced the fundamental concepts and initial experiments of UST[9]. But only within the past decade or so has the increasing availability of affordable high performance computing facilities and multi-channel data acquisition systems led to renewed interest in UST, and the development of clinically useful devices.

Ultrasound tomography

UST systems comprise a patient bed on which the patient lies prone[10]. The patient's breast is suspended through an opening in the bed into a water tank underneath the bed[10]. There is therefore no painful breast compression. The breast is surrounded by a ring or bowl array of ultrasound transducers. (The water is a coupling medium between the transducers and the breast.) Scanning typically involves sending pulses of ultrasound into the breast from one or more of the transducers and measuring the reflected and transmitted pulses on some or all of the remaining transducers. Some systems then physically rotate and repeat the measurements at multiple angles.

Acoustically, the breast can be considered as an inhomogeneous medium containing numerous structures (glands, lobules, muscle, fat etc) that result in spatial variations in sound speed, density and acoustic absorption. As a sound wave propagates through such a medium, it will be scattered, refracted and attenuated, resulting in measured signals that contain information about the distribution of acoustic impedance, sound speed, and attenuation. These measurements can therefore be used to form images of these quantities, the acoustic impedance depending primarily on the scattered waves, and the sound speed and attenuation on the through-transmitted parts of the signal[9].



Below: Figure 2: UST sound speed and reflection images of a fatty human breast and a dense human breast using the QTUS system (Image courtesy of Dr James Wiskin and Dr Bilal Malik)

The earliest approaches to image reconstruction made an analogy with X-ray computed tomography, in which the measurements are line integrals of the X-ray absorption[9]. If the sound is assumed to travel along rays between emitters and receivers, then the measured drop in signal amplitude can be related to the line integrals of the attenuation along those rays. Furthermore, the time it takes the sound to pass from an emitter to a receiver can be linked to the line integral of the sound speed along the ray joining the two. The simplest algorithms assume that the rays are straight; more advanced algorithms can include the refraction of the rays[19]. Either way, quantitative images of the sound speed and attenuation can be recovered from the line integrals. Reflection images, which are closer to conventional B-mode images can also be obtained. More recently, there has been a move towards reconstruction approaches known as full-wave inversion approaches, in which a numerical model of acoustic propagation is iteratively updated, e.g. the sound speed distribution is updated, until the output matches the measurements[20, 21, 22]. This approach to recovering the sound speed or attenuation maps makes fewer assumptions, and is more flexible, than ray-based approaches and higher quality images can be obtained in this way. However, it is non-trivial and can be very computationally expensive, especially in 3D.

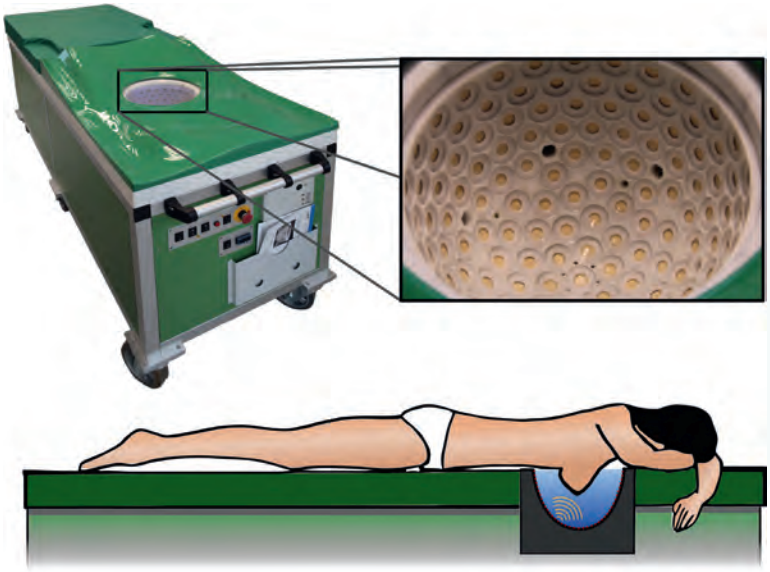
The resulting images, particularly the quantitative images of sound speed and attenuation, provide different contrasts, which can help differentiate between different P54

tissue types, for example between benign and malignant soft tissue masses, cysts and background breast tissue. Furthermore, the quantitative nature of the images will facilitate comparisons over time. The production of images which show quantitative distributions of multiple acoustic parameters, increases the ability to differentiate structures and provides an opportunity for fusion images which may be useful in lesion detection.

Current systems

Several UST systems have been developed by research groups to carry out pilot clinical work. For UST, transducer elements are ideally distributed around an aperture to achieve full coverage of the breast, but research groups have met this criteria using many different configurations.

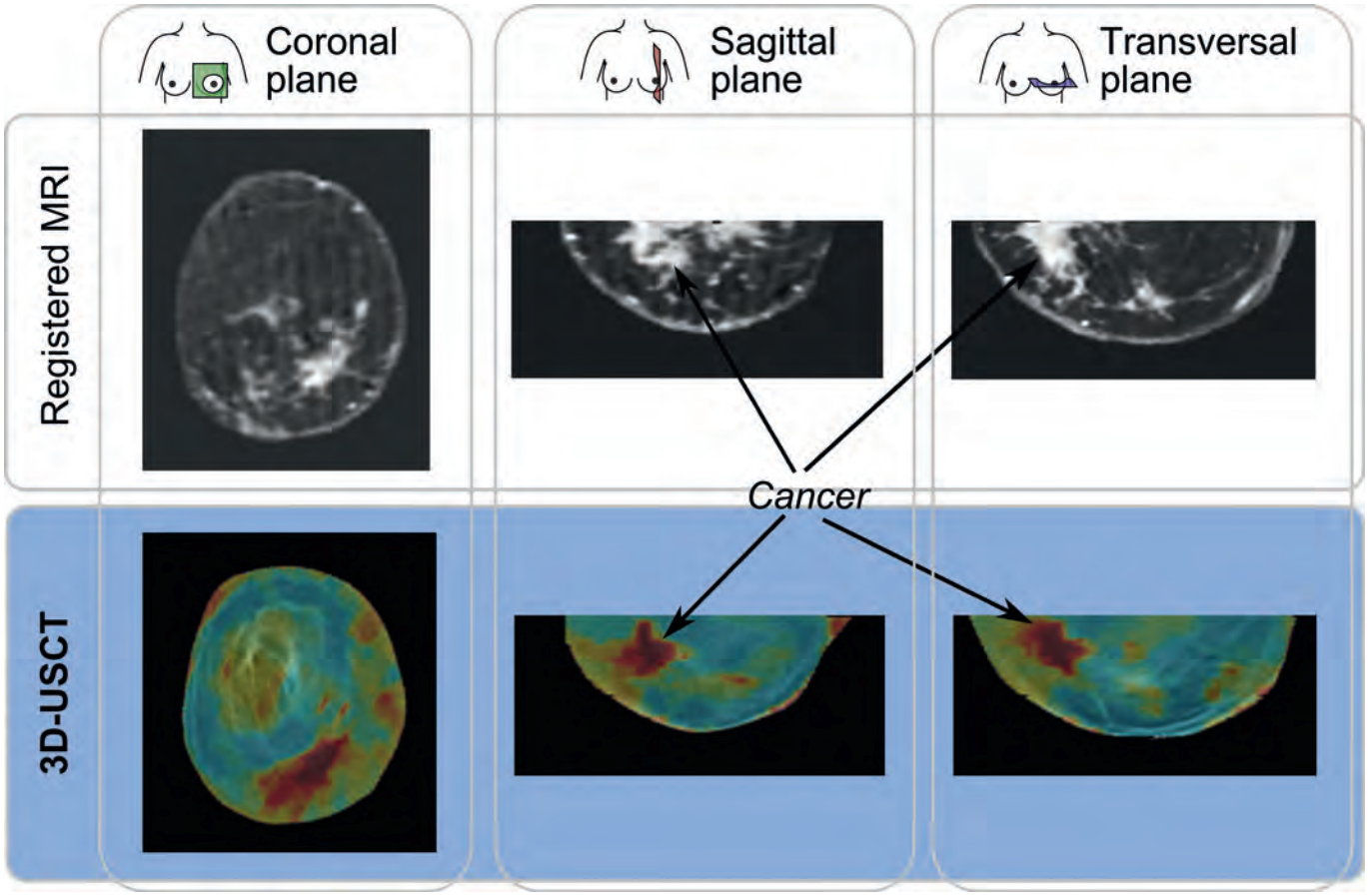
The SoftVue system has been developed by Delphinus Medical Technologies (Karmanos Cancer Institute). It acquires 2D coronal slices of the breast using a ring array of 2048 identical transducer elements, which focus energy into a narrow plane[11]. The ring is mounted on a motorised gantry which moves from the chest wall all the way to the nipple, and acquires multiple slices which can then be stacked to form a pseudo-3D/2.5D volume[11]. Figure 1 shows as image obtained using the Soft~Vue system.



Right: Figure 3: Schematic of the KIT 3D UST system (Image courtesy of Dr Torsten Hopp) These images can also be found in: T. Hopp, M. Zapf, E. Kretzek, J. Henrich, A. Tukalo, H. Gemmeke, C. Kaiser, J. Knaudt, N. V. Ruiter, "3D ultrasound computer tomography: update from a clinical study," Proc. SPIE 9790, Medical Imaging 2016: Ultrasonic Imaging and Tomography, 97900A (1 April 2016); **https://doi.org/10.1117/12.2216686**

Below: Figure 4: 3D UST fusion (reflectivity and sound speed) images of a human breast using the KIT 3D UST system. The cancer can be seen as an uptake of contrast agent in the MRI images. The MRI images are registered to the UST images such that it has the same shape (Image courtesy of Dr Torsten Hopp)

The QT Ultrasound Breast Scanner is a breast scanner which acquires data using separate arrays for transmission and reflection mode[12]. For transmission mode, a large single-element transmitter generates an unfocused plane wave that propagates through the breast and is detected by a 2048-element rectangular receiver array[12]. In reflection mode, there are three linear arrays which are focused at different depths within the breast, these acquire data in a manner similar to standard B-mode imaging[12]. The scan head rotates and translates the arrays to achieve full coverage of the breast, and uses fully 3D methods to reconstruct images[12]. Although, its FDA clearance is for use as an adjunct to mammography, the company is generalising this imaging modality for use in other parts of the body,



and have demonstrated that quantitative transmission tomography can still be used in the presence of bone and air, which generate large reflections. An example QT scan of the human breast is shown in Figure 2.

The Karlsruhe Institute of Technology (KIT) have designed a system which uses a semi-ellipsoidal bowl aperture, shown in Figure 3. There are 2041 small omnidirectional elements distributed over the bowl surface, which emit spherical waves so that a 3D reconstruction method can be used[13]. The bowl can also be rotated and translated to acquire data from more positions. Images from a clinical study using the KIT system are shown in Figure 4. The KIT group is currently developing another system, 3D UST III, which will have a larger aperture to accommodate fatty breasts which spread horizontally due to buoyancy[14]. They are also improving the distribution of transducers on the surface of the bowl, which reduces the number of rotations needed and therefore the acquisition time, which reduces the image artefacts that arise from patient motion[14].

Finally, Wroclaw University of Technology have designed an ultrasound transmission tomography system which also uses a solid-state ring array. Their design is such that it uses printed circuit boards and simplifies production of the system leading to reduced cost and time to manufacture[15], [16]. They have also developed an approach to recognising lesions within an UST image based on the characteristic of transmission, reflection and fusion images, based on in vivo xamination of breast lesions[17]. This method of interpretation for clinicians helps translate this modality into routine clinical practice.

Summary

Shortly after the inception of X-ray computed tomography, Greenleaf et al. introduced UST in 1974, by using an analogous approach with ultrasound. Now, UST is a rapidly emerging technology for medical imaging which is gaining greater interest for a wide range of applications. Recently, the 2nd International Workshop on Medical Ultrasound Tomography (MUST) was hosted in Detroit, which discussed recent work in system design, reconstruction and translation towards routine clinical use. It bought together a growing community of researchers to exchange ideas and research results. The work presented at the conference demonstrated progress towards UST as a routine breast screening imaging modality which produces quantitative images in an ionising radiation and pain-free manner.

Acknowledgements

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Preena Patel is a medical student at University College London (UCL). Her interest in UST was sparked by doing a project in UCL's Biomedical Ultrasound Group with Bradley Treeby and Ben Cox. Morgan Roberts is also a member of the group, working towards a PhD on UST.

References

1. Cancer Research UK. Breast Cancer Statistics. **https://www.cancerresearchuk.org/health-professional/cancer-statistics/statistics-by-cancer-type/breast-cancer#heading-Zero** (Accessed July 25, 2019).
2. Marmot M., Altman D., Cameron D. et al. The benefits and harms of breast cancer screening: an independent review. Br J Cancer (2013) 108 2205–2240 doi:10.1038/bjc.2013.177.
3. Boone J.M., Kwan A.L.C., Yang K. et al. Computed Tomography for Imaging the Breast. J Mammary Gland Biol Neoplasia (2006) 11 103. **https://doi.org/10.1007/s10911-006-9017-1**.
4. Brem R.F., Lenihan M.J., Lieberman J. et al. Screening Breast Ultrasound: Past, Present, and Future. American Journal of Roentgenology (2015) 204 234-240 doi: 10.2214/AJR.13.12072.
5. Leach M.O., Boggis C.R., Dixon A.K., et al. Screening with magnetic resonance imaging and mammography of a UK population at high familial risk of breast cancer: a prospective multicentre cohort study (MARIBS). Lancet (2005) 365 1769–78 doi: **https://doi.org/10.1016/S0140-6736 (05)66481-1**.
6. Agnese D.M. Advances in breast imaging. Surg Technol Int (2005) 14 51–6.
7. Kaplan S.S. Automated Whole Breast Ultrasound. Radiologic Clinics, (2014) 52 539 – 546.
8. Li C., Duric N., and Huang L. Clinical breast imaging using sound-speed reconstructions of ultrasound tomography data. Proc SPIE. (2008) doi:10.1117/12.771436.
9. Greenleaf J., Johnson S., Lee S., et al. Algebraic reconstruction of spatial distributions of acoustic absorption within tissue from their two-dimensional acoustic projections. Springer US (1974) 5 591–603.
10. Duric N., Littrup P., Li C et al. Breast ultrasound tomography: bridging the gap to clinical practice. Progress in Biomedical Optics and Imaging - Proceedings of SPIE (2012) 8320. doi: 23.10.1117/12.910988.
11. Duric N., Littrup P., Schmidt S. et al. Breast imaging with the SoftVue imaging system: First results. In Medical Imaging 2013: Ultrasonic Imaging, Tomography, and Therapy (2013) 8675, 86750K. International Society for Optics and Photonics, 2013.
12. Malik B., Terry R., Wiskin J., and Mark Lenox. Quantitative transmission ultrasound tomography: Imaging and performance characteristics. Medical physics (2018) 45 7 3063–3075.
13. Stotzka R., Widmann H., O Mueller T., et al. Prototype of a new 3d ultrasound computer tomography system: transducer design and data recording. In Medical Imaging 2004: Ultrasonic Imaging and Signal Processing. 5373, 70–80. International Society for Optics and Photonics.
14. Gemmeke H., Berger L., Hopp T., et al. The new generation of the KIT 3D UST. In Proceedings of the International Workshop on Medical Ultrasound Tomography: 1.- 3. Nov. 2017, Speyer, Germany. 271–282. KIT Scientific Publishing, Karlsruhe, 2018.
15. Opieli´nski K.J., Pruchnicki P., Gudra T., et al. Ultrasound transmission tomography imaging of structure of breast elastography phantom compared to US, CT and MRI. Archives of Acoustics (2013) 38(3):321–334.
16. Opieli´nski K.J., Pruchnicki P., Gudra T., et al. Imaging results of multi-modal ultrasound computerized tomography system designed for breast diagnosis. Computerized Medical Imaging and Graphics (2015) 46 83 – 94. Information Technologies in Biomedicine.
17. Opieli´nski K.J., Pruchnicki P., Szymanowski P. et al Multimodal ultrasound computer-assisted tomography: An approach to the recognition of breast lesions. Computerized Medical Imaging and Graphics (2018) 65 102–114.
18. Manohar, S., Dantuma, M. Current and future trends in photoacoustic breast imaging. Photoacoustics. (2019). 16 100134.
19. Li S., Jackowski, M., Dione D.P., et al. Refraction corrected transmission ultrasound computed tomography for application in breast imaging. Medical physics, (2010) 37 5 2233-2246.
20. Wiskin, J., Borup, D.T., Johnson, S.A., & Berggren, M. Non-linear inverse scattering: High resolution quantitative breast tissue tomography. The Journal of the Acoustical Society of America, (2012) 131 5 3802-3813.
21. Wang, K., Matthews, T., Anis, F., et al. Waveform inversion with source encoding for breast sound speed reconstruction in ultrasound computed tomography. IEEE Trans. Ultrason. Ferroelectr. Freq. Control (2015) 62, 475–493.
22. Proceedings of the International Workshop on Medical Ultrasound Tomography. 1.- 3. Nov. 2017, Speyer, Germany. Hrsg.: T. Hopp,. KIT Scientific Publishing, Karlsruhe, 2018.

The Royal Albert Hall Sound of the Future project

By Stephen Stringer MSc, BEng, CEng, MIOA, MCIBSE, partner, Sandy Brown Associates
Darren McGaghran, Senior Engineer, Sandy Brown Associates BEng, MIOA

Opened in 1871 to fulfil Prince Albert's vision of a central hall to promote the arts and sciences, the Royal Albert Hall (RAH) is one of the world's most treasured and iconic venues. Over the past 149 years, it has hosted everyone from Winston Churchill, Albert Einstein and Edward Elgar to The Beatles, Ella Fitzgerald and Adele. However, amplified sound quality in the Hall can vary hugely and needed improvement.

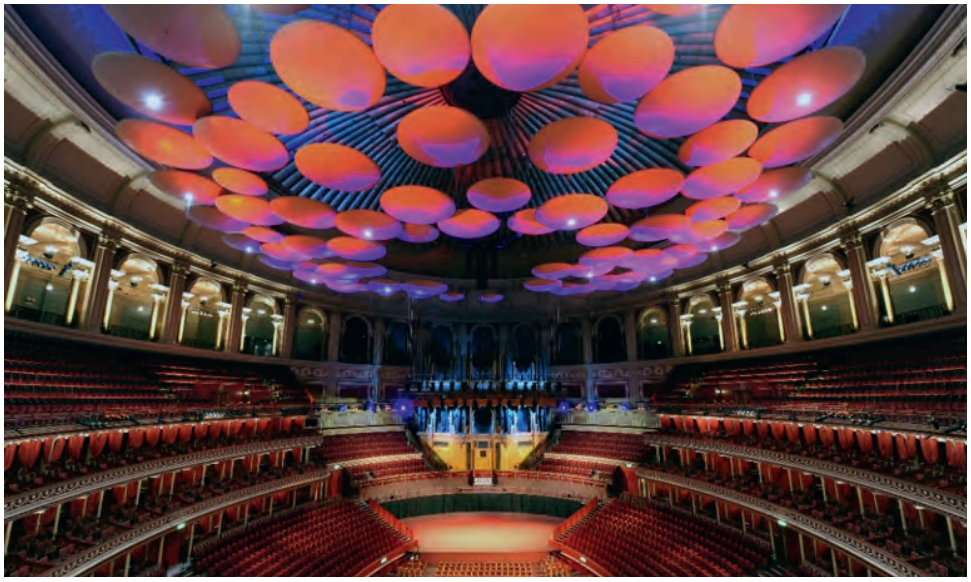
Built in an era of unamplified sound, the auditorium of this Grade I listed building has a capacity of 5,267 and hosts more than 400 performances a year. The venue regularly offers a diverse schedule of music, film, dance and artistic performances throughout each year.

Main image: External view of the Royal Albert Hall © Royal Albert Hall

The RAH has control on certain show elements but influence over the sound system has historically been limited. Generally, the sound system was supplied by third party rental companies or brought in by touring productions.

Amplified sound quality in the Hall can vary hugely, even when the same equipment is used. Historically, this has led to a number of complaints about amplified sound, which is something they wanted to improve.

The Sound of the Future project was an ambitious undertaking to replace the existing sound system and bring the biggest improvement to sound in the auditorium since the installation of the iconic acoustic 'mushrooms' in 1969. P58



Sandy Brown undertook an acoustic review of the auditorium including the previous in-house sound system, identified areas where improvements could be made, compiled the new sound system specification, advised throughout the tender process, the final system design and commissioning.

The brief

The Sound of the Future project comprised two main aspects:

- replacement of the in-house sound system serving the auditorium; and
- a review of the auditorium in relation to potential room acoustic improvements both for amplified and unamplified events.

Replacement of the in-house sound system originated from a desire to have a greater degree of control over the audience's audio experience at the Hall. Occasionally, the audio quality for shows fell short of the RAH's high standards and complaints were received especially on social media. The core philosophy of the project was that: "The world's most famous stage deserves a world-class audio solution". Bringing the audio system in-house would make this possible.

In order to deliver on the project requirements, the following was needed:

- engagement with the audio industry;
- design a world class audio system;
- build a respected in-house team; and
- purchase and install the in-house audio equipment.

As part of building an in-house team the position of audio manager was created to oversee the operation of the new sound system and to manage its use, both in house and with external promoters. This led to the creation of an audio department within the RAH to be staffed by an experienced team of engineers, led by a well-known and respected figure appointed in 2017.

With the wide range of shows that the RAH hosts, any new sound system would have to cater for all types of programme material while still delivering excellent audio quality. These include:

- classical, ballet and opera;
- rock and pop;
- schools and community performances;
- conferences;
- spoken word;
- film with live orchestra;
- musical theatre;
- massed choirs; and
- sports events.

From the beginning of the project it was emphasised that the acoustic characteristics of the auditorium would have a significant impact on the design of any new sound system. Consequently, an acoustic review was essential and is discussed in the next section.

Historical acoustic review

In liaison with the Hall's archive department, a detailed historical review of the auditorium was undertaken from its first opening on 28th March 1871 to the current day. This considered its original construction and adaptations over the years as briefly summarised below.

In his opening address at the Hall, the Prince of Wales (later King Edward VII) was audible not once but twice and therefore, remedial measures were immediately instigated. A calico velarium weighing 1.25 tons (1,136 kg) was installed to mitigate the focusing effect and echo off the domed roof. By 1874, further improvements were made by lowering the velarium and adding stencilled valence hangings around the cove. The velarium was renewed in 1884, this time made of woven duck linen.

The fabric velarium was replaced in 1949 by the current perforated fluted aluminium lining (with fibre glass quilt to the rear) built around the glazing bars of the lower dome from which the glass was entirely removed. It is formed of two skins of radially arranged, tapering elements of semi-circular section. The lower skin is perforated and backed with fibre glass insulation to provide sound absorption.

The aluminium velarium was designed to provide blackout, reduce echo/focusing, improve the thermal insulation and catch rainwater. The elaborate cornice, scrolls and fielded panels that originally decorated the cove above the gallery in the auditorium, and had a beneficial acoustic effect, were removed following water damage.

In order to reduce the focusing effect of the domed roof and to improve early reflections to the audience at the upper seating levels, a series of convex glass reinforced plastic diffusers ('flying saucers' or 'mushrooms' as they are more commonly referred to now) were recommended by AIRO. P60

Above: Internal view of the auditorium © Royal Albert Hall/ Andy Paradise

Below: Internal view of original inner daylit auditorium with glass domed roof © Royal Albert Hall

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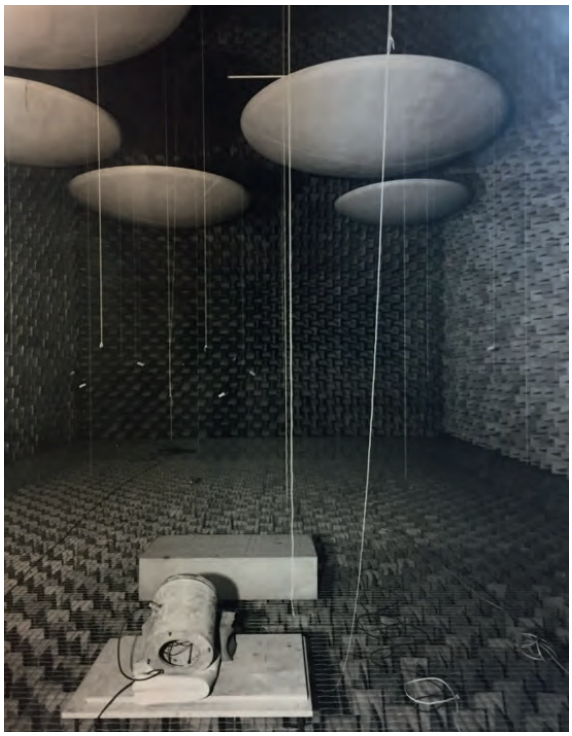
135 mushrooms, made by the Yorkshire Fibreglass Company, were installed at the level of the gallery ceiling, 109 in December 1968 and another 25 in June 1969. They ranged in diameter from 6' (1.83m) to 12' (3.66m) and covered approximately 50% of the dome with the largest weighing only 80lbs (36.3kg). The mushrooms were tested at the Building Research Establishment anechoic laboratory prior to installation.

The mushrooms reduced the unoccupied reverberation time at mid/high frequencies from approximately 3.5s to less than 3s and significantly reduced the focusing/echo from the domed roof. Although the number and location of mushrooms has since been adjusted, they now form part of the Grade I listed interior and are considered by many to be an iconic symbol of the Royal Albert Hall.

Above left: Internal view of original fabric velarium © Royal Albert Hall

Above right: Installation of anechoic laboratory © Royal Albert Hall

Below: Testing of diffusers at BRE anechoic laboratory © Royal Albert Hall



In preparation for hosting the Proms, which were moved from the bombed Queen's Hall in 1941, a sound reflector was installed over the stage which weighed 40 tons (40,640kg) and was 40' wide (12.2m). Further studies were undertaken in 1969 and three new replacement canopies were introduced; each of which is convex in shape from front to back and also laterally giving a slightly scalloped effect. These canopies also now form part of the Grade I listing.

Further improvements to the acoustics of the auditorium were made on the advice of Peutz (1996-2002) involving removal and reconfiguration of the mushrooms.

Auditorium investigations

Improving the acoustics of the auditorium for amplified events and determining the best audio solution required an understanding of the key issues. Amplified sound in the auditorium was assessed in three ways:

- the use of a sound feedback log;
- subjective listening of shows; and
- objective measurements.

Benchmark testing of the existing system was carried out in August 2017 while subjective listening assessments began in July 2017 and continued to February 2018.

Sound feedback log

Typically, complaints were received from only a small proportion of audiences and mainly for amplified events. To understand the nature of the complaints a sound feedback log was established noting:

- the genre of show;
- the type of sound system;
- the sound system provider;
- the nature of the complaint;
- the seat location; and
- any follow up action.

Of the 382 shows logged in 2017, 176 complaints were recorded with a genre breakdown as shown in the table below.

Genre	Number of complaints
Classical/orchestral (amplified)	48
Classical/orchestral (unamplified)	2
Film	10
Rock and pop	88
Spoken word	22
Sports	2

From the amplified shows, three main complaints were noted (as listed below) with general comments extracted from the sound feedback log:

- sound quality of the sound system — unclear, muffled, distorted, poor clarity, over amplified, too loud, unbalanced;
- speech intelligibility — cannot understand vocals, could not make out every word, cannot understand every word, struggled to hear anything clearly; and P62

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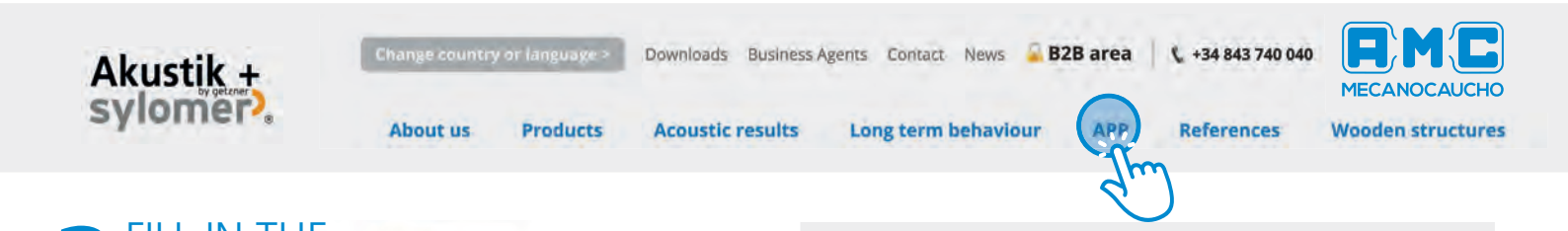
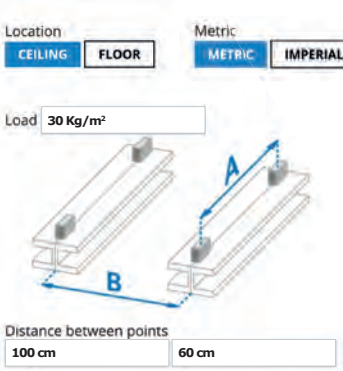
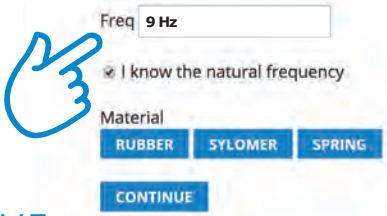


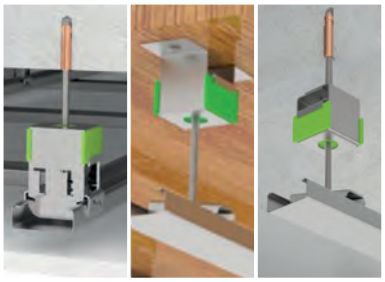
2 FILL IN THE **INPUT DATA**



3 SELECT THE **PERFORMANCE LEVEL**



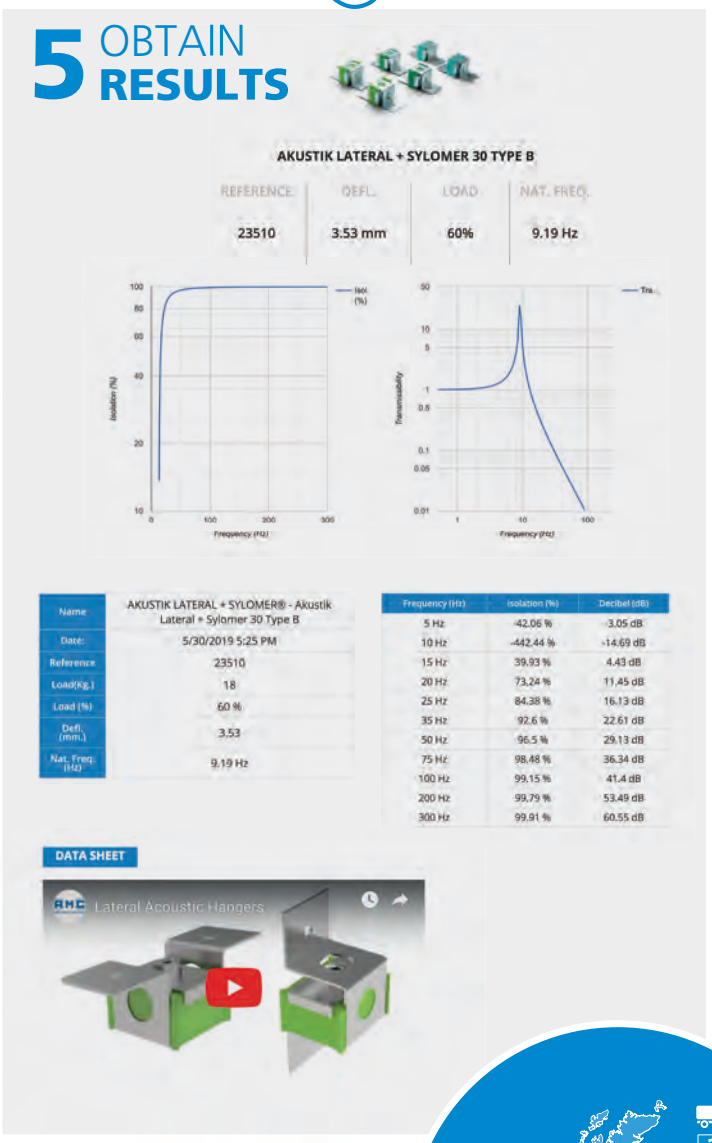
4 SELECT THE **INSTALLATION TYPE**

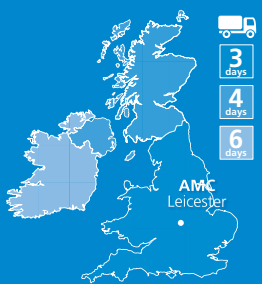


Straight to profile | Straight to slab | Between threaded rods

SEARCH RESULTS

5 OBTAIN **RESULTS**





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- sound reflections from the rear of the auditorium — echo.

In most instances, the locations of the complaints were noted in the sound feedback log. The number of complaints in each area is shown in the table below.

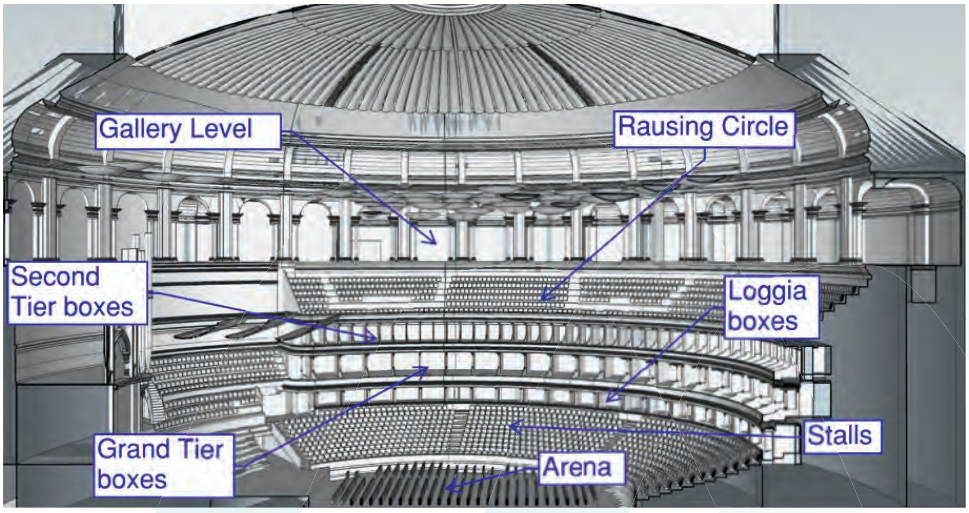
Location	Number of complaints
Gallery	11
Circle	57
Second Tier	6
Grand Tier	3
Loggia	10
Choir	20
Stalls	33
Arena	22

In summary, 42% of the complaints arose from high level (Circle and Gallery), 12% from the boxes, 12% from Choir and 34% from the Stalls and Arena.

Objective acoustic measurements

Benchmark testing of the existing system was carried out in August 2017 as part of wider acoustic review of the auditorium that also included extensive room acoustic measurements.

An IRIS 3-D acoustic measurement system with an omni-directional sound source was used as the primary measurement system with additional measurements taken using WinMLS for verification. At the time of the survey the IRIS system did not output STI values so a separate STIPA assessment was carried out using a handheld sound level meter, with WinMLS providing additional data for verification purposes.



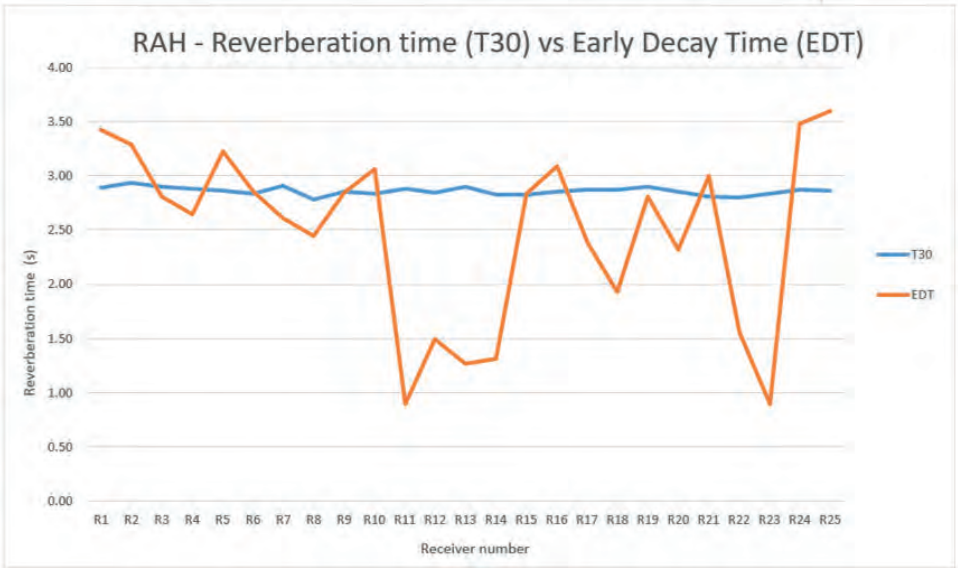
The areas with the lowest STIPA values were the Gallery and Circle Level. These are also noted as areas where the subjective quality of performances was typically lower. Speech intelligibility was generally higher towards the centreline of the auditorium and decreased at the sides of the stage.

It is clear from a comparison of the measured unoccupied mid-frequency reverberation times (T30) and early decay time (EDT) that the physical reverberation time (T30) is reasonably consistent across the auditorium, however the EDT exhibits a large variation.

Locations with the lowest EDT were the private boxes many of which are partially 'screened' from both the direct and the majority of the reflected sound. This effect becomes more pronounced when the sound source is flown at high level, when the receiver moves to the sides of the auditorium and towards the rear of boxes, in particular those at Loggia level.

Above: Internal cross-section of the auditorium

Below: Unoccupied reverberation time (T30) vs Early Decay Time (EDT)



Subjective assessments

Separate from the sound feedback log, a number of critical listening visits were made from July 2017 to February 2018.

The approach taken was to listen in as many areas as possible which typically involved:

- Gallery level (whether occupied or unoccupied);
- Circle level door entranceways;
- Second Tier, Grand Tier and Loggia boxes where possible;
- Choir (when sold); and
- the Stalls and Arena (where the show would permit).

Subjectively, the sound quality of amplified shows varied considerably. This appeared to be due to several factors:

- audience location in the auditorium;
- orientation and height of the sound system;
- level and distance from loudspeakers; and
- overall sound level and balance.

Performances from several artists bands or other groups were assessed.

Audience location

Overall, three distinct acoustic zones were identified within the auditorium:

- the Arena and Stalls;
- the Boxes; and
- the Circle and Gallery.

The Stalls (and Arena with seats installed) have upholstered seating. These provide acoustic absorption and scattering, which reduce local sound reflections. In these areas the acoustic environment is more suited to amplified sound. Despite this there seemed to be some difficulty in ensuring adequate coverage from the main loudspeaker arrays, particularly those supplied by an

external party. This may have been due to the need to avoid sound 'spill' to the stage.

The Grand Tier and the front seats of the Second Tier boxes are situated within the main volume of the auditorium. These generally have direct lines of sight to loudspeakers which is desirable.

The rear seats in the Second Tier boxes are recessed and not in the main auditorium volume, in addition, some of Loggia boxes have no line of sight to loudspeakers due to balcony overhangs. This was particularly noticeable to those seated to the sides of the stage. This significantly reduces the sound quality to the listener.

The Circle and Gallery are exposed to the main volume of the auditorium and are predominantly surrounded by reflective surfaces, affecting the clarity and making the sound appear 'muddy'. This was worse at low frequencies resulting in a 'boomy' sound, which correlates with the objective acoustic measurements.

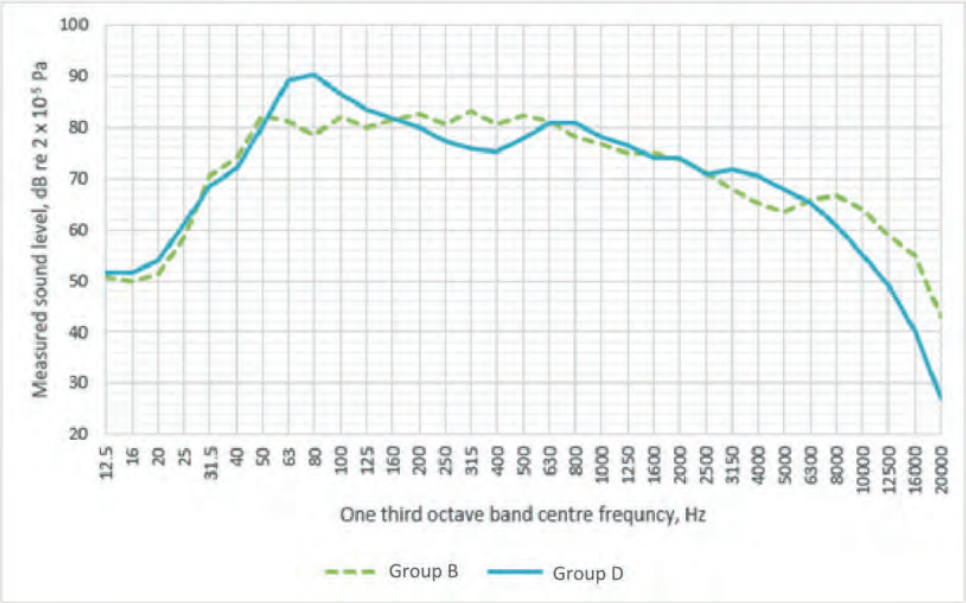
Sound system orientation

The height and orientation of the suspended loudspeaker arrays influenced the subjective quality of the performance. This is believed to be caused by too much sound energy being directed towards hard reflective surfaces around the upper rear of the auditorium, causing late sound reflections which can be heard as a distinct 'echo' and exciting the reverberant field at high level.

During the critical listening visits, it was noted that two bands used the same sound system with the major difference being the height of the main loudspeaker arrays. For 'Group A', the Gallery was occupied, and the system was flown higher to cover this area, which resulted in several complaints. For 'Group B', the Gallery was not open and the system was flown lower and subjectively acceptable sound was achieved throughout.

While it would be desirable to have the main loudspeaker arrays lower, this is sometimes not possible due to show constraints, such as sightlines for video screens.

As well as height, the angle of loudspeakers was found to have an impact on show quality. When angled too high this again causes the unwanted excitation of the upper hard reflective surfaces at the rear of the auditorium.



Above: Comparison of sound level between Group B (good) and Group D (poor)

Loudspeaker sound levels

On several occasions, it was noted that the sound levels between loudspeaker hangs had not been properly balanced. This was particularly noticeable in the Circle from side stage delays. In the Choir, front fill loudspeakers were particularly loud in the front seats, assumed to be due to the need to cover seats further back.

These issues were mostly associated with touring sound systems as there is often insufficient time to fully commission the sound system between different shows.

Sound level and balance

The overall sound level and the balance (amount of bass) has a significant impact on the perceived sound quality. During rehearsals for a show, it was noted that speech intelligibility was good throughout the auditorium. However, during the show, sound levels were much higher and speech was much less intelligible.

This may, in part, be due to auditory masking making it difficult to separate direct from reverberant sound when played at high levels. Most shows sounded better when the sound level was relatively low (L_{Aeq} 90 dB).

Balance has another effect on sound quality. Shows that incorporated large subwoofer arrays or had a significant bass component tended to sound worse. Two factors considered in the assessments (particularly in the Circle and Gallery) are:

1. at low frequencies, the dominant reverberant field has insufficient time to decay before the next sound arrives, resulting in a 'muddy' sound and poor clarity (C80) values;
2. upper auditory masking where high levels of low frequency sound can mask higher frequencies. This may mean bass sounds are temporarily masking vocal levels.

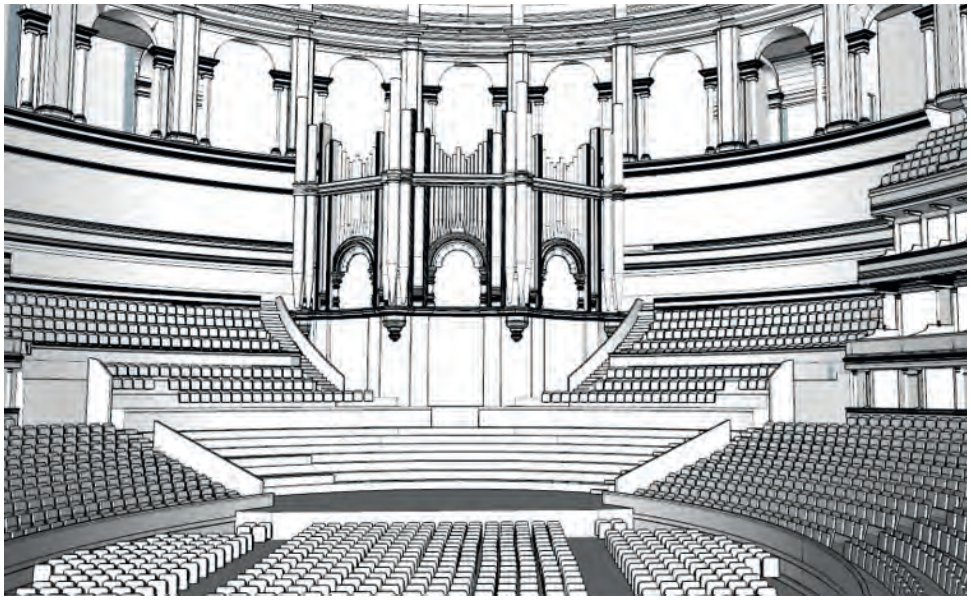
Long-term sound logging measurements

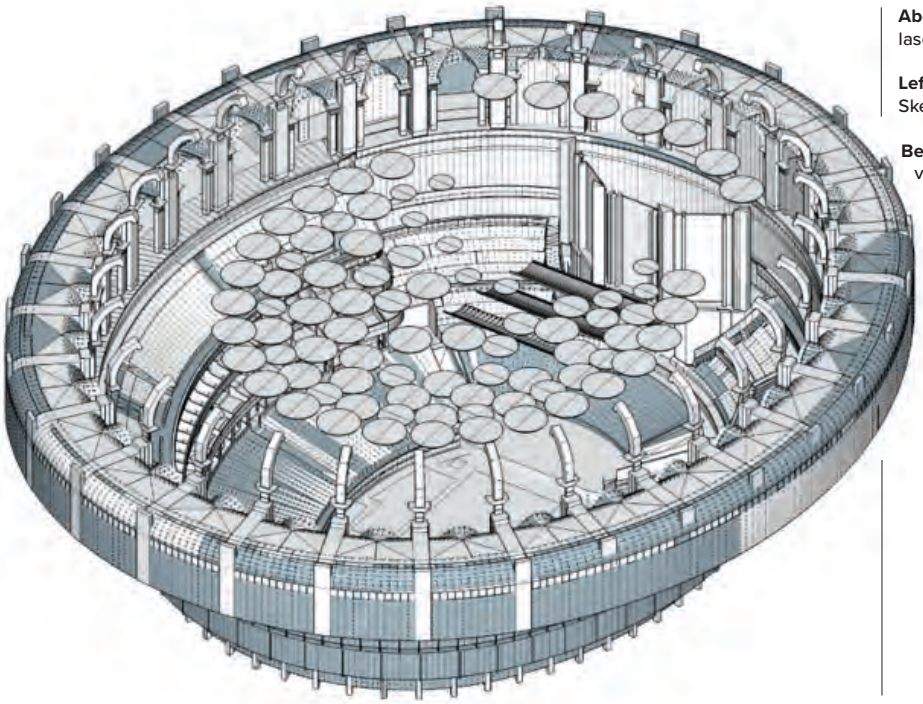
During subjective listening it was determined that the low frequency sound in the auditorium required further investigation, and this led to the installation of monitoring equipment at gallery level set to record the sound levels and frequency content during shows each night from November 2017 to February 2018. Subsequent analysis showed some trends appearing when comparing the measured data to subjective assessments.

The measured sound logger results indicated significant low frequency sound energy present down to 50 Hz. After a performance from 'Group D', comparison of hand-held measurements with the logged data confirmed that the higher low frequency sound levels noted in the Gallery were not present in the main volume of the auditorium. This indicates that these were caused by local room acoustic conditions.

Sound spectra of shows that were subjectively noted as both good and poor were compared. 'Group B' were generally considered to have good sound quality whereas 'Group D' received significant complaints.

Both measurements were made at Gallery level. Coincidently, both achieved an overall level of L_{Aeq} P64

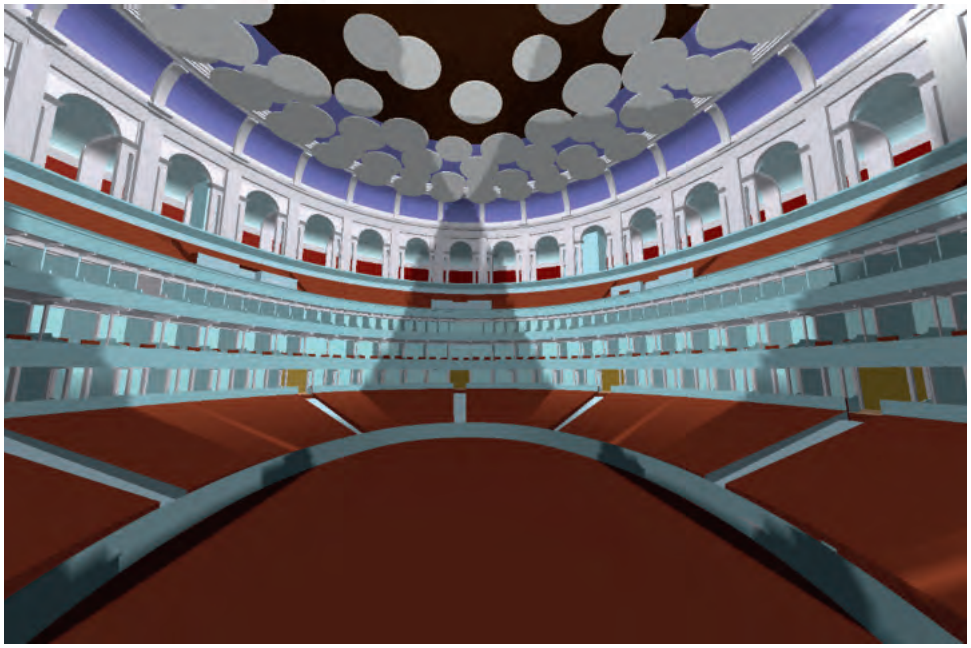




Above: Image of laser scan model

Left: Image of Sketchup model

Below: Internal view of acoustic model



dB. At lower frequencies it was noted that measured sound levels in the 63 Hz and 80 Hz third-octave bands were approximately 10 dB higher during the 'Group D' performance than during 'Group B' concert.

Acoustic modelling

In order to help assess future acoustic improvements to the auditorium and evaluate the new sound system, a three-dimensional acoustic computer model was constructed. Due to the absence of accurate scaled drawings, a highly detailed three-dimensional laser scan was commissioned with the model comprising more than 1.5 million lines and surfaces.

The model was then simplified within Sketchup before being imported into ODEON.

The acoustic model was calibrated using a combination of historical information on the auditorium room surfaces, in-situ sound absorption measurements of a range of surfaces and limited intrusive investigations, with off-site laboratory analysis where practicable. All of these were used to refine the model to ensure that the predicted acoustic characteristics of the auditorium were in line with those measured.

A further more simplified acoustic model was subsequently constructed within EASE in order to assist in the development of the new sound system.

Developing a sound system specification

In addition to the RAH technical team, at an early stage in the project a number of 'advocates' were engaged who had extensive experience of working at the Hall, as well as an excellent audio industry reputation across a wide range of genres.

The advocates provided an invaluable contribution to the development of the new in-house sound system specification, short-listing of suppliers, design evaluation and trials.

Existing in-house sound system

On the basis of objective testing and subjective evaluations, the main issues associated with the existing sound system were:

- large front-of-house hangs trying to cover the entire auditorium;
- poor direct sound coverage further away – speech intelligibility suffers;
- Circle level received the most

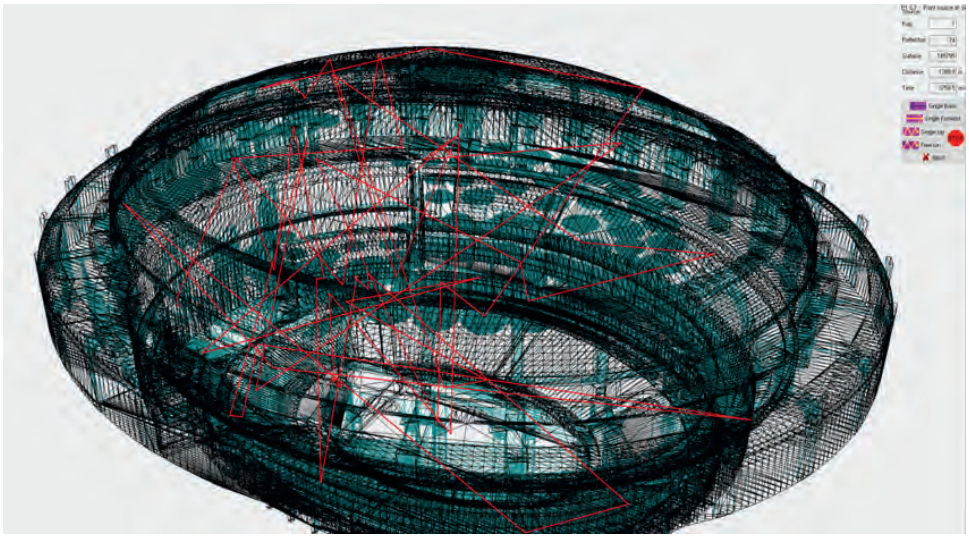
complaints – little direct sound;
- previous gallery delay system not effective;
- speakers need to fire upwards to cover Circle and Gallery levels;
- system playing louder to achieve this;
- low frequency energy in the Gallery – reducing intelligibility, correlates strongly to complaints;
- exciting the auditorium surfaces at high level – strong late reflections; and
- poor coverage in the boxes, particularly towards the rear.

It was also noted that due to the constraints of rigging and setting up a system with limited time, often critical listening was not carried out on the higher levels such as the Circle and Gallery.

Key design requirements for new sound system

Developing the above further, the key design requirements for the new sound system were identified as follows:

- main hangs covering stalls, arena and boxes only
  - o no longer trying to cover Circle and Gallery from single point;
- new circle delay system
  - o adds direct sound coverage to circle level without exciting the auditorium at high level
  - o much improved speech intelligibility – objective measurements and subjective assessment;
- new Gallery delay system – improving speech intelligibility
  - o less low frequency energy as main hangs aren't firing up to the Gallery;
- additional box speakers
  - o Adds direct sound and subtle reinforcement/envelopment; and
- minimising sound to the stage areas.



In addition to the above, the design of the new sound system had to be cognisant of aesthetics and sightlines, both for audience and television broadcasts.

Sound system specification

With input from the advocates and the RAH technical team, an audio system performance specification was compiled for the selected sound system manufacturers.

The specification had to take account of what was electro-acoustically possible considering the acoustic characteristics of the auditorium as well as what was practical given the historic listed building status of the Hall. This then had to be balanced against providing the best sound system.

It was agreed that the Grand Tier and Second Tier as well as the Loggia Boxes would benefit from individual speakers within each box. These speakers were to provide further sound reinforcement to the front of the box as well as to add additional reverberation to counter the 'decoupling' from the main auditorium that these areas experienced.

Above: Wireframe view of acoustic model with single sound path shown

Below: Image of internal construction of velarium roof © Royal Albert Hall/ Sandy Brown

Tender process

The overall tender process is summarised here:

- development of manufacturers/ supplier's shortlist;
- factory visits;
- objective ratings;
- company evaluation;
- selection of final two manufacturers/suppliers;
- audio demo day;
- subjective impressions questionnaire;
- objective acoustic measurements; and
- final decision.

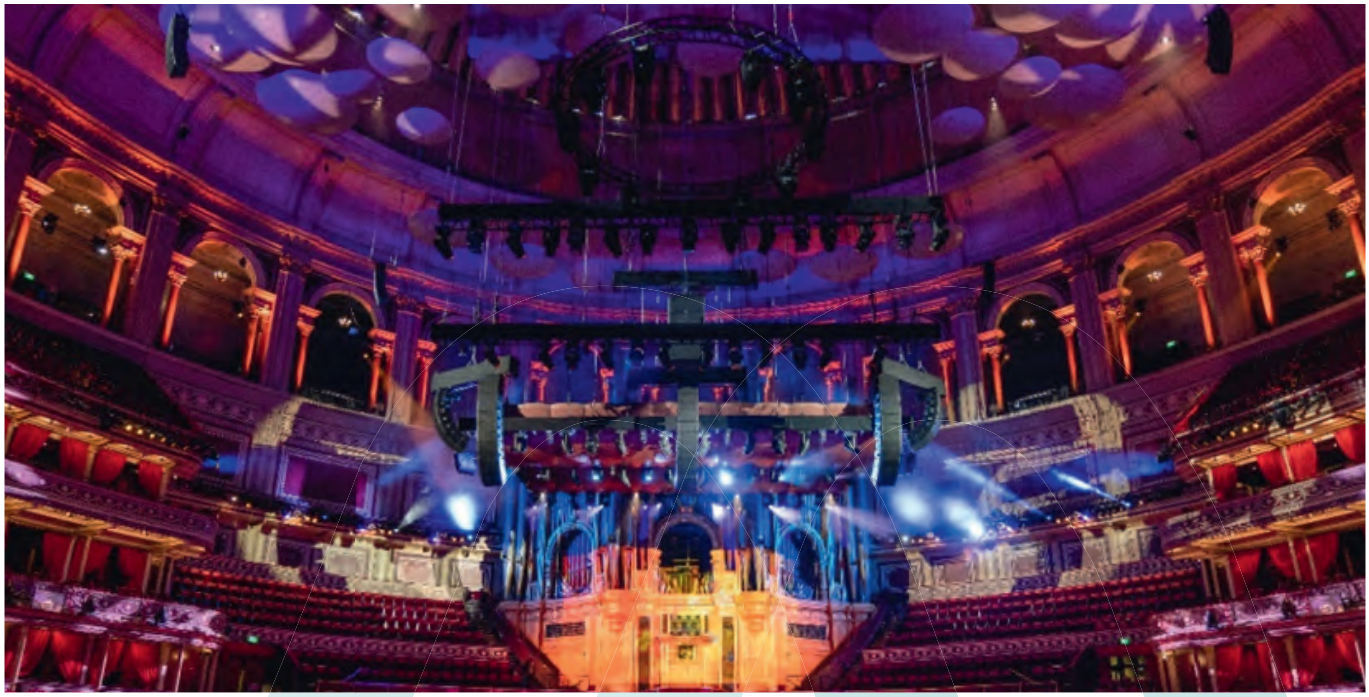
An initial tender request was submitted to a shortlist of six sound system manufacturers, compiled with input from the advocates and RAH technical team.

Each sound system manufacturer was asked to submit a proposal that would cover the main auditorium and crucially also cover the Circle, Gallery and Boxes independently of each other.

After an initial round of tender reviews, the list was reduced to three and then a second review was held to determine the final two that would proceed to the in-situ system trials.

The final two manufacturers were asked to install their concept system design within the auditorium on consecutive days in April 2018. Subjective and objective assessments were carried out for each manufacturer's system with a selection of the advocates, RAH staff and trustees asked to complete a subjective questionnaire rating each system's performance in key areas.

The trials helped to solidify the concept of what the eventual P66



system would look like. The idea of a split system with a separate Circle and Gallery delay system was verified. These areas showed the biggest objective and subjective improvement in sound quality compared to the previous in-house system. The final selection of d&b audiotechnik was made in April 2018.

System design and installation

Sandy Brown worked closely with d&b audiotechnik and the RAH technical team assisting with evolution of the design through to commissioning and fine tuning.

As a Grade 1 listed building, the new sound system required special building consent and features the first ever circle, gallery and box speakers, bringing the sound closer, radically improving levels, tone, and clarity for every seat.

In each of the boxes there are three small speakers. The one at the front centre provides enhancement to dynamic content and vocal intelligibility. The two at the rear corners provide an improved sense of envelopment using de-correlated reverberation of more non-transient based instruments such as strings and choirs via the d&b audiotechnik En-Space Soundscape module which utilises the unique technology of boundary plane emulation and sampled impulse responses from renowned large concert halls.

The project took 693 days of labour, using 15,291m of cable, 211 microphones and 465 individual speakers for the world's largest loudspeaker install in a single room. During the six months of overnight installation works by SFL the RAH hosted 327 individual events without impact.

Above:
Main system
© Royal Albert Hall/ Andy Paradise

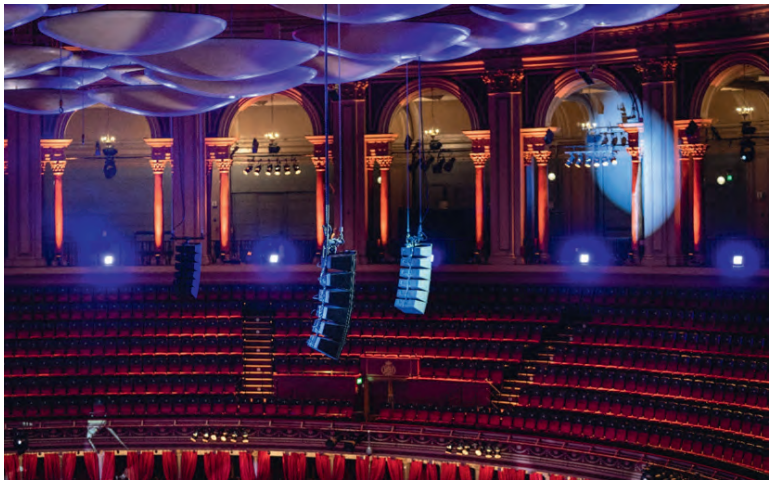
Below left:
Circle and gallery delay system
© Royal Albert Hall/ Andy Paradise

Below right:
Boxes showing front and rear speakers © Royal Albert Hall/Andy Paradise

In the first four months following the installation (Sept-Dec 2018), the uptake of the system was in the region of 85% rising to 100% throughout 2019 and surpassing all expectations. Although occasional constructive criticism for specific events is still received and indeed welcomed by the Hall, positive comments on the sound quality within the auditorium are now regularly received including via social media.

On-going work

Sandy Brown continues to advise on acoustic improvements to the Hall including the recently installed variable acoustic drapes system to the rear of the gallery wall (for amplified events) and is currently reviewing the stage acoustics working closely with the BBC Proms, solo instrumentalists, singers and performing artists.



Need to measure really low noise levels?

The noise floor of ½" microphones supplied with Class 1 sound level meters is usually 16 – 18 dB(A). Consequently, the lower limit of the linearity range of sound level meters is typically 25 dB(A), which can present a problem for some projects where it may be necessary to conclusively measure below 30 dB $LA_{max\ S}$ or NR 25.

It may be possible to correct for the noise floor of the sound level meter and consideration of the signal to noise ratio in octave/third octave bands can also help. But if you want to be sure that measurements of relatively low sound pressure levels are well above the noise floor, ANV Measurement Systems are offering a Rion system with a typical noise floor of 2 dB(A). The noise floor is below 0 dB (linear) in third octave bands at 16 Hz and above. The system is based upon the Rion UC-35P 1" microphone (pictured) and the Rion DA-21 solid-state, battery-powered ('silent' operation with no fan) data recorder.

Realistic speech and sound testing of voice-operated devices

Brüel & Kjær Sound & Vibration Measurement A/S, supplier of advanced technology for sound and vibration, puts focus on the importance of realistic testing when developing and incorporating smart speaker functionality into consumer products.

An often-used method when testing speech intelligibility and sound quality in voice-operated devices is to measure the response accuracy rate (RAR), which is done by replaying recorded voice commands and evaluating how often the voice command is correctly perceived and responded to. A common approach is to use a standard loudspeaker and microphone, but this can give a false indication of the performance because it doesn't accurately reproduce the directivity and frequency response of a human voice. The precise method is to use mouth and ear simulators.

Brüel & Kjær offers products that facilitate more realistic speech synthesis and listening, by faithfully reproducing human characteristics with very tight tolerances on accuracy to ensure repeatability. Its mouth and ear simulators, led by the new High-frequency Head and Torso Simulator (HATS), accurately match human voice characteristics to ensure quality and efficiency in smart device testing and development.

The company's High-frequency HATS Type 5218 family is the new standard in the field of product audio evaluation. Its capability of both issuing voice commands and measuring the quality of the smart speaker response makes fully automated testing of smart speakers and other voice operated devices possible. Brüel & Kjær also offers a Mouth Simulator Type 4227; a high-performance artificial mouth, which simulates human speech dispersion patterns.

Sound advice for improving student wellbeing

The case for designing and building schools in a way that contributes to positive student wellbeing grows stronger as new research comes to light. And improving acoustics in the learning environment is an extremely powerful and easy way to make improvements to a school's estate.

UK manufacturer, Sound Reduction Systems, offers an extensive range of solutions which can enhance any learning environment and improve student wellbeing.

Diarmaid Lawlor, of Architecture & Design Scotland, an advocate of design for wellbeing in education, said: "The foundation of learning is wellbeing. Healthy social and emotional development in childhood and adolescence has been shown to be positively associated with better educational outcomes. The quality of our environments directly affects the experience of wellbeing."

While design for wellbeing has to consider the whole school estate, the quality of indoor spaces is critically important for everything from teaching engagement to socialising. The main acoustic issue indoors is sound reverberation, which can be tackled effectively using the Sonata range of acoustic panels from Sound Reduction Systems.

A healthy learning environment is one where children can feel relaxed and comfortable, without disruptive behaviour. But when students have difficulty hearing what their teacher is saying, they are likely to 'switch off' or misbehave.

The effects of excessive noise are more severe for children who have greater sensitivity to noise – those with Special Educational Needs and Disabilities (SEND). It is important to recognise that noise impacts can be significant on children with ADHD or autism in particular, and be more challenging for students with a hearing impairment. By not addressing these sensitivities, schools could inadvertently be failing on their inclusion goals.

With the government committing an extra £780 million in 2020-21 to help children with Special Educational Needs and Disabilities (SEND) to reach their potential, improving acoustics in schools has to be a priority from this budget. Funding is set to be available from April.

Armstrong Ceiling Solutions has simplified its recycling scheme

Armstrong Ceiling Solutions, has fine-tuned its award-winning* programme to make recycling as simple and as accessible as possible.

It is now even easier for contractors to reduce their environmental impact and divert waste from landfill which also saves them money from the subsequent taxes as well as from skips and transportation costs.

All contractors are now required to do is simply take down the old Armstrong acoustic mineral ceiling tiles** and stack them on pallets. In partnership with the local distributor, Armstrong will arrange collection free of charge*** and the old tiles will be completely recycled into new ceiling tiles at the company's production facility in Gateshead.

The scheme for the UK and Ireland, which has been in place since 2003, enables Armstrong to minimise its impact on the environment by not only diverting its old products from landfill but also producing mineral ceiling tiles with even higher post-consumer recycled content, currently up to 82%.

Armstrong's recycling programme for demolition, construction and renovation schemes has saved 15 million m^2 of old ceiling tiles globally and diverted 61,000 tonnes of waste from landfill. And with 2,000m^2 of recycled ceiling tiles equating to 7.6 tonnes of waste diverted from landfill, that is a 14,000 kWh saving on energy.

* Awards include Sustain Magazine 2010; Green Apple 2011; AIS (Association of Interior Specialists) Eco Innovation 2011.

** Dated after January 2000

*** Armstrong may apply charges in special circumstances, e.g. out of hours collections or multiple collections of small quantities.

Sto acoustic system for royal college auditorium

The StoSilent Distance system has been installed in the main auditorium space at the Royal College of Physicians of Edinburgh.

The college provides specialist education, training and examination services for the medical profession, and the Physicians International Conference Centre auditorium plays a key role in these activities. "As the auditorium is used for all types of presentations and events, speech intelligibility here is of paramount importance," says Neil Greenshields of LDN Architects. "Our aim was to reduce the auditorium's reverberation times, increase speech intelligibility and to work to the 0.9 second remit. The StoSilent Distance system provided an excellent way to achieve the required acoustics and aesthetics within the space."

The StoSilent Distance system incorporates a metal profile sub-construction, onto which the recycled, expanded glass granulate acoustic boards are fitted. This lightweight, monolithic system can be used to create clean, seamless and uncluttered ceiling solutions. Where ceiling voids are being used to accommodate services behind the system, it can be adjusted to suit the requirements, as in this case, and to achieve a certain aesthetic and shape to suit the space.

StoSilent Décor M acoustic plaster was used to finish the acoustic system. This spray-applied finish features a minimal granular aesthetic which has a high degree of light resolution, and this helped create a visually attractive finish for the auditorium. StoSilent Décor M can be tinted to match both RAL colours, subject to confirmation, and a wide range of shades from the StoColor system.

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Committee meetings 2020

DAY	DATE	TIME	MEETING
Wednesday	**18 March**	**10:30**	**Council**
Tuesday	24 March	11:00	CPD Committee
Thursday	26 March	10:30	Meetings
Tuesday	7 April	10:30	CCWPNA Examiners
Tuesday	7 April	1:30	CCWPNA Committee
Thursday	23 April	10:30	Membership
Thursday	7 May	11:00	Publications
Thursday	14 May	10:30	CCHAV Examiners
Thursday	14 May	1:30	CCHAV Committee
Wednesday	20 May	10:30	Executive
Tuesday	26 May	10:30	Research Co-ordination (London)
Wednesday	**10 June**	**10:30**	**Council**
Tuesday	23 June	10:30	ASBA (Edinburgh)
Tuesday	14 July	10:30	Distance Learning Tutors WG
Tuesday	14 July	1.30	Education
Wednesday	15 July	09.30	CCBAM
Wednesday	15 July	10:30	CCENM Examiners
Wednesday	15 July	1.30	CCENM Committee
Thursday	16 July	10.30	Meetings
Thursday	6 August	10:30	Diploma Moderators Meeting
Thursday	13 August	10:30	Membership
Wednesday	9 September	10:30	Executive
Thursday	17 September	10:30	Engineering Division
Wednesday	**23 September**	**10:30**	**Council**
Tuesday	29 September	11.00	CPD Committee
Thursday	8 October	10.30	Meetings
Thursday	15 October	11.00	Publications
Thursday	29 October	10.30	Membership
Tuesday	3 November	10.30	Research Co-ordination (London)
Tuesday	10 November	10.30	CCWPNA Examiners
Tuesday	10 November	1.30	CCWPNA Committee
Wednesday	11 November	09.30	CCBAM Examiners
Wednesday	11 November	10:30	CCENM Examiners
Wednesday	11 November	1:30	CCENM Committee
Thursday	12 November	10.30	Diploma Tutors and Examiners
Thursday	12 November	1:30	Education
Tuesday	24 November	10:30	ASBA Examiners (Edinburgh)
Tuesday	24 November	1:30	ASBA Committee (Edinburgh)
Wednesday	25 November	10:30	Executive
Wednesday	**9 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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