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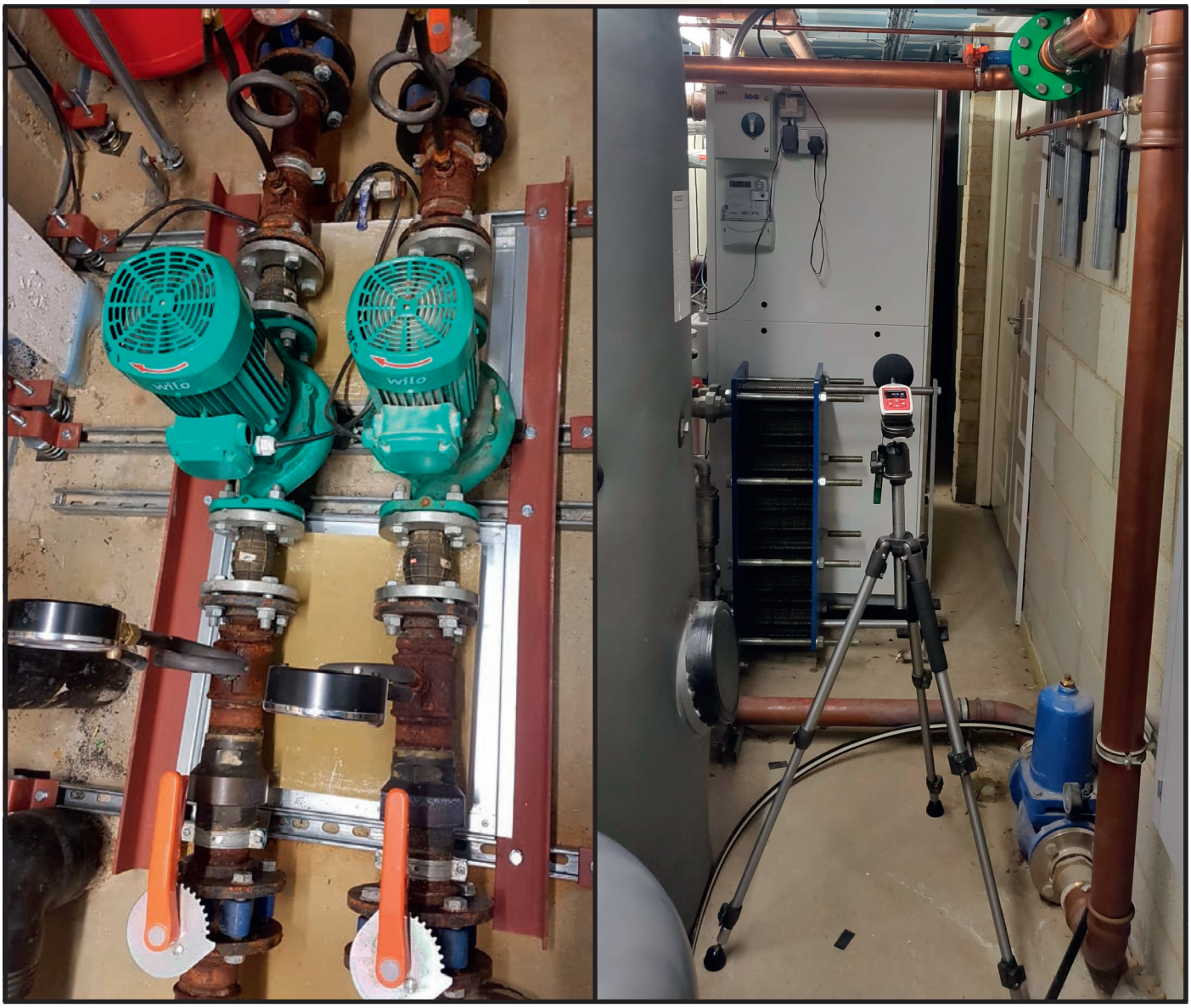
ACOUSTICS BULLETIN



Institute of Acoustics

ACOUSTICS BULLETIN

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Institute affairs

Features

Technical

Regular

Ground source heat pumps (GSHP) are becoming an increasingly common response to the requirements for sustainable and efficient sources of heat, but they are not without problems, noise being one of these. In the article on page 36, Richard Collman and Mike Hewett describe some of the issues with finding solutions to noise problems caused by GSHP installations.

Technical articles review procedure
All technical contributions are reviewed by an expert identified by publications committee. This review picks up key points that may need clarifying before publication, and is not an in-depth peer review.

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 Member

Internoise 2022

If you go to the Internoise 2022 website (**https://internoise2022.org/**), there is a countdown measure showing how long there is until the start of this event. (At the time of writing: 184 days, eight hours and 56 minutes). The closing date for receiving abstracts has now passed, and I understand that around 990 were received from around the world, including 200 or so from the UK. This is a terrific result. Thank you very much to all those members who have submitted abstracts. Thank you, also, to the many and still growing number of exhibitors and sponsors. Around 700 delegates have indicated that they are planning to attend the conference in person, so all being well we should have a really vibrant event. Consequently, now is the time for you start thinking about registering to attend and booking your accommodation. All the details can be found on the Internoise 2022 website.

End of year audit

Around November 2020, at the height of the pandemic, Exec and Council were carefully monitoring the situation and, frankly, were concerned about exactly what the impact would be on our 2021 finances. Our education offering was being hindered, advertising was down and we were unsure what the pandemic would do to our membership numbers.

Well, I am delighted to say that the Institute's accounts have just been audited, and the emerging outcome seems very good. My thanks to you all for helping secure this result, in whatever capacity that may have been. However, I must single out one person for special thanks. It is very easy for me to write a couple of lines about how we are doing, but that masks the enormous work done by our staff at HQ and, in particular, Julie Clements, who has to be on top of the complexities of our finances and ensure that we comply with all the relevant procedures. Thank you for all your efforts Julie – we really do appreciate it.

Members' Forum

Those of you who have attended the two Forum sessions this year will know that we are addressing a couple of important noise management issues. In January we focused on air source heat pumps. As a result of those discussions, there is currently a plan to hold an online workshop to look at the various aspects of this issue. Crucially, the relevant Government civil servants have indicated that they would like to join us to understand more about the noise challenges that exist with the Government's plan to phase out domestic fossil fuel heating systems. The Institute's response to the recent consultation can be found on our website: **https://www.ioa.org.uk/news/noise-must-be-properly-considered-heat-pump-installation-policy-%E2%80%93-consultation-response**

In February, we had a record attendance at a Forum session when the recently published Part O of the Building Regulations was discussed. Attendees heard how there was uncertainty over how these regulations should be implemented. To address this issue, the Institute's Building Acoustics Group has set up a working party to consider developing some guidance to assist the process. Anyone interested in helping out should contact HQ – **ioa@ioa.org.uk**

The Queen's Platinum Jubilee

And finally, I happened to notice that, to mark this event, The Times newspaper published a copy of its edition dated 7 February 1952 (the day after Her Majesty's accession to the throne). I always enjoy looking at old newspapers and magazines. In addition to the main stories, I like reading the smaller items, the adverts and notices.

In that edition of The Times, there was a heading entitled 'Today's Arrangements'. The entries included:

- Leeds By-election: Polling Day
- University College: Mr W.P.Packard on 'Himalayan landscapes and life' 1.15
- King's College: Professor H.A. Hodges on "The Maurician discipline of understanding" (I), Strand 5.30 And then
- Physical Society (Acoustics Group): Science Meeting, Imperial College 2.30

Using a well-known search engine, I tried to find out more about this group. I uncovered the item shown in the box from an edition of Nature dated 19th April 1947.

How many names do you recognise?

THE Acoustics Group of the Physical Society has been formed at an inaugural meeting held at the Royal Institute of British Architects. Mr. H. L. Kirke was in the chair and Dr. Alex Wood gave an address entitled "The Contribution of Acoustical Science to Allied Studies". The meeting was attended by some 170 persons. The principal object of the Group is to provide an opportunity for the very varied types of workers engaged on acoustical problems to meet and discuss the scientific and technical implications of their work. The officers and committee of the Group, elected at the inaugural meeting to serve for the year 1947-48, are as follows : Chairman : Mr. H. L. Kirke ; Vice-Chairman : Dr. A. Wood ; Joint Secretaries : Messrs. W. A. Allen and A. T. Pickles ; Committee: Messrs. H. Bagenal, R. S. Dadson, Dr. C. S. Hallpike, J. McLaren, B. C. Sewell, W. West, Dr. A. B. Wood and Dr. W. Greenhouse Allt. Membership of the Group is open both to members and also to non-members of the Physical Society. It is hoped to arrange for some six meetings a year, including at least one special summer meeting, which will take the form of a symposium covering a particular aspect of acoustical investigation ; reprints of papers will be circulated to members when available, and it is hoped to arrange for research panels on special topics. For further particulars application should be made to the Joint Honorary Secretaries, at the Physical Society, 1, Lowther Gardens, Prince Consort Road, London, S.W.7.

In the meantime, stay safe

President

Engineering Division

By Blane Judd BEng FCGI CEng FIET FCIBSE, Engineering Manager

The IOA Engineering Division will support you through the process to help you become one of almost 229,000 registrants that hold international professional recognition.

While some parts of the world are still in lockdown and managing their response to Covid variants, the UK has moved to a more accepting level of managing life with the virus. That said we are still limiting numbers in the office to try to avoid infection impacting on our operational activity.

We are gearing up for the next set of interviews in April 2022. Candidates are provided with guidance material when they first apply, and we are always ready to comment on the content of their professional review report prior to them submitting the final draft.

All interviews are now conducted using the Engineering Council UK SPEC version 4 which is available from their website here: **https://www.engc.org.uk/ukspec**

Emma Lilliman is doing a great job in keeping response times down to a minimum while hybrid working between home and the office. Neil Ferguson continues to help us with academic equivalence support for those candidates who do not have recognised qualifications. You can check for yourself if your qualifications meet the required specification by visiting the **http://www.engc.org.uk/courses.** But please don't panic if your specific qualification is not listed, as we can still help you through the process using individual assessment (see later in this article).

We still have a number of candidates working towards interview dates later in the year and we expect our Engineering Council Liaison Officer, Malcom Carr-West from the Institute of Agricultural Engineers, will be sitting in on the next round of interviews, subject to diary commitments.

We hold a number of interview events through the year, depending on the number of candidates we have coming forward for registration. If you are interested in taking the next step to becoming a professionally registered engineer, email us on **acousticsengineering@ioa.org.uk** sending a copy of your CV and copies of certificates and transcripts of your qualifications. It is important that we have all of your further and higher education certificates, not just your highest attainment.

There are two routes to registration:

The **recognised qualification** route, if you have achieved the required learning outcomes through recognised qualifications in acoustics. Qualifications which provide the required level of knowledge and understanding are for IEng and accredited bachelor's degree and for CEng an accredited integrated master's degree or a combination of accredited bachelor's and master's degrees (see table below).

Incorporated Engineer (IEng) One of the following:	Chartered Engineer (CEng) One of the following:
An accredited bachelor's or honours degree in engineering or technology	An accredited bachelor's degree with honours in engineering or technology, plus either an appropriate master's degree or engineering doctorate accredited by a licensee, or appropriate further learning to master's level*
An accredited Higher National Certificate (HNC) or Higher National Diploma (HND) in engineering or technology started before September 1999	An accredited integrated MEng degree
An HNC or HND started after September 1999 (but before September 2010 in the case of the HNC) or a foundation degree in engineering or technology, plus appropriate further learning to degree level	An accredited bachelor's degree with honours in engineering or technology started before September 1999
A National Vocational Qualification (NVQ) or Scottish Vocational Qualification (SVQ) at level 4 that has been approved by a licensee, plus appropriate further learning to degree level*	Equivalent qualifications or apprenticeships accredited or approved by a licensee, or at an equivalent level in a relevant national or international qualifications framework†
Equivalent qualifications or apprenticeships accredited or approved by a Licensee, or at an equivalent level in a relevant national or international qualifications framework†	

* See: www.engc.org.uk/ukspec4th for qualification levels and HE reference points.
† For example, UNESCO's International Standard Classification of Education (ISCED) framework.

The **individual assessment** route, for applicants who do not have the recognised qualifications and who will have an individual assessment of their qualifications and any other relevant learning; such as formal academic programmes, in-employment training and experiential or self-directed learning. In many cases, it is likely to be a combination of some or all these options.

We are here to help you get through the process and advice and support is offered to every candidate personally.

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

Above: Experience gained in the workplace can be used to help demonstrate you meet the competencies

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 also offer support for registration via a 'technical report' route, if you do not have the relevant qualifications to help you demonstrate you are working as a professional engineer in acoustics. If you need to follow the technical route, we will discuss this with you before you embark on that process.

Election 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 ever-growing number of 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.

The opportunity is there, and we are ready to support you through it, so that you can become one of over 229,000 registrants that hold international professional recognition.

Engineering Division successful candidate

The Engineering Council is the UK regulatory body for the engineering profession. It holds the national registers of Engineering Technicians (EngTech), Incorporated Engineers (IEng), Chartered Engineers (CEng) and Information and Communications Technology Technicians (ICTTech).

It also sets and maintains the internationally recognised standards of professional competence and ethics that govern the award and retention of these titles. This ensures that employers, government and wider society can have confidence in the knowledge, experience and commitment of professionally registered engineers and technicians.

The IOA is pleased to announce that Neo Cheung has attained the standard required for admission to the national register at Chartered Engineer level.

Neo Cheung BEng (Hons), CEng, MIOA

Left:
Neo Cheung BEng (Hons), CEng, MIOA

I received BEng(Hons) in mechanical engineering from the Hong Kong Polytechnic University in 2013. Afterwards, I started my career in acoustics and joined Allied Environmental Consultants as an assistant acoustic consultant where I was involved in projects in architectural acoustic and audiovisual system design consultancy. I realised an acoustic engineer could become an "interface" in room acoustics and system engineering to deliver an all-around solution. I determined to explore this further.

I then joined AECOM Hong Kong in 2015. With the specialisms in acoustics and system design, I led the team to complete an electro-acoustic design for the public address system for the stations of the Johor Bahru – Singapore Rapid Transit System Link and the new terminal buildings in the three-runway system of Hong Kong International Airport, as well as the architectural acoustic design and noise and vibration control engineering for various types of building.

Besides CPD, travel allows me to acquire a lot of knowledge, enrich my experience in acoustics and get some ideas for my projects; I worked out how I could design the layouts of the public address system's loudspeakers and sound absorption materials in an airport terminal when I had a stopover in Dubai International Airport; I got an idea of public address system design for a high reverberant area when I was visiting La Sagrada Familia in Barcelona; I learned how theatre design makes the music from the orchestra richer and better while I was watching an opera in Abay Kazakh State Academic Opera and Ballet Theatre in Almaty; I noticed how the loudspeakers set up for the sound reinforcement system in a theatre when I went to a show at a London venue.

I also picked up my clarinet and theory of music just after starting my career in acoustics. With this unique experience, I was involved in new affiliated rehearsal rooms and singing practice rooms acoustic consultancy for a Cantonese operatic theatre. From the perspective of a performer, I can explain the acoustical requirements for the rehearsing facilities to client and determine their acoustic criteria.

Route to registration

I began my application for CEng registration by approaching the IOA Engineering Division. Blane Judd, IOA Engineering Manager, provided an example of the professional review interview (PRI) report and some guidance so I could prepare my own. I explained the processes, background theories, design assumptions and outcomes of my projects in this report to demonstrate my competency.

I also received guidance from my senior colleagues on how to improve the wording on my draft PRI report to make it more presentable.

I submitted my report and my interview was held by Zoom a few months later. While I was waiting for the interview, I reviewed the engineering processes which I had done in my projects and made some slides to explain the background and the technical approaches I used.

The CEng registration is not only a recognition of my professionalism and working experience, it also gives me, my employer, and our clients the confidence to let me explore any new possibilities and to meet new technical challenges. I feel very proud and hope I can help the acoustic industry to deliver a better world by engineering.

I would like to express my gratitude to all the people and friends who helped and supported me in the CEng registration and my career.

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Reproduced Sound 2021 – You're on mute – The importance of audio

The 37th annual Reproduced Sound conference, organised by the IOA's Electro-Acoustics Group (EAG), took place in Bristol and online from 16 – 18 November 2021. 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.

By Adam Hill

Left: John Taylor managing the technical aspects of the conference *(Image credit: Dan Pope)*

Organisation of the conference was led by EAG Chair, Keith Holland, supported by the 11 committee members and the IOA's Linda Canty. Complete in-person and online audio-visual support was provided by EAG committee members, John Taylor and Andrew Horsburgh, along with James Morris who handled the streaming system and Ludo Ausiello who managed the Mentimeter Q&A, with support from students, Ciaran Maxwell and Hazel Warren-Cook. d&b audiotechnik have generously provided technical support for Reproduced Sound for many years, to the great benefit of the conference.

Considering the ongoing pandemic, the conference was held both in person at the Bristol Hotel and virtually. There were 76 delegates (55 in person and 21 online), representing a healthy balance between industry and academia, with participants joining the conference from across the globe.

Pre-conference activities

Although the conference wasn't set to officially open until the P12

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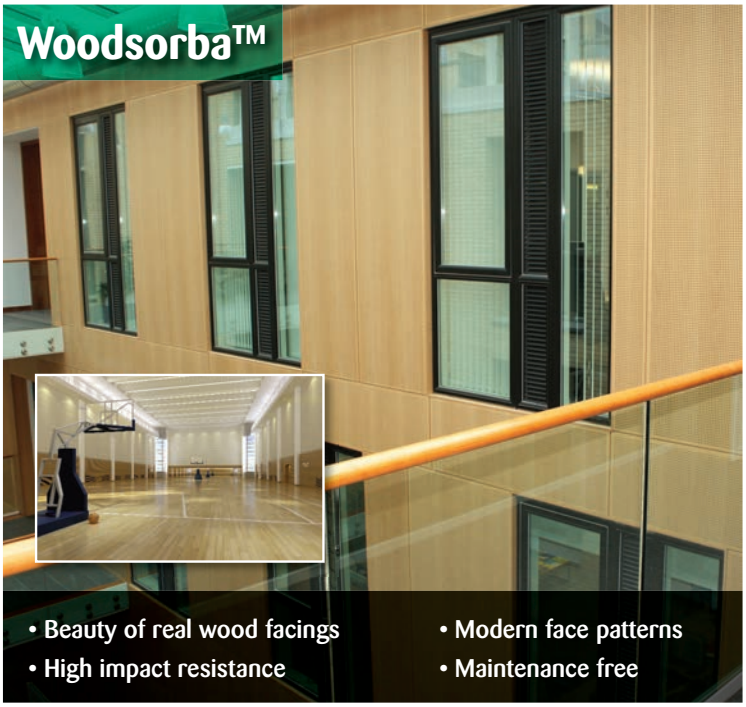

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following morning, Reproduced Sound often includes a special event the evening before the conference, consisting of a more informal talk and demonstration from a member of industry or academia.

This year's Tuesday evening presentation was given by Barney Heywood, of Stroud-based company, Stand and Stare. He described how the company develops activities and interactive exhibits to share stories by combining digital and physical experiences. Barney introduced a device known as the magical 'translatorphone', which was of particular interest to the delegates. These translatorphones are portable baskets that contain a loudspeaker that children carry with them while exploring the nature and wildlife at places such as the Slimbridge Wetland Centre. As they approach exhibits, the children can hear the sounds of the birds and animals via the translatorphone; a truly interactive digital/physical experience!

CONFERENCE – DAY 1

The first formal day of the 37th Reproduced Sound conference was launched by EAG Chair, Keith Holland. After a brief introduction to the IOA and the EAG itself, Keith expressed his excitement for being (mostly) back in person this year, with the characteristic enthusiastic buzz of Reproduced Sound. He noted that the conference theme this year was the importance of audio, including online platforms, which have been so critical during the pandemic.

Peter Barnett Memorial Award – Professor Wolfgang Klippel

IOA President, Stephen Turner, was on hand to present this year's Peter Barnett Memorial Award. The award, which is typically 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 Wolfgang Klippel for his significant contributions to knowledge and education surrounding the areas of transducer design, modelling, analysis and optimisation.

After being presented with the award, Professor Klippel delivered a captivating lecture on the use of smart transducers within professional loudspeakers. Loudspeakers tend to be the weakest part of the production chain, the question, therefore, is how to increase output, but reduce size, while maintaining good efficiency and endurance? Wolfgang suggested that the true challenge is with large signal performance, as this is where most nonlinearities arise. His solution to combat these problematic nonlinearities utilises DSP based on loudspeaker modelling (leading to so-called 'smart' loudspeakers).

While lumped and distributed parameter models can cover most loudspeaker characteristics at low and high frequencies, respectively, they overlook most nonlinearities. A time-varying model is required. With such a model in place, alongside real-time voltage and current monitoring, there can now be adaptive nonlinear system control with self-learning capabilities.

Professor Klippel noted, however, that DSP can't be relied upon to solve all problems – the physical loudspeaker design requires careful optimisation as well. This leads to the synergy between hardware and software, where the adaptive DSP is built into the loudspeaker itself, often in a very compact package which is critical when designing 'green' loudspeakers where efficiency is the top priority.

Live demonstrations were interspersed throughout the presentation, effectively showcasing the smart loudspeaker technology. Wolfgang's presentation prompted many questions and comments from the delegates, resulting in a very engaging discussion.

Right: Prof. Wolfgang Klippel delivering the Peter Barnett Memorial Award lecture *(Image credit: Paul Malpas)*

SESSION 1 – Signal processing (Chair, Paul Malpas)

Neural networks for audio signal processing

The first paper of the conference was delivered online by Vlad Paul (ISVR) covering an aspect of his PhD research. He investigated the use of a neural network to denoise speech. Vlad specifically used a class of feedforward neural networks called a multilayer perceptron (MLP), where complex and real valued MLPs were tested. Results were analysed using three performance metrics and showed that the real MLP was best for signal to noise ratios (SNR) of 0 and 5dB, with the complex MLP best for -5dB SNR, which was unexpected. Vlad highlighted the performance of the system through audio examples (using a single word in this specific study), where clear directions for future work were revealed. Questions from the audience focused on limitations of the MLP and clarification of some of the mathematics.

Achieving 32-bit precision in modern DACs

The session on signal processing continued with Reproduced Sound regular, Jamie Angus. Jamie's talk investigated the finer points of digital to analogue converters (DAC). She began with an informative overview of basic DAC topologies and their inherent limitations. Using oversampling, noise shaping and a thermometer code to spread amplitude error across all resistors, Jamie clearly demonstrated that a 32-bit DAC isn't necessary, with useful examples from the history of DAC development to support this idea. A member of the audience asked how many bits were needed, where Professor Angus suggested that in the extreme, no more than 28 bits are required. P14

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Accessible acoustic measurement software

The final paper of the session was presented by Dominic Griffiths (Solent University) focusing on research from his final year undergraduate project, supervised by Ludo Ausiello. The work aimed to develop an accessible mobile device-based app for acoustical measurements. The primary focus of the app's development was for acoustic guitar measurements, but it was not intended to be limited to this use case. The app was tested using loudspeaker measurements and compared with a widely used commercial piece of software. Results showed generally a good agreement above 1 kHz, with clear areas for improvement as further work. The audience was receptive of this idea and suggested a few useful extra features and approaches to testing the app's performance.

SESSION 2 – Measurement and modelling (Chair, Bob Walker)

Radar based loudspeaker measurements

The second session of the conference was on measurement and modelling, with the first paper delivered by Ludo Ausiello (Portsmouth University) on measuring loudspeakers with radar technology. The focus of this work was on cost-effective but precise end-of-line testing of loudspeakers in challenging environments. It was shown that a low-cost radar could measure a loudspeaker at a distance to a reasonable degree of accuracy. The radar-based measurement largely relied on the movement of the transducer's voice coil, as this is the most reflective component within the loudspeaker, through tracking the micro-Doppler shift. Future applications could use this approach to non-invasively detect transducer defects. The audience responded with many questions focusing on practical applications of this approach.

Acoustical effects of flexible boundaries

Reproduced Sound regulars, Patrick Macey (PACSYS) and Kelvin Griffiths (Electroacoustic Design), jointly presented the second paper of the session which investigated an apparent disagreement in the literature. This revolved around whether flexible boundaries shifted room modes up or down in frequency. A BEM model was designed where all surfaces were rigid except for one, allowing for the flexible boundary's effect on axial modes to be isolated for analysis. It was found that the flexible boundary effectively shortens the room, causing the axial mode in this 10:1 scale model to increase from 263 to 287 Hz. The pair showed that panel thickness had a significant effect on the modal shift, where thicker panels resulted in less shift (similarly, greater damping gave a similar effect).

Above: Ludo Ausiello delivering a talk on radar-based loudspeaker measurements *(Image credit: Dan Pope)*

Modelling acoustic soundboards

Ludo Ausiello returned to the stage to present the final paper of the session, which was a continuation of his work on acoustic guitar soundboards, research he has presented at several previous Reproduced Sound conferences. This instalment focused on FEM modelling of soundboards, to avoid the time-consuming and physically challenging task of experimenting with actual soundboard construction. The goal was to allow for consistent products to be manufactured, potentially exhibiting a response identical to a well-known guitar. The model was experimentally validated, showing good agreement, although Ludo was quick to point out that further work is needed to include the sides and back of the guitar body to make the model more complete. Several questions from the audience on the possibilities emerging from this approach and resulted in an interesting discussion to conclude the session. P16

Sound Masking

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Sound Masking is a cost effective solution to the problem of improving speech privacy in today's modern office environment. Best installed during office fit out but often installed as retrofit, Sound Masking from AET has improved the office environment for many international companies throughout Europe over the last 20 years.

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- Confidential conversations can be almost impossible to conduct

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

SESSION 3 – Cinema sound and loudspeakers (Chair, Keith Holland)

Centre audio channel reproduction with LED video walls

The third session of the conference, focusing on cinema sound and loudspeakers, started with a paper delivered remotely from the USA by Perrin Meyer (Meyer Sound). Perrin described the challenges presented by reproducing the centre channel in a cinema when an LED video wall was used instead of a conventional projection screen. Early tests have given clear evidence that using the left and right channels to create a central phantom image is perceptually undesirable. A potential solution, therefore, is to focus ceiling-mounted loudspeakers on the screen so that their sound reflects off the LED screen to the audience, thus providing a virtual centre channel signal. Perrin detailed the modelling software used to inspect this approach, but, unfortunately, was still awaiting a high-spec computer to carry out the detailed simulations.

Exploring audio primacy in multisensory cinema

Mat Dalgleish followed with a paper, delivered remotely, looking into recasting the popular film 'Four Weddings and a Funeral' as a post-anthropocentric film entitled 'And a Funeral' from the perspective of the coffin, with audio taking on the central storytelling role. This showed that films don't necessarily have to be visually based, and when an audio primacy approach is used the film is made more accessible to visually impaired audiences. The resulting 370-minute film was meant to be watched in short segments, where viewers could dip in and out as they desired, following an ambient inspired model of engagement.

Multiphysics simulation of a low frequency horn loudspeaker

The cinema sound and loudspeakers session was concluded with a paper presented by James Hipperson (Funktion One). James highlighted the challenges of measuring large-scale subwoofer arrays and thus the need for an acceptably accurate model of such systems, noting that "all simulations are wrong to a certain extent, but some are useful". The work started with a lumped element model implemented to model the drive units themselves, with a two-port method model to cover the behaviour of the low-frequency horns. This hybrid model was found to be inaccurate. Instead, James found that a finite or boundary element model coupled to the lumped element drive unit model provided satisfactory results. With this model now in place, it allowed for engineers to better explore aspects of subwoofer array behaviour such as the observed stage rejection with certain spacing between neighbouring array elements.

Below: James Hipperson presenting recent findings on LF horn loudspeakers to the delegates *(Image credit: Dan Pope)*

SESSION 4 – Diversity (Chair, Mark Bailey)

The first day of Reproduced Sound's technical programme was capped with a discussion on diversity and inclusion, led by Mark Bailey and Susan Witterick. The overarching message the two delivered was that "you can't be what you can't see", meaning that issues surrounding diversity and inclusion aren't always apparent. They suggested that one key to improving this would be to have strong, diverse role models front and centre within the IOA, since the Institute will only attract more of what they show to the outside world.

From the IOA's perspective, it is essential that members answer P18

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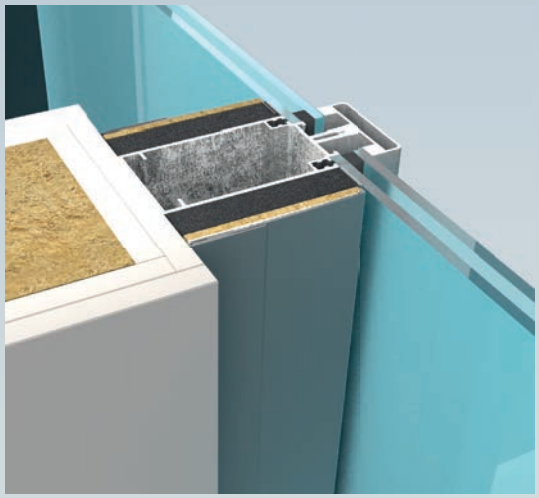

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Above:
(L-R) Robin Cross accepts his Award for Services to the IOA from Institute President, Stephen Turner

diversity questions on the circulated questionnaires to give the Institute as complete a dataset to work from as possible. Susan noted that the IOA working group focusing on this is open to welcoming new members. IOA President, Stephen Turner, suggested that meeting organisers strive to ensure accessibility, which boosts inclusivity since members unable to attend in person will still be able to participate. This is something the IOA has successfully implemented over the past year. Mark concluded the session requesting delegates contact him and Susan about these issues to keep the dialog open.

Conference reception and dinner

To minimise the risk in relation to the pandemic, the conference dinner and reception were held in same space as the technical programme at the Bristol Hotel. Delegates were happy to have the opportunity to chat with each other in person after over one year of virtual meetings. After the meal, IOA President, Stephen Turner, presented an Award for Services to the Institute to long-time EAG member (and former chairman) and Reproduced Sound contributor, Robin Cross.

Robin has worked tirelessly for many years in pursuit of workable techniques and systems to solve complex problems in many areas of acoustics and has similarly strived to help the institute through involvement with the EAG.

Following Robin's award, Stephen Turner announced three IOA 'Thank You Awards' to Keith Holland, John Taylor and Ludo Ausiello for their significant contributions to Reproduced Sound 2020. The conference's organisation was led by Keith while John and Ludo took on the enormous task of coordinating and delivering the full technical package for the online conference (work that would have otherwise cost multiple thousands of pounds if the EAG had decided to hire an external firm). Their work, along with the rest of the EAG committee members, ensured a smooth running, enjoyable and memorable conference with very reasonable registration fees for the delegates.

CONFERENCE – DAY 2

SESSION 5 – Psychoacoustics, subjective assessment and auralisation (Chair, Dan Pope)

WHAM.... To Asymmetry and Beyond!

The second day of Reproduced Sound was kicked off by Mark Dring and Bruce Wiggins (University of Derby), where they presented a paper to update the delegates on their research since the last Reproduced Sound. The pair questioned the common practice of assuming symmetry of the reverberant field in ambisonics-based auralisation systems. To achieve this in an efficient manner, the research required the development of the Dynamic Binaural Reverberation Acquisition Technique (D-BRAT). The technique was tested by capturing a classroom, a church and an anechoic soundfield with listening tests carried out using a novel web-based platform utilising webcam-based headtracking and asymmetrical binaural rendering. The listening tests are still underway and can be accessed at **brucewiggins.co.uk/WHAM/**

Binaural assessment of listening effort

Taking on the always unenviable task of following WHAM! on the bill was Ossi Raivio (Head-Acoustics) talking about research he conducted with his colleague, Jan Reimes, on a binaural method to assess listening effort. The requirements were that the assessment should use real speech stimuli and background noise and operate as a black box approach. For this specific work, focus was placed on a simulated public address system with one loudspeaker for the speech signal and a further eight loudspeakers for the background noise. The system was measured in a hemi anechoic chamber. In general, the results were as expected: a greater listening distance or greater reverberation time resulted in a greater listening effort. This was just one application of such an assessment system and the presentation prompted a very lively discussion amongst the delegates, with many suggestions for additional applications. P20

experts in acoustics for industrial applications

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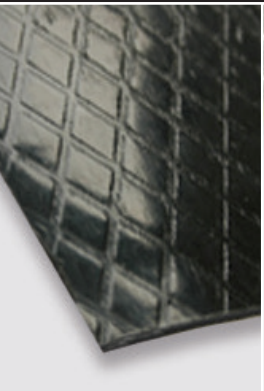
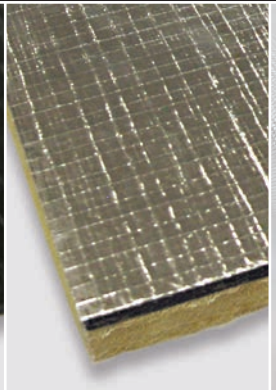

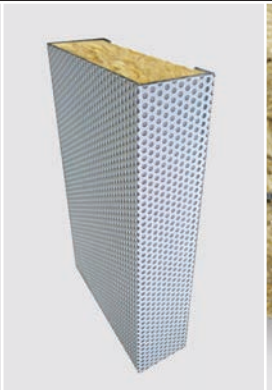

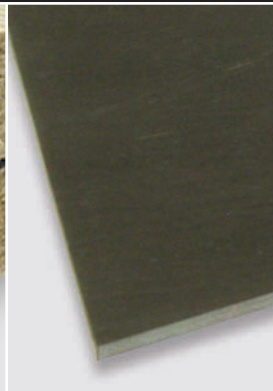

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Audible differences between recording formats
The paper session finished with a look into audible differences between CD quality and high-resolution audio recordings by Joseph Fossard (University of Central Lancashire). Joseph explained that there was a lack of reliable evidence of any significant difference between the two formats, but this hasn't slowed the debate within the recording industry on the appropriate recording format, where there is no accepted standard at present. Tests for this research were carried out in four stages (some on studio monitors, some on headphones), largely providing inconclusive results. It was noted, though, that some of the studio monitors used for the test automatically downsampled everything to 48 kHz, thus invalidating the experiment. The delegates offered a few suggestions for further work in this area.

SESSION 6 – Events, installations, live sound, venues, Part 1 (Chair, Adam Hill)

Sound pressure levels near sound-reinforcement loudspeakers
The first of the conference's paper sessions on live events and venues started with a joint presentation from Ian Wiggins (University of Nottingham) and Ken Liston (Nottingham Trent University). The pair detailed research on audience safety in relation to loudspeakers proximity in music venues. Results were gathered through in-situ measurements at a small music venue using a head and torso simulator and showed around 17dBA increase in SPL when moving from 3m to 30cm in front of a loudspeaker. This suggests that audience members should be prevented from standing within the nearfield of such loudspeakers. The presentation drew many questions from the audience, resulting in a lively discussion with delegates agreeing that work in this area was very important.

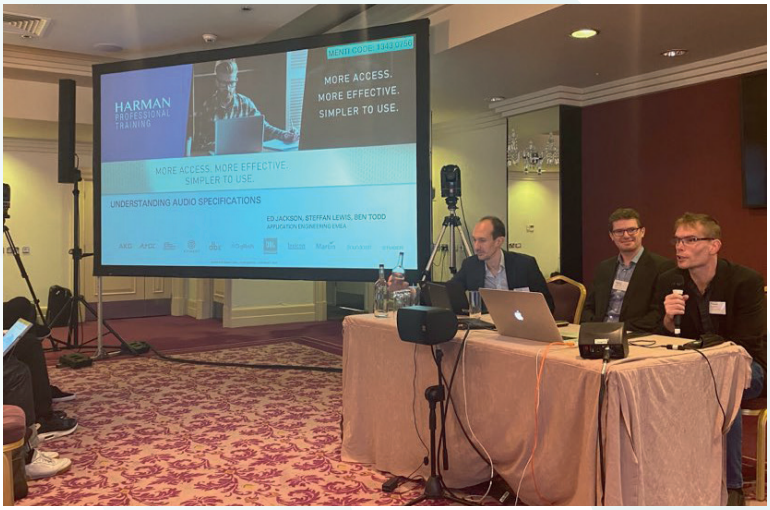
RhumbLine: Plectrohyla Esquita
The second and final paper within this session was delivered remotely from the USA, led by Margaret Schedel (Stony Brook University). The primary thrust of the research was to raise awareness of an endangered species of frog through an interactive sound installation that could be accessed in person or via a bespoke website. Although a recording doesn't exist of the call of the endangered frog in question, small remote-controllable mechanical devices were developed to replicate a call of sorts, creating a chorus of mechanical frogs. Research questions examined whether users could "hear" the shape of the pond and whether such an installation reinforced people's relationship with nature.

SESSION 7 – An instruction manual for instruction manuals (Chair, Mark Bailey)
The last session before lunch was a panel discussion on how to understand audio product specification sheets. The panel consisted of staff from Harmon's application team, Ed Jackson, Steffan Lewis and Ben Todd, and was chaired by Mark Bailey. The overall issue, which has been discussed in the industry for many years, is the lack of like for like comparisons between product data sheets, causing difficulties in selecting appropriate products. The panel proceeded to go through common metrics used to quantify performance of power amplifiers, demonstrating along the way how seemingly identical metrics can be completely different if you don't pay attention to the fine print (if it's even included). This resulted in a passionate discussion between the delegates and panel members, where it was clear that action must be taken to update existing standards and to ensure that manufacturers are adhering to these when communicating product performance on data sheets.

SESSION 8 – Room acoustics (Chair, Ludovico Ausiello)

Statistical optimisation of room dimensions and layout
The first paper of the room acoustics session was presented by Pratmesh Thakkar (GP Acoustics), where he detailed research looking into the optimisation of room and loudspeaker topology for listening applications. This was related to the construction of a new listening room in his workplace, where the opportunity was present to define optimal room dimensions and source locations. An optimisation approach was implemented using three figures of merit within an acoustic model of the space. While the aim of the work was identified as focusing on stereo reproduction systems, the testing only utilised a single loudspeaker. Several delegates pointed out this oversight, where Pratmesh indicated that measuring a stereo setup would be included in further research, in addition to the inclusion of psychoacoustics-based metrics and frequency-dependent surface properties within the model.

High-performance studio rooms for simple domestic construction
Reproduced Sound regular, Philip Newell, presented the final paper of the session (co-authored with Keith Holland) that came out of a significant increase in demand for high-quality, but cost-effective, home-based studios during the pandemic. Philip stressed that in this instance the focus was predominantly on the functionality of the space, not the look. As such, it was most important to control room resonances and reflections so that the control room modal decay



Right:
Engineers from Harmon take questions from the audience during their panel session on interpreting specification sheets

is inaudible. This, along with well-informed absorption and source placement to avoid problematic modal excitation, provided very good results in practice. A number of questions were posed regarding specifics on Philip's implementations and measurement techniques.

Electroacoustics Group AGM

The annual general meeting of the Electroacoustics Group (EAG) was held prior to the final paper session of the conference. The meeting was chaired by Keith Holland and was attended by 13 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. With the challenges posed by the pandemic, the conference has been run in a hybrid manner, with in-person and online attendees. Keith expressed thanks to the committee members for maintaining momentum with the conference planning throughout the pandemic and specifically thanked John Taylor for his leadership on the technical side of the conference delivery.

SESSION 9 – Events, installations, live sound, venues, Part 2 (Chair, John Taylor)

Spatial rendering over distributed fill systems in immersive live sound reproduction

The final paper session of the conference started with a remotely delivered paper by Etienne Corteel (L-Acoustics) detailing research into an enhanced approach to immersive live audio using virtual sources placed around the performance area. So-called 'spatial fills' are used to restore cross coverage across an audience area and can be formed through the combined use of flown loudspeaker arrays and front fill loudspeakers. The spatial fills can be fine-tuned to provide greater perceived depth of the performance by implementing a gain gradient. A collection of metrics was detailed to rate the effectiveness of such a system using a star system. Some example sound systems were examined to highlight how such a technique can be practically implemented using existing hardware and software.

Designing systems to deliver successful immersive audio experiences

The final paper of the conference was delivered by Bob McCarthy and Steve Ellison (Meyer Sound), with Bob in person and Steve dialling in remotely. The pair presented work on Meyer Sound's immersive audio system, focusing on a live demonstration on how to design and mix on such a system. Bob stressed the importance of clearly defining the necessary loudspeaker spacing and placement, where in the example application, all sources should be aimed to the centre of the room. In the conference room, which was being used for the system design, the ceiling was relatively low, requiring any height loudspeakers to be aimed above the heads of the closest audience members and towards the furthest audience members to achieve acceptable level consistency (like surround speakers in cinemas). Once Bob walked the delegates through the physical system design, Steve picked up the discussion, giving delegates a demonstration of the mixing software. Questions came from the audience focusing on the finer points of implementation of such a system.

Above: Bob McCarthy beginning his talk on immersive audio systems *(Image credit: Dan Pope)*

Conference closing

John Taylor brought the conference to a close by thanking the technical team as well as the delegates for following all the pandemic-related protocols put in place.

Two months after the close of the conference, the EAG are pleased to report that to their knowledge not a single case of COVID was reported in connection with the conference. Thank you again to all the delegates for making the extra effort to have a safe and successful conference.

Left: Etienne Corteel takes question live from France for his presentation on immersive live sound reproduction

Government policies

The IOA actively monitors developing government policy across England, Ireland, Scotland and Wales. Mary Stevens, IOA Policy Support, reports.

A range of consultations and announcements have given IOA the opportunity to comment, and to offer input into policy development over the past couple of months. In particular, highlighting the gaps in current knowledge around the acoustics of air source heat pumps (ASHP).

Air source heat pumps for properties off the gas grid

Two recent consultations from the Department for Business, Industry and Industrial Strategy (BEIS) revealed that acoustic issues presented by the installation of air source heat pumps are not being taken into account. The consultations cover England:

1. Phasing out the installation of fossil fuel heating in homes off the gas grid; and
2. Phasing out the installation of fossil fuel heating in businesses and public buildings off the gas grid,

ask whether a heat pump first approach should be taken to replacing fossil fuel heating for homes and businesses off the gas grid.

Stephen Turner submitted a response on behalf of IOA, saying no, this should not be the approach taken until noise issues have been properly addressed. Assurance is sought that noise issues associated with widespread installation of heat pumps will be properly managed in line with government noise policy set out in the Noise Policy Statement England. In responding, the Institute pointed to compromises made in the detail of the noise element of the Microgeneration Certification Scheme (MCS), which was developed to help reduce adverse impacts that might arise from heat pump installation. Government is urged not to think the MCS can simply be rolled out as a means of managing the noise now.

In drafting the response to these consultations, members were asked to feedback their experience of ASHP installations. Concerns were reported about adverse noise impacts, mitigation measures, inconsistency in noise emission data provided by manufacturers and acoustic characteristics. For most domestic situations, there are potential noise and vibration impacts that could affect both pump users and their neighbours.

This also revealed the lack of objective data on complaints about noise from existing domestic air source heat pumps, so a survey has been set up to gather experience from the public, acousticians and environmental health professionals. **tinyurl.com/kmxvbu3m** and **tinyurl.com/ybuh6hxb**

Restrictions on construction operations eased

In a Parliamentary statement on 10 December 2021, Housing Minister, Christopher Pincher, announced that, in England: "Wherever possible, local planning authorities should respond positively to requests for flexibility for operation of construction sites to support the sector's recovery." This easing of restrictions on the time and duration of operations is deemed necessary as construction output has not returned to pre-pandemic levels. The measures aim "to facilitate flexibility within the delivery supply chain and mitigate challenges faced by construction sites." They are in force until 30 September 2022, putting them on the same timescale for review as the easing of measures supporting pavement licenses and alcohol off sales for hospitality. Read the full statement here: **tinyurl.com/mpudar73**

Onshore wind policy refresh – Scottish Government

The Scottish Branch used the consultation by Scottish Government on onshore windfarm policy to offer continued support in matters of technical assessment of noise from wind turbines using the extensive experience of our members to optimise policy outcomes. Given Scottish guidance may, at times, vary from the approach taken elsewhere in the UK, the IOA expressed willingness to work directly with Scottish Government and other bodies, like the Royal Environmental Institute of Scotland (REHIS), towards achieving UK-wide consistency in assessment methodology. **tinyurl.com/2vs2mxcu**

Police, Crime, Sentencing and Courts Bill

The Police Crime and Sentencing Bill was the subject of extensive debate during its third reading in the House of Lords of Lords in January. A number of amendments were voted through, including removal of some wording around restriction on noisy protest. We will continue to monitor the wording of the Bill as it progresses back to the House of Commons. **https://bills.parliament.uk/bills/2839/news**

About the author:
Mary Stevens supports the IOA to bring acoustics to the attention of policy makers.

2022 Certificate courses

Subject to recruitment and despite the pandemic, the IOA will be offering the following Certificate courses in 2022 at accredited centres.

Holders of certificate courses may apply for Tech IOA membership (further details at membership@ioa.org.uk).

- Certificate of Competence in Building Acoustics Measurement (CCBAM): April and September at KP Acoustics Research Labs, Southampton.
- Certificate Course in the Management of Occupational Exposure to Hand Arm Vibration (CCMOEHAV): April at the Institute of Naval Medicine, Gosport.
- Certificate of Competence in Environmental Noise Measurement (CCENM): May and October at University of Liverpool, University of Derby, London South Bank University (LSBU), Leeds Beckett University, KP Acoustics Research Labs, Colchester Institute, Moloney and Associates, Shorcontrol and Ulster Environmental. Note that some centres may only offer the course at one or other presentation date.
- Certificate of Competence in Workplace Noise Risk Assessment (CCWNRA): March at Make UK and Shorcontrol and September at centres to be confirmed.

It is possible that further centres for CCENM and CCWNRA will be accredited in Scotland before the end of 2022.

A Certificate course in technical report writing and preparation and an Advanced Certificate in report evaluation are being developed. Subject to sufficient progress, these courses will be available at accredited centres in November.

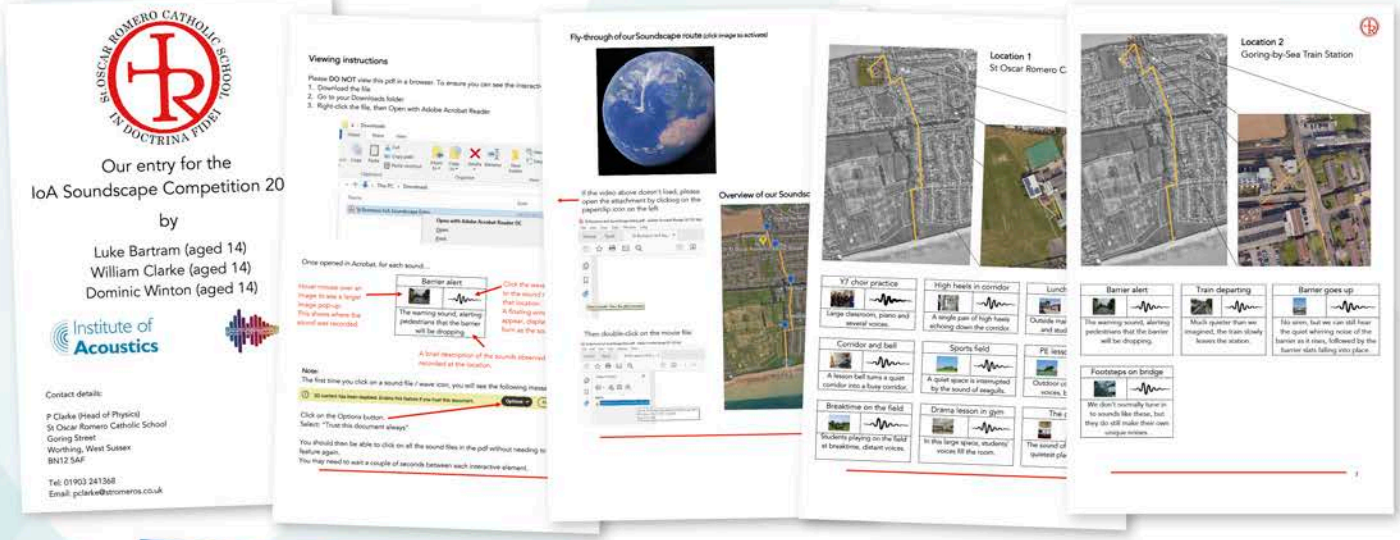
Most courses are delivered either face-to-face or/and through a hybrid presentation combining online and face-to-face attendance.

Subject to acceptance of the arrangements by appropriate management committees, centre tutors may be able to deliver onsite bespoke courses on request.

If this is of interest to your organisation you should approach the IOA Education team in the first instance via **education@ioa.org.uk**

Discovering the basics of sound measurement

The IOA first ran its schools' competition in 2021 and it was specifically designed for secondary school pupils. Following that success, this year's competition will also be open to primary schools.



The IOA recognises that introducing children to acoustics is essential for the development of the subject by future generations. In creating the primary and secondary schools competitions we hope that we will inspire children to think more consciously about their aural environment and perhaps even encourage them to consider a future career in acoustics.

The results of the inaugural secondary schools competition last year certainly suggest that there is an appetite for an increased awareness of acoustics as the Head of Physics and Head Teacher of the winning school, St Oscar Romero Catholic School in Worthing, are now actively engaging with the IOA to arrange acoustics-related events for their pupils.

The competition is just one of the STEM activities that the IOA supports, with a virtual work experience programme planned for 1,000 students in 2022. It is hoped that with ongoing efforts to raise awareness of acoustics to the next generation, we will be able to establish a pipeline of future acousticians into our industry.

Secondary schools

Activity: Measurements of sound

This competition is for a small team of up to three pupils aged between 11 and 16 years to think about the basics of sound measurements and perform measurements of their own. Pupils can be from different year groups and classes; however, they need to be from the same educational establishment.

Pupils need to install the sound recording app, Decibel X onto a smartphone or multiple smartphones and the IOA will provide user guides for the app that have been prepared by IOA members.

Task: Measurements
Pupils are asked to measure at least three different types of indoor sound and three different types of outdoor sounds. They are encouraged to include some sounds they like and some they don't like and then think about how the duration of their measurements may affect their results.

They may be using more than one smartphone, and therefore have to analyse differing results, so they are asked to describe the sounds they record and consider the factors that affect the sound level they measured on their phones. From these recordings, they then have to select one of the sounds they don't like, and work out what measures could be made to mitigate it and make it less intrusive.

The winning entry will receive £500 for their school plus an engraved crystal trophy. COVID permitting, the winning school will be invited to receive their prize at this year's Noise Abatement Society's John Connell Awards ceremony.

Primary schools

This competition is for children aged seven to 11 years working individually or in groups of up to four children.

Activity:
They will also be asked to think about some of the sounds they like to hear and some the sounds they don't like to hear. They will then have to make a list of sounds they like and dislike and think about how the different sounds make them feel (happy, unhappy, excited) for both sets of sounds.

Task: The children then have to produce a hand-made drawing, picture, patchwork, collage or similar to illustrate some of those sounds and including some words describing how these sounds make them feel. They have free artistic licence and can use pencils, pens or crayons, paper, paint and cardboard, pipe cleaners, fabric, glue and sticky tape, balloon, lollipop sticks, yogurt pots, glitter or old magazines etc.

The winning entrant(s) will each receive a prize of £25 plus a prize of £500 for their school, the winning school will also receive an engraved crystal trophy. In addition, the winning school will be given the opportunity for an IOA STEM Ambassador to visit them to present the award and speak a little about what it is like to work in acoustics.

COVID permitting, the winner plus one friend or winning group, one teacher and one parent/guardian per child will also be invited to visit their nearest science centre, e.g. Winchester Science Centre, Glasgow Science Centre or the University of Salford.

Above:
(Back row L-R) Peter Clarke, Head of Physics at St Oscar Romero Catholic School, IOA President, Stephen Turner, Sir Peter Bottomley, MP for Worthing West, Father of the House of Commons, Angela Lamacraft, IOA Council Member and Diversity Champion and Peter Byrne, Headteacher at St Oscar Romero Catholic School. (Seated L-R) William Clarke, Dominic Winton and Luke Bartram

2021 winners

Year 9 pupils from the St Oscar Romero Catholic School, Goring by Sea, Worthing, Sussex, Luke Bartram, William Clarke and Dominic Winton won the competition last year.

Their interactive entry was innovative, yet simple to follow, with great descriptions of the sounds the pupils encountered. They seemed to be clearly inspired by the competition, demonstrating the emotion involved with soundscapes and not just the sound levels heard.

Peter Clarke, physics teacher at the school, said that the competition really captivated the pupils, he said: "Dominic, Luke and William came up with some great ideas about which sounds they wanted to record, culminating in a soundscape walk with a huge variety of natural and artificial sounds, presented in an interactive format. It has changed the way they view, or rather, hear, their surroundings."

Headteacher, Peter Byrne said: "We are so proud of our pupils who took up the challenge of this fascinating STEM competition. They dedicated a lot of time to making sure their entry conveyed the variety of sounds around them. It was also a wonderful opportunity to reflect on our natural world and the sounds within it."

Pupil, Luke Bartram, really enjoyed taking part in the competition, he said: "It was really interesting to think about all the sounds that we normally take for granted."

Team mate, Dominic Winton said: "Making a soundscape walk was great fun, and we learned a lot about the sounds in our local environment. It was an amazing experience to go to the Palace of Westminster to receive the award."

William Clarke felt that the IOA competition really made the boys think about acoustics, saying: "We wanted to make our entry interactive, so our soundscape walk included sound recordings at each location along the 2km route. We really enjoyed making the recordings and listening to them. We were so pleased to find out we'd won!"
The closing date for both competitions is 31 July 2022.

Full details and terms and conditions are at:
www.ioa.org.uk

See the winning 2021 competition entry here:
https://www.ioa.org.uk/secondary-schools-soundscape-competition-2021-winner

New acoustics technician apprenticeship is open for business

London South Bank University (LSBU) is delighted to be the first establishment to offer the new Acoustics Technician Apprenticeship, starting 19 September 2022. It was developed in collaboration with the Trailblazer Group led by Richard Grove.

Left:
Dr Hyun Lim

Below:
The aim of the apprenticeship is to increase the number of suitably trained acousticians

The apprenticeship combines a traditional academic qualification (18 months on a day release basis), designed by Professor Stephen Dance and developed by Dr Luis Gomez-Agustina and Dr Hyun Lim, Senior Lecturer in Acoustics and Building Services Engineering, leads the apprenticeship programme at LSBU. He has had frequent involvement in government-sponsored, industrial collaboration research projects and has a current focus on building acoustics, room acoustics and noise control.

The aim of the apprenticeship is to increase the number of suitably trained acousticians.

The academic portion is delivered at level 4 (1st year undergraduate). As part of the scheme, an industry portfolio is produced by the apprentice throughout the course which, along with a short presentation, constitutes the End Point Assessment (EPA) and requires an employer-based mentor. The EPAs are assessed by the IOA as the nominated EPA organisation.

Cost

The apprenticeship is effectively free of charge for larger employers who have paid the apprenticeship levy over the past few years, so, is a way to recoup the levy paid. For smaller employers, the government will pay 90% of the fees. The funding band is £12,000[1].

Qualifications

An apprentice would be eligible to apply for TechIOA at the end of the taught course, and AMIOA after successfully completing the EPA, they could also apply for TechEng status.

The apprenticeship was designed to upskill candidates and as it includes many acoustic design tools, it complements the IOA Diploma in Noise Control.

So, if you are an employer in a field related to acoustics; we strongly recommend developing your employees through this carefully designed scheme.

For more information visit:
https://www.lsbu.ac.uk/study/course-finder/acoustics-technician-apprenticeship

References

1 Apprenticeship standards are all assigned a funding band by the Government – these funding bands are the maximum amount the Government will fund via the levy towards a given apprenticeship standard.

IOA Early Careers Group webinar – the IOA committees showcase

The IOA Committees Showcase was held on Thursday 20th January at 12:00 hours featuring the following committees:

- Building Acoustics
- Environmental Sound
- Noise and Vibration Engineering
- Speech and Hearing

The different groups presented an overview of their activities, explained how to get involved, and answered questions from webinar attendees.

By Tom Galikowski, Early Careers Group Chair and Josie Nixon, IOA Eastern Region Early Careers Group Representative

The IOA has a number of specialist groups, (https://www.ioa.org.uk/about-us/specialist-groups) which attract members according to their interests or specialities within the industry. On average, each IOA member joins 2.6 groups; the Environmental Sound Group is the largest as 58% of IOA members have joined it. The chart below gives a brief summary of membership numbers for each group:

Specialist Group	Members	
Building Acoustics	1712	51%
Early Careers	466	14%
Electroacoustics	537	16%
Environmental Sound	1944	58%
Measurement and Instrumentation	880	26%
Musical Acoustics	604	18%
Noise and Vibration Engineering	1380	41%
Physical Acoustics	430	13%
Senior Members	129	4%
Speech and Hearing	398	12%
Underwater Acoustics	341	10%
Sound and Health (coming soon)		

At the webinar, the **Building Acoustic Group** was represented by Adrian Popplewell, who explained that the group is made up predominantly from the consultancy sector, but also includes two long-standing research committee members. Although no manufacturers are currently represented, the group is willing to change this. The group is directly involved in publishing and/or reviewing industry guidelines and standards, for example, the Acoustics Ventilation and Overheating Guide. The group also organises conferences, meetings, social events, invites papers for the meetings and comments on the relevant acoustic 'hot topics'.

Steve Mitchell spoke about the **Environmental Sound Group** (formerly known as the Environmental Noise Group). The term 'noise' was replaced with 'sound' to signify increasing importance of positive sounds and soundscapes within acoustics. The committee comprises members from local authorities, academia and consultants. The committee responds to consultations and briefs the IOA Council on related consultation documents and is occasionally involved in publishing formal guidance. An example is the ProPG on which the group collaborated with the Association of Noise Consultants and the Chartered Institute of Environmental Health. The guidance was brought out to offer additional information previously included in Planning Policy Guidance 24.

Noise and Vibration Engineering Group was introduced by George Taylor. The committee comprises a diverse range of members working as consultants, sound instrumentation suppliers, manufacturers, and a member with expertise in health and safety. The Noise and Vibration

Engineering Committee members try to present as many guest speakers as possible, covering a wide range of topics and tend to include valuable case studies. As the presentations and attendees are diverse, the events usually prompt great discussions.

Zach Simcox presented on the **Speech and Hearing Group.** Zach explained that 40% of the members are consultants, but the group also has members from healthcare, audiology, medicine, and academia. The group organises educational events to outline the latest research and technology, for example, on algorithms on cochlea implants, or regional accents and speech perception.

IOA members can join any specialist group and some groups are looking for more committee members. If you are interested, please get in touch with the Chairs. (**https://www.ioa.org.uk/about-us/specialist-groups**)

Upcoming events:

Indoor soundscapes webinar

The next ECG webinar will be held on 15th March 2022 and will be dedicated to indoor soundscapes with guest speaker, Simone Torresin, who will introduce the concept.

If the soundscape approach has revolutionised the way we think about and measure the perceived urban acoustic environment, so why not apply it where we spend most of our time? Building on this question, insights will be drawn from the results of an online survey conducted in the UK (London area) and Italy within the CIBSE small grant project *'Home as a place of rest and work: the ideal indoor soundscape during the Covid-19 pandemic and beyond'* (PI: Prof. Jian Kang, UCL). This will shed light on the mutual interaction between the acoustic environment, the building, and building occupants, the possible effects on human wellbeing and the role of ventilation openings in connecting indoor and outdoor soundscapes, considering the new social functions that housing must accommodate in the post-pandemic future.

'Art of Being a Consultant' in-person event

The ECG is also organising an 'Art of Being a Consultant' event, which will be held (in person!) in Manchester on 23 March. You can find more information on the IOA website and on page 67 of this issue of Acoustics Bulletin.

ECG Vacancies

There are vacancies for ECG representatives at Central Branch, the Environmental Sound Group, the newly established Sound and Health Group, the Research Committee and the Physical Acoustics Group – if you are interested, please get in touch with the ECG or the relevant groups directly.

Below:
Home as a place of rest and work

Please join us

The ECG is open to all members of the IOA (both corporate and non-corporate) who shall normally be under 35 years of age or within first five years of their career. The group is always keen to hear from members and non-members alike. To join the Early Careers Group, to find out more information or to voice your concerns, visit **https://www.ioa.org.uk/early-careers-group**

Net zero toolkit

Edinburgh Science has developed a comprehensive and scientifically sound, eight step toolkit that helps gets businesses on the road to net zero carbon emissions by 2040.

Hashtags, Handles and Links

	Website	Twitter	Instagram	LinkedIn
EdinburghScience	sciencefestival.co.uk	@EdSciFest	@EdSciFest	@EdinburghScience
The NetZeroToolkit	thenetzerotoolkit.org	@NetZeroToolkit	@NetZeroToolkit	@NetZeroToolkit

#NetZero #NetZeroScotland #SME #ClimateAction #EdinburghSME #CarbonReduction #FutureProof #NetZeroToolkit #Environment #GetNetZero #FuturePlanet #BusinessForNetZero #WorkTogether #Community #NetZeroCommunity #WatchThisSpace #LetsDoNetZero

The NetZeroToolkit by Edinburgh Science is a free resource that provides practical support to SMEs starting out, or accelerating, their journey to net zero.

The toolkit breaks carbon management down into eight actionable steps, each focused on reducing emissions in individual business areas. Each step signposts to a carefully selected set of resources.

Completing The NetZeroToolkit allows SMEs to:

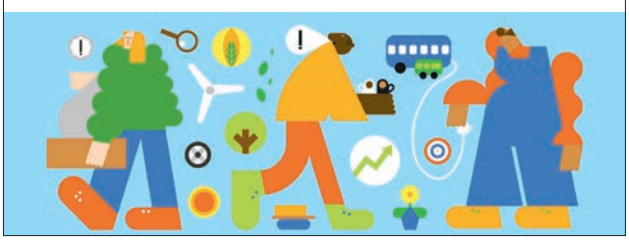
- identify the changes that they need to make;
- access a simple directory of resources to help implement them; and
- create an actionable carbon management plan.

This becomes a skeleton reduction strategy and something that can be referred back to when making future decisions. Following the process will futureproof businesses by supporting them to achieve net zero carbon emissions by 2040.

To find out more and to start your net zero journey today visit **www.thenetzerotoolkit.org**

NetZeroToolkit

The NetZeroToolkit has been built by Edinburgh Science with support and funding from Baillie Gifford, CityFibre, Dickson Minto, Galbraith, M&G, NatureScot Parabola and Target Fund Managers. It is based on the pledge created by Protect Our Winters UK.



IOA Events for 2022

Understandably, the 2022 conference programme may be affected by the COVID-19 virus.

23 March 2022
THE ART OF BEING A CONSULTANT
Organised by the Early Careers Group
The Pendulum Hotel, Manchester

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30 March 2022
HEAR FOR TOMORROW
Organised by IOA and Hearing Conservation Association
Royal Academy of Music, London

20-23 June 2022
ICUA 2022
Organised by the Underwater Acoustics Group
Grand Harbour Hotel, Southampton
https://icua2022.org

21-24 August 2022
INTER-NOISE 2022
SECC, Glasgow
The 51st International Congress and Exposition on Noise Control Engineering (INTER-NOISE 2022) will be held in Glasgow at the Scottish Event Campus (SEC). The SEC is located just outside Glasgow city centre in the west-end and the campus is accessible by numerous transport options.
For details:
+44 (0) 131 336 4203
internoise2022@in-conference.org.uk
https://internoise2022.org/

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inter.noise

21-24 AUGUST
SCOTTISH EVENT CAMPUS
GLASGOW
2022

Join us for Inter-Noise 2022 in Glasgow

The Congress theme is Noise Control in a More Sustainable Future

The 51st International Congress and Exposition on Noise Control Engineering (Inter-Noise 2022) will be held in Glasgow, UK at the Scottish Event Campus (SEC) from 21–24 August. The SEC is located in the west end of Glasgow city centre. The campus is accessible by numerous transport options.

KEY DATES:

1 December 2021	Call for abstracts
1 December 2021	Registration opens
4 February 2022	Abstract submission deadline
4 March 2022	Abstract notification
4 March 2022	Paper submission opens
28 March 2022	Paper submission deadline (requiring assessment)
29 April 2022	Paper submission final deadline
29 April 2022	Assessed paper submission final deadline following feedback
29 April 2022	Early bird registration for authors
8 July 2022	Early bird registration for non-authors

For more information contact organising secretariat In Conference:

In Conference Ltd. Unit 1, Q Court,
Quality Street, Edinburgh, EH4 5BP

Tel: +44 (0) 131 336 4203
Email: internoise2022@in-conference.org.uk

https://internoise2022.org/

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Institute of Acoustics

acoustics.ac.uk
THE UK ACOUSTICS NETWORK

Alan Dudley Wallis (1935 – 2022)

It is with sadness that Cirrus Research plc announces the death of one of its modern-day founders, Dudley Wallis. Dudley was instrumental in the early years of Cirrus Research and the development of many of the key projects it is still known for today.

Cirrus Research Ltd was founded in 1970 to specialise in the design and manufacture of different types of acoustic measuring instruments. The pioneering work that Dudley and his team started set the global standard for acoustic technology that others could only follow, and has led to Cirrus Research being amongst the world leaders in the design and manufacture of acoustic measurement instruments for prevention and eradication of noise-induced hearing loss and environmental noise pollution.

His pioneering work included developing sound level meters that included noise exposure times – a revolutionary idea at the time, using integrated circuitry in place of transistors and developing the world's first L_{eq} or equivalent continuous sound level meter for both hearing damage and environmental measurements, something everyone in the business takes for granted these days.

In 1982, Dudley Wallis was seconded to the International Standards body (IEC) and he, with three other British engineers, were responsible for much of the IEC's noise measurement standard IEC 61672 used today.

In 1991, under Dudley's steer, Cirrus Research was awarded the Queen's Award for Export Achievement, with their noise measurement equipment exported to over 50 countries worldwide. After winning this, Cirrus introduced the world's first twin-channel data logging dosimeter, and, in 1995, launched its revolutionary doseBadge Noise Dosimeter. This was the world's first truly wireless noise dosimeter – a product with a completely new design for a personal noise measurement, different from anything that had come before or after.

Dudley retired from day-to-day involvement with Cirrus Research in 1996. He is survived by his wife of some 46 years, Lynda, two daughters and three sons, one of which is Daren, CEO of Cirrus Research since 2003, and several grandchildren.

Perhaps the best way to sum up Dudley comes from his self-penned book, 'The Cirrus 'Group – How we started – a short history', where he writes:

"Did my 70-year old childish dreams work out? They most certainly did, far beyond anything I could ever have imagined. Very few people are lucky enough to end their career having achieved everything they ever wanted to do as I have. I am far from being a brilliant designer, but I have been seriously lucky and have had wonderful co-workers, most of whom became friends, so I hope the company continues on a similar path – but I shall never know!"

"How has it been done? Basically simply by having wonderful friends and associates who joined in with the concept of "doing it differently". Any fool can follow the herd and produce "me too" instruments where price alone becomes the selling point. Most people have no choice here as they do not have the imagination to do anything else. I hope that we continue along the path of "being different" and keep innovating. Some ideas will fail, but if just one in three is a success you will continue.

Staying small and independent means you are masters of your own destiny and will stand or fall by your own actions; all you lose are the bragging rights that "We are the biggest!"

Dudley will be deeply missed by family, friends and staff of Cirrus Research.

Your memories of Dudley

We know that many members will have known Dudley well and for a long time. Therefore, we welcome your memories and anecdotes and we would like to publish them in our next issue. Please write to Acoustics Bulletin editor, Nicky Rogers, at **nickyr@warnersgroup.co.uk** by 31 March 2022.

IOA STEM round-up

In this issue IOA STEM Committee Chair, Matt Muirhead, provides a round-up of some initiatives you could become involved in to further promote acoustics.

By Matt Muirhead

The Nuffield Research Programme: Nuffield Research Placements are funded by the Nuffield Foundation and delivered by STEM Learning. They consist of A-Level students, from a diverse range of backgrounds, completing a summer project under the supervision of a tutor from either industry or academia. Tutors are invited to create a project outline and help guide the student as they work towards a final report and poster. It's a great opportunity for students to supplement skills and knowledge learned at school so that they can apply themselves to a situation or problem encountered by professionals.

This programme has been shown to enhance UCAS personal statements, increase access to university courses in STEM subjects and expose students to a wide variety of career paths they may not have otherwise known about. I acted as a tutor last year and found it to be an enjoyable and worthwhile experience that only required a time commitment of an hour a week across part of the summer. The programme is also flexible enough to work around existing work and holiday commitments that both tutors and students may have.

For more details visit: **https://www.nuffieldfoundation.org/students-teachers/nuffield-research-placements**

Training in public engagement: The UK Acoustic Network (UKAN) is running a six-month professional development opportunity for up to 40 members to enhance and improve their public engagement work. The programme will cover all aspects of designing effective public engagement programmes, from developing an appropriate approach to evaluating its impact.

The programme is free to take part in and will take place online. It will run from April until September 2022 and consist of:

- two day-long online sessions (6 hours per session) on 21 April 2022 and 14 July 2022, and a 90-minute event in early September. Note that any formal networking will take place during the online workshops;
- three peer learning group sessions (two hours per session). Dates to be decided amongst learning groups; and
- one informal networking session.

Applications from a diverse range of people in both academia and industry are encouraged.

For further details and to apply for a place please visit: **https://www.publicengagement.ac.uk/ukan-impactful-public-development-programme**

There was a lunchtime webinar in February in which participants had the opportunity and ask any questions they had.

Completed application forms must be received by 16:00 on Monday 14 March. If you have further queries on this programme please email **T.J.Cox@salford.ac.uk**

Big Bang at school: EngineeringUK is gearing up for their next tranche of exciting STEM activities in schools **https://www.thebigbang.org.uk/big-bang-at-school/** and this time the IOA is fully engaged and ready to be part of the initiative. Look out for further updates from the STEM team once we have firmed up some of the details.

Virtual work experience

A big thank you to everyone who has got in touch to offer to help with this programme. By the time you read this we should be well underway towards the creation of some inspiring content!

As usual, if you have any questions about the above initiatives or just some ideas or comments on STEM in general, please get in touch at **STEM@ioa.org.uk**

Above: Nuffield Research Placements are for A-Level students to complete a summer project under the supervision of a tutor from industry or academia





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Milton Keynes MK9 2AF
Telephone: +44 (0)300 999 9675
education@ioa.org.uk
www.ioa.org.uk

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Anti-Social Behaviour (Scotland) Act 2004 - Noise Measurements

Courtesy of LSBU 2021

Controlling noise from ground source heat pumps

Acoustical Control Engineers Limited is 50 years old in 2022. As part of the celebrations, the company is preparing a series of articles describing some of the technical challenges encountered in finding practical solutions to noise problems.

Ground source heat pumps (GSHP) are becoming an increasingly common response to the requirements for sustainable and efficient sources of heat, but they are not without problems, noise being one of these. In this article, Richard Collman and Mike Hewett describe some of the issues with finding solutions to noise problems caused by GSHP installations.

Background

Over the past couple of years, Acoustical Control Engineers and Consultants (ACEC) has been working at numerous high quality multi-occupancy retirement living premises to control the noise within some apartments due to GSHP installations. Most of the affected apartments are directly adjacent to the plant rooms but some are elsewhere in the buildings. This work has involved analysis of the problems; identification of the most appropriate solutions; and then design, manufacture, delivery and installation of acoustic engineering solutions and specification of other work as appropriate.

Being high quality premises the residual sound level within the apartments is generally very low, providing little masking sound, and the residents' expectations are understandably relatively high. The elderly residents may also have reduced higher frequency hearing sensitivity (presbycusis) potentially making them more sensitive to the lower frequency plant noise. Sound from the plant exhibits both tonal and amplitude modulation characteristics and can also excite modal responses (standing waves) within rooms. The buildings are relatively acoustically live with lightweight concrete construction, with the plant mounted on what are in effect suspended (beam and block) concrete floors.

In order to avoid or minimise any disruption to the residents, it has been necessary to carry out the installation work while the plant has remained operational i.e. without altering pipework, plant location, etc. P38

Right:
Figure 1
Ground loop pumps on resilient pads

architectural acoustic finishes

Herbal House offices, London.

SonaSpray K-13 in grey applied directly onto old concrete slab to refurbish and acoustically treat this stylish two-storey, Manhattan loft style office.

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With our range of 5 spray applied, acoustic decorative finishes from textured industrial chic, to the smoothest acoustic plaster on the market, there is a finish to suit every project and budget.

Credit to TP Bennett, BW Workplace Experts & Tom Green Photography.

NBS Source

NBS National BIM Library

OSCAR acoustics

Above:
Figure 2
Ground loop pumps on isolated support frames showing very restricted work area

The GSHP system distributes hot water directly through the building's radiators and indirectly provides the building's domestic hot water via a heat exchanger. The system comprises:

- two GSHPs;
- two ground loop pumps (one per GSHP) to pump the fluid (brine) through the ground loop and GSHP;
- various pumps to circulate the water through the GSHPs, storage cylinders, and the building; and
- heat exchangers, pipework, storage cylinders, valves and other fittings.

Much of the equipment and pipework is supported in the plant rooms by a support frame constructed from an MFMA (Metal Framing Manufacturers Association) standard strut channel system (e.g. Unistrut). At the different sites this was found to be connected to plant room walls floors and ceilings with a variety of connection methods.

Prior to ACEC's involvement the client had previously:

- fitted inertia bases to GSHPs at some sites;
- fitted resilient pads between the support frames and building surfaces to which they were attached;
- installed false ceilings in some plantrooms; and
- relocated some plant items to a new external plant room building.

However, for various reasons, this appeared to have provided little if any improvement.

Preliminary investigations

To start with, several of the sites were visited to gain an initial understanding of the situation. The visits included some preliminary testing such as:

- discussion with residents to establish the nature and scale of the problem and the most significant times of day/night;
- measurement and subjective observation in affected apartments simultaneously with controlled plant operation to evaluate the level and character of problematic sound, identify the relative significance of different items of plant and assess likely sound transmission paths;
- indicative airborne sound insulation testing between the plantroom and adjacent apartments; and
- indicative impact energy transmission tests to the pipework, using a mallet, to assess the relative strength of some structure-borne energy transmission paths.

Above:
Figure 4
GSHPs on inertia bases. The springs provide vibration isolation, but the concrete is unnecessary

Above:
Figure 5
GSHPs on isolated frames (fitted whilst the plant remained operational)

Right:
Figure 3
GSHPs on resilient pads

This initial research established the following:

- the predominant acoustic energy transmission path between the plant and apartments was structure-borne, with the building providing adequate airborne sound insulation, probably without the need for the false ceilings that had been fitted in some cases;
- the most significant sources of plant noise within the apartments were the ground loop pumps not the GSHPs themselves;
- the use of inertia bases for the GSHPs was inappropriate. The sole purpose of an 'inertia' base (i.e. mass of concrete attached to the source) is to reduce the amplitude of vibration of the attached plant, which, in this case, is not particularly significant. However, the vibration isolators on which the inertia base was mounted were appropriate and a more suitable solution for the GSHPs would be to mount on the vibration isolators using support frames;
- it appeared that significant energy was being transmitted into the structure via pipework connections to the plantroom floor, walls and, in some cases, ceilings as well as directly from the plant supports into the floor;
- the energy in the pipework through the remainder of the buildings was generally relatively insignificant;
- the building construction was relatively live and provided an efficient structural energy transmission path, exacerbated by the beam and block spanning over void ground floor construction, which did not allow the ground underneath to provide damping to vibration transmitted from the plant above;
- there were strong modal responses in some rooms, typically in one or more of the 100 Hz, 250 Hz and 315 Hz one third octave bands;
- on some occasions there were significant interactions between the two GSHP systems adding a beat frequency to the sound;
- effective vibration isolation of the relevant parts of the GSHP system should be able to provide significant attenuation to the sound within the affected apartments without the need for any additional airborne sound insulation; and
- the strut channel frames used to support the plant and fittings could provide a useful mounting system for appropriate vibration isolation in most cases. However, without significant alteration or replacement with stiffer structural support frames, it was not sufficiently rigid for such an application with the ground loop pumps.

In addition to several sites with existing noise problems, three new sites were under construction. This gave the opportunity to incorporate appropriate mitigation during the design and installation phase of the GSHP systems. However, this could not delay construction, so decisions had to be made based on the information available at that time.

Remedies

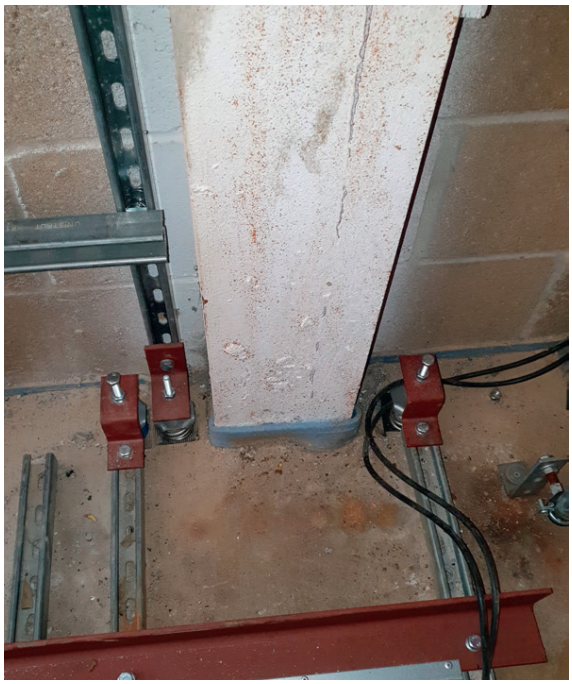
At the existing sites, the plant and pipework were decoupled from the building structure. The resilient pads that had been fitted were unsuitable both because they would be expected to provide little deflection (and associated vibration isolation) under the loads and in the locations where they had been applied and because the frames were bolted directly to the structure through the resilient pads, bridging any isolation they may otherwise provide. It was determined that the necessary isolation could best be achieved with steel spring isolators.

Above:
Figure 7
Strut Channel bolted to wall with resilient pads

Below:
Figure 6
Strut channel bolted to wall with resilient pads, and pump on resilient pad on cantilever bracket

Given the very limited space, difficulty of supporting the existing strut frame sections, and large number of connection points that required steel spring vibration isolation, it was beneficial to develop some low cost vibration isolators that could relatively easily be installed, provide good vibration isolation (high deflection spring, effective 'noise' pad, and height adjustment) without incorporating unnecessary materials or taking up more space than necessary, which was particularly important as many parts of the plant rooms were very congested. P40

Above:
Figure 8
Strut channel decoupled from wall with isolated support brackets



Left:
Figure 9
Strut channel decoupled from wall and floor with isolated support brackets

Right:
Figure 10
Bespoke vibration isolator decoupling the upper horizontal steel strut from the vertical one

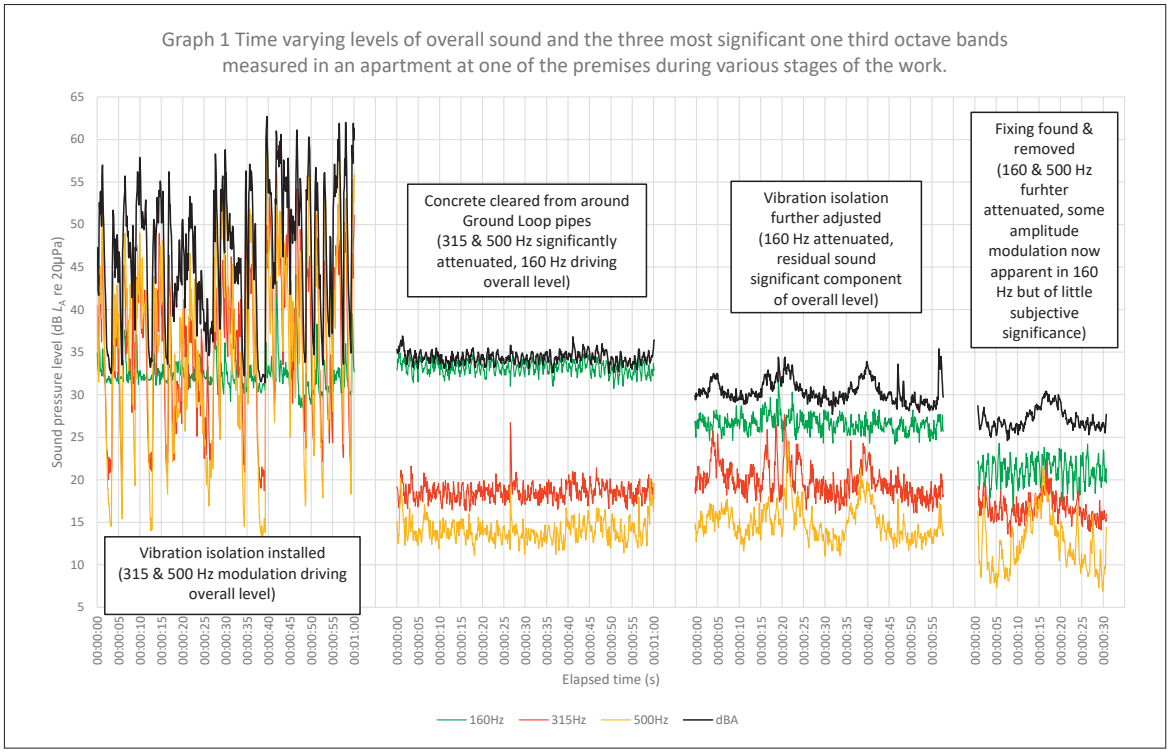
Results

The initial results were mixed; with reductions large enough to satisfy the residents at some sites and significant remaining levels and little improvement at others. There were several reasons for this:

- it was difficult to identify all structural bridging points due to the often crowded plant rooms preventing access to view all areas;
- for the same reason it was very difficult to access all of the identified bridging points particularly with the need to keep system running in the occupied buildings; and
- the ground loop pipes exited the plant room through the floor and had been 'concreted in' creating a rigid connection to the floor. This rigid connection was generally in a part of the floor close to an external wall providing a short route for connection to the rest of the building.

Above:
Figure 11
Ground loop pipes concreted in

Above:
Figure 12
Ground loop pipes broken out



Left:
Figure 13
Graph of progress in sound reduction

At several sites it became apparent that the issue of ground loop pipe coupling to the floor was significant and we advised that the concrete around the pipes should be broken out (by others). This work was also undertaken while the systems remained in operation and was successful in achieving further reductions of varying significance at different premises. This also allowed yet further reductions to be achieved by adjustments and refinements to the other isolating elements.

Graph 1 shows the time varying levels of overall sound and the three most significant one third P42

octave bands measured in an apartment at one of the premises during various stages of the work. The first series was measured once the initial vibration isolation work had been completed. Although this had achieved some improvement, the overall level remained very high, with significant amplitude modulation, particularly in the 500 Hz band. This was when the ground loop pipe concreting was identified as a significant transmission path. The pipes were therefore cleared, following which, the temporal modulation virtually ceased leaving the overall level steadily around 35dBA, due primarily to the 100 Hz band. Further adjustments were made to the vibration isolation systems which reduced the 100 Hz level by around 7dB. The corresponding overall dBA level fell but was then more affected by residual sound so did not show as great a reduction. Finally, one further fixing was found and removed providing a further improvement. It should be noted that the final 100 Hz band shows some temporal amplitude modulation, although the level is sufficiently low that this is not significant.

Other sites

At another site, there remained a problem after similar work had been completed. Initial investigations had already included checking that pipework outside the plantroom was not a significant transmission path. It was then found that a steel column within the plantroom may have been compromising the attenuation system's performance. The concrete was broken out from around the column and the level and character of sound in the apartment became demonstrably suitable. However, the resident remained dissatisfied. It was identified that sound from the plant was most noticeable close to one wall, so the wall lining was removed and replaced with one that was decoupled from the structure, providing a further slight improvement for the resident.

At a different site, although the sound level was low, its tonal nature meant it was still slightly intrusive, although the resident was happy with what had been achieved. Further testing showed that the GSHPs were generating standing waves within the plantroom, resulting in relatively high levels of tonal sound that was then breaking through the ceiling/floor slab into the apartment above. Rather than trying to increase the slab's sound reduction index, a better solution was to install some strategically placed absorption within the plantroom to reduce its modal response. This achieved a further improvement as predicted.

Some of the residents are still disturbed by sound which has been reduced to well below standard criteria (BS 8233, NANR45 etc). This may in part be due to the very low residual sound levels in the flats but also to a degree of hyper-sensitivity and sensitisation in the residents.

As the isolation/attenuation schemes were installed, adjusted and refined the sound reductions achieved were significant and most of the residents felt that the results were satisfactory. However, inevitably at some of the sites, plant noise was still present to some degree. Options for further reductions, within the constraints of the sites, are limited as there are potential transmission paths and issues which cannot be practicably addressed. For example; there is a possibility that there are further transmission routes between the underground ground loop pipework and the building. The pipes may pass close to, or touch the foundations, or vibration may even pass through the ground. Access to these pipes is not possible. There are similar potential problems with working on pipework in inaccessible parts of the building.

There is therefore a practical limit to what further reductions can be achieved.

About the author:
Richard A Collman BSc (Jt. Hons), CEng, MIOA, Tech IOSH is Managing Director of Acoustical Control Engineers Ltd and Acoustical Control Consultants Ltd having joined the company in the 1980s and has specialised in the measurement and assessment of sound from industrial and commercial plant for over 35 years. He pioneered the use of digital instrumentation for short duration consecutive logging techniques. As an expert on sound from refrigeration and air conditioning plant he represented the Institute of Refrigeration on BSI committees responsible for various acoustic standards.

About the author:
Mike Hewett MIOA is Principal Acoustician with Acoustical Control Consultants Ltd having joined the company in 2021 bringing more than 30 years' experience of Acoustic consultancy. Mike's particular expertise is in the assessment, prediction and control of noise and vibration from structures, plant and equipment. He is a former examiner for the Noise Control Engineering module of the IOA Diploma and a former Secretary and Chair Noise and Vibration Engineering specialist group.

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Structural Vibration Isolation

It is becoming more and more common for whole buildings to be isolated against the vibration from train lines and road vibration, as typically more cost effective and space efficient than introducing isolation breaks internally. A prime example of structural isolation is the prestigious 55-93 Knightsbridge project. The development involved the demolition of the existing early Edwardian structure, whilst retaining the elegant façade.

The new isolated structure had cores, shear walls and first floor supported on 8Hz bearings and was resiliently connected back to the retained façade. The building was not originally designed to be isolated, but vibration from the adjacent tube line and road would have re-radiated as undesirable noise levels within the building, a 25dB(A) criteria applied. The project was challenging in that the isolation line had to be accommodated with minimal disruption to the existing design.

The value of the property meant that millimetres mattered. We went through enormous efforts to reduce the envelope required for bearing assemblies within the building. The column capitals included the bearings supporting the structure above, lateral restraints, tension anchors to meet disproportional collapse requirements, fire protection and first fit architectural finishes.

There were approximately 60 columns and each one was engineered differently to save space. Multiple wall interfaces were also isolated; we engineered the bearings and special telescoping lateral restraints which fitted within the existing wall width.

▲ *Render of the completed building, courtesy MSMR architects*

◀ *Mason bearings being placed in one of the core pits*

▼ *Wall and column isolation systems engineered for compactness.*

This project is an example of how we can solve many challenges through good design and coordination. We would be pleased to discuss in more detail or if we can help with any other building isolation project.

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Sound level meters calibration – what's it all about?

We are all used to the idea that sound level meters (SLMs) need calibration, ranging from the simple field calibration checks before and after each measurement project through to routine calibration in an external laboratory. Just as there is a wide selection of sound level meters available there are a wide range of calibration services on offer to support them.

By Ian Campbell, Technical Director at Campbell Associates Ltd.

It may not be practical to calibrate devices such as mobile phone apps, while simple sound level indicators could not justify on cost grounds anything more than a simple acoustic check at a couple of frequencies or levels.

At the other extreme professional SLMs require comprehensive tests covering the full range of functions and environments over which the instrument is designed to perform to specification. So, the user is presented with a range of options from a simple check calibration on a sound level indicator to a full statement of conformance to a published specification as required for legal metrology applications.

In this series of Instrumentation Corner articles, we will look at the various options available in the types of calibration service on offer. This will include going into more detail on the choices the user has in specifying how and what needs to be done to ensure their instruments are giving all the information at the level of precision they require. In addition, there is the need to provide the necessary data to include in their measurement's uncertainty budget.

The articles will cover the decision between calibration and conformance, the use of nominal data in calibrations, the use of associated sound calibrators and offsets as well as the instrument configuration during calibration.

Part 1: 'Calibration' or 'conformance

We are concerned here with what is required and how individual laboratories set about meeting those needs.

There is no doubt that 'noise' is a problem in society and, as a result, a wide range of rules and regulations to control the acoustic environment has built up.

It follows that before you can control noise, you must be able to measure it to defined standards of accuracy; enabling limits to be set and enforcement procedures put in place. Hence, we enter the field of legal metrology.

There are, however, other areas of professional practice where high levels of accuracy are needed but the conformance and verification requirements are less demanding; as well as measurement tasks where lower standards of detail and precision may be acceptable. For these applications the controlling standard is BS EN IEC 61672:2013 with type approved class 1 precision instruments for legal metrology applications through to class 2 general purpose sound level meters. Below these there are other applications where just relative measurements are required, for example, setting up a domestic hi-fi system. This last case is the area covered by sound level indicators and, as there are no generally recognised specifications for these, each manufacturer publishes their own.

Unfortunately, there are many examples of these low-cost instruments being offered for sale as sound level meters and many even quote the BS standard number. The technical aspects of these matters were investigated by a recent Institute of Acoustics Measurement and Instrumentation Group project that tested several different models of sound level indicators marketed in the UK that were all claimed to meet the BS EN IEC 61672 standard.

They all failed to do so – often quite spectacularly.

Buyer beware

So, we have instrumentation costing from a hundred pounds or so to many thousands and the buyer must ensure that the calibration service offered meets their requirements.

For most applications, we are trying, directly or indirectly, to quantify the human reaction to sound. This means we must deal with the very wide dynamic and frequency range of human hearing as well as taking account of the time history of the subjective noise.

So basically, we need a measurement microphone and some electronics that display the sound numerically. The electronics can be quite complex and are designed take care of the non-linearity of the subjective reaction

to noise in terms of both level and frequency. In addition, it must provide the necessary time history analysis to take care of very short transient sounds as well as to provide long-term time history indices. It follows the electronics must be provided with an output from a microphone that is always correct and stable. Sound pressure level changes can be very small and hence microphones are delicate, they are also affected by changes in temperature, humidity and barometric pressure; so are often seen as the weak link. Unfortunately, acoustic testing is the expensive part of the verification of the meter's accuracy, and is the area where compromises are often made on cost grounds.

Test results

To keep the costs of calibration as low as possible the usual procedure is to make as many of the tests as possible using electrical signals injected into the sound level meter via a dummy microphone. These results then must be corrected to take account of both the performance of the microphone and the acoustic effects of the instrument in the sound field. It follows that the instrument must have the necessary test points to inject these signals and allow for the separate acoustic testing of the microphone. Most sound level indicators do not provide these facilities; hence, it becomes necessary to test the complete instrument in an anechoic chamber. This is usually ruled out on cost grounds.

The only practical alternative is to use a multi-frequency and multi-level sound calibrator. Apart from limiting the verification to just a few points it provides the pressure response of the sound level indicator when it is required to show the free field sound level. So, the calibration laboratory will need to determine the corrections to apply. This normally means measuring a number of the microphones of the type used in the meter in a free field room, again, difficult on cost grounds.

These corrections can be large, relative to the tolerances, at high frequencies. So, if the calibration documentation states that a sound calibrator was used, it is necessary to check the pressure to free field corrections have been applied. These should also have associated uncertainty values with them. If the corrections are not available, the basic sensitivity should be set against a 250 Hz calibrator and any higher frequency data just used for drift considerations. This represents the simplest form of calibration on offer from laboratories and, in fact, does not represent much more than a simple pre-measurement field calibration check. But that is what you get for a £55 'calibration'.

Performance and tolerances

As far as legal metrology applications are concerned the measurements must be accurate and traceable to primary standards as well as being stable with both time and environment. To ensure compatibility of competing sound level meters, a set of three British and International standards (BS EN IEC 61672 series) have been developed to ensure that the legal process can concern itself with the merits of any individual case and not become diverted into debating the accuracy of the measurement instrumentation.

The primary requirement of the standard is to specify the performance of the instrument and the tolerances that should apply; this is all covered in part 1 of the standard. The second part defines a series of type approval tests (known as 'pattern evaluation' in the standard) for each model put onto the market. This is the responsibility of the manufacturer who must contract with an independent national laboratory to test the instrument for conformance with the specification; normally three samples of each model are submitted for testing. These tests cover all aspects of the performance, including detailed acoustic, electromagnetic compatibility and electrical testing of the complete instrument as well as a full range of temperature, humidity, and barometric pressure tests.

In addition, from the detailed acoustic testing, a series of corrections are derived to allow subsequent electrical tests to be corrected for the acoustic effects of the instrument case, windscreen, or other front-end accessories, to reflect the overall performance of the instrument in the sound field. All this work makes the final stage of ('periodic verification', which is covered by part 3 of the standard) much quicker and therefore less expensive.

Calibration schedule

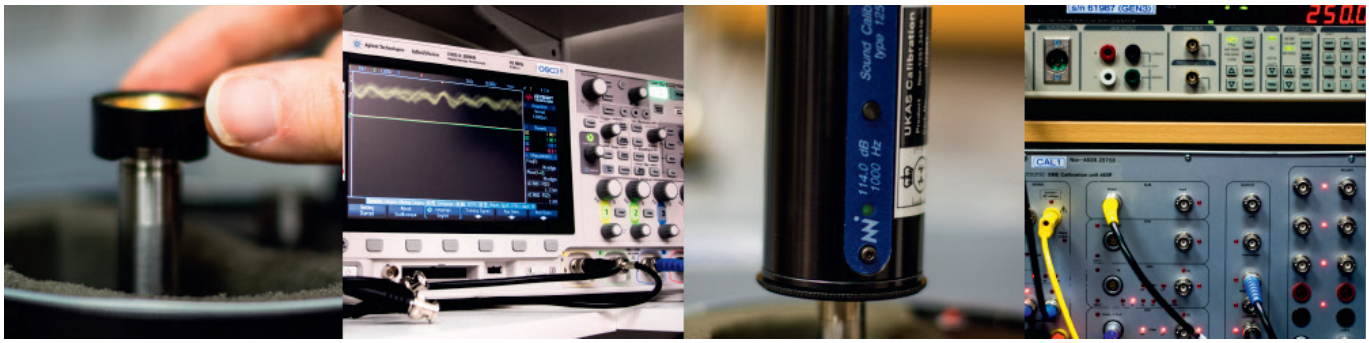
This biennial routine calibration is the responsibility of the user who must contract with an appropriate laboratory to have the work carried out. So, having identified the parameters that are likely to drift or be damaged, the number of tests necessary can be minimised. Furthermore, by use of the correction data derived from the pattern evaluation the number of expensive acoustic tests can also be minimised; and yet the results will still reflect the overall performance of the meter. To make all this happen the standard requires that all the necessary test points are provided in the instrument and that the necessary correction data is made available to the user and the accredited calibration laboratories.

So, we have a comprehensive audited procedure to determine compliance with the standard, as that is exactly what the noise control regulations require, i.e. the meter should comply with BS EN IEC 61672[1] . So, if a meter has undergone part 2 'pattern evaluation' at an independent national laboratory and has completed the part 3 'periodic verification' at an accredited calibration laboratory, where the uncertainties of the results are below the required maximum, then the instrument is deemed to comply with the standard.

A certificate of 'Calibration and Conformance' may then be issued in accordance with legal metrology requirements. The statement of conformance on the accredited certificate will state full conformance or detail the reasons why it cannot be confirmed, such as failure of the part 3 tests or no evidence of part 2 pattern evaluation. P46

References

1 BS 61672 has a comprehensive statement of what is necessary to confirm compliance. Other standards or specifications do not always have this information and it is necessary for the calibration client and laboratory to agree the testing that is required and the decision rules to be used to confirm compliance.



Above: Figure 1
Conformance to the Standard is confirmed when all requirements are met. This entails combining acoustic and electrical test results with reference data provided by the manufacturer from pattern evaluation testing

The maximum uncertainties mentioned above are given in the standard. The accreditation authority, United Kingdom Accreditation Service (UKAS) in the UK, will ensure these are maintained as well as exercising a quality control audit programme covering the accredited calibration laboratories' activities. Some laboratories also issue 'traceable' certificates covering both calibration and conformance. As these do not incur the oversight and verification of the accreditation authority, they are usually less expensive. They may not, however be accepted as evidence in legal or commercial disputes.

Testing options

To meet the needs of those users who do not require the full legal metrology status but still need to know the degree of precision their meters are delivering have other options. Naturally the non-accredited route mentioned above is one possibility. Any laboratory or supplier quoting BS EN IEC 61672-3 as the calibration standard should be aware that it requires that all the specified tests must be carried out.

We have seen in specifications statements such as: "frequency response per BS 61672 class 2", that may well be so, but what about the rest of the specification? It would still need to be calibrated to verify the claim. If, for example, you never need to measure peak levels, then you could dispense with that test by specifying a meter that does not have that function as the standard only requires you to calibrate features provided. So, in some circumstances it is possible to have an edited series of tests to reduce the cost of the calibration. But care is needed to ensure those using the results are aware of the limitations such a procedure would introduce.

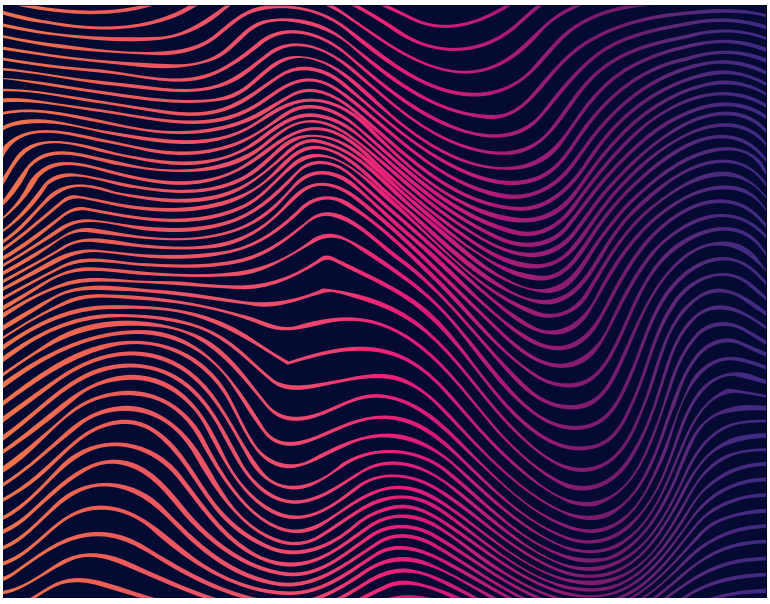
In conclusion, the 'Full Monty' is the accredited certificate of calibration and conformance. For those situations where that level of QA and compliance is not necessary there are other options. These need to be evaluated with care to ensure that they are providing the required information.

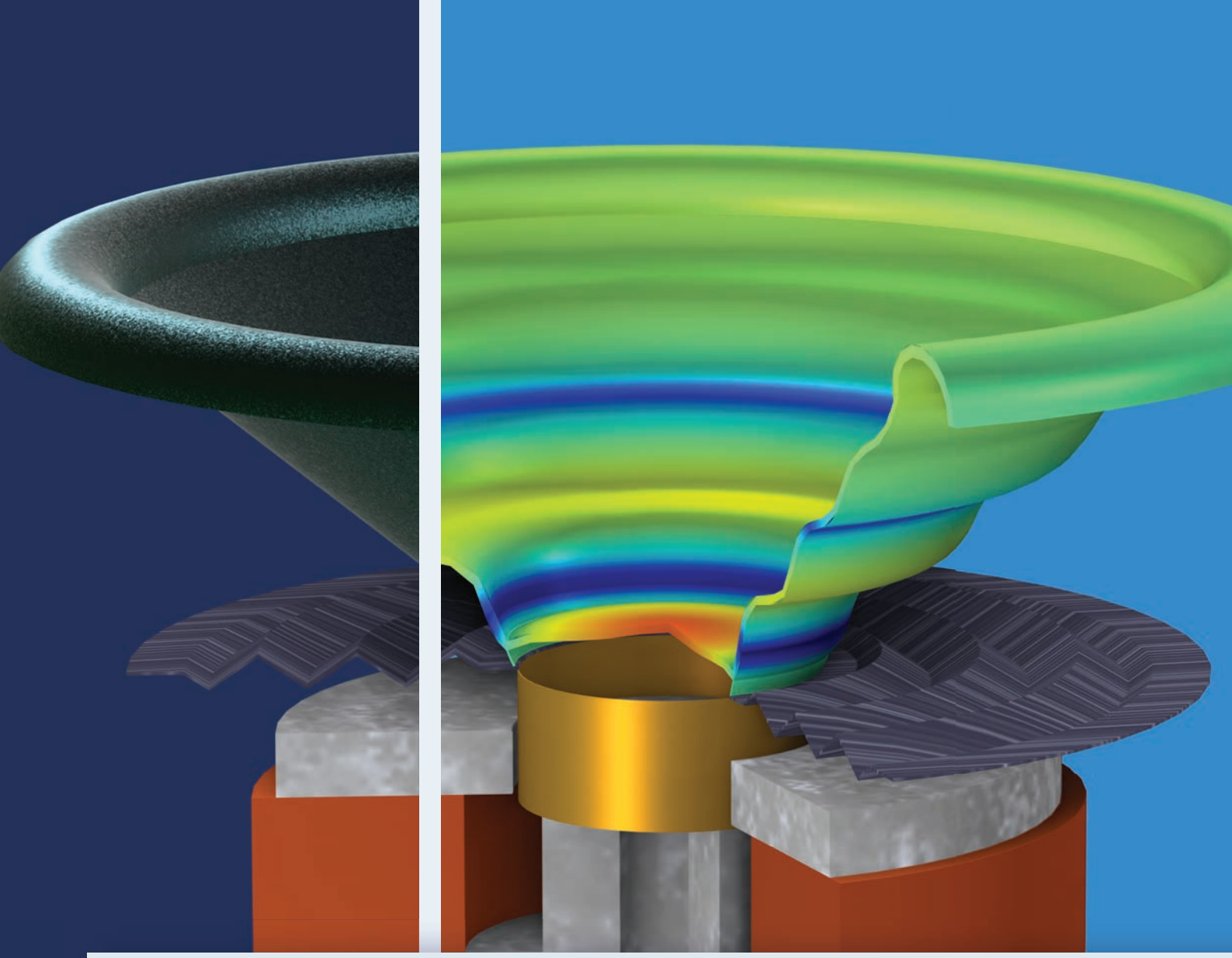
Part 2: Use of nominal microphone data

As part of the periodic verification of a sound level meter the standard requires that the overall performance of a class 1 sound level meter should be determined at octave band centre frequencies from 63 to 16k Hz for each of the weighting networks provided. To do this for each individual instrument in an anechoic chamber would be prohibitively expensive. So, the usual procedure is to make acoustic tests on the bench and then correct them for the acoustic effects of the case and other front-end accessories. This requires four sets of data to be combined:

1. electrical test of the frequency weighting networks undertaken by the calibration laboratory;
2. acoustic tests on the microphone undertaken by the calibration laboratory;
3. corrections to account for case reflections and defraction around the microphone from data provided from pattern evaluation testing; and
4. effects of weather protection provided by the manufacturer or measured by the calibration laboratory.

Each element comprises the deviation from the target response required by the standard (in dB) and the expanded uncertainty (dB, k=2) with which this result was obtained. Combining these individual elements will show how the complete instrument will perform in an actual sound field. This result can then be compared to the acceptance interval and uncertainty P48





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requirements given in the standard for the complete instrument; thereby allowing a pass/fail decision to be made.

A typical presentation of this data is shown in Figure 2 below.

The upper part shows the assessment using the actual microphone response extracted from a full microphone calibration. As such, a microphone calibration is an expensive undertaking. The standard allows, in certain circumstances, for the acoustic tests to be limited to just 125, 1k and 8k Hz and for 'nominal data' to be used for the other six octave band values.

In the lower table the real values have been replaced by the manufacturer's nominal data along with its uncertainty. Fortunately, in this case they both pass, but with different data and uncertainty calculations.

Combined response for BS 61672 Ed2 meter for A weighted response with measured microphone response

Frequency Hz	SLM Electrical		Microphone		Case reflection		Weather protection		Comb. Uncert.	Data Limit	Deviation	Decision
	Meas.	U	dB	U	dB	U	dB	U				
	dB	dB	dB	dB	dB	dB	dB	dB	dB	dB	dB	
63	0	0.1	0	0.1	0	0.1	0	0.1	0.20	± 1	0	Pass
125	0	0.1	0	0.1	0	0.1	0	0.1	0.20	± 1	0	Pass
250	-0.1	0.1	0	0.1	0	0.1	0	0.1	0.20	± 1	-0.1	Pass
500	-0.1	0.1	-0.1	0.1	0.1	0.1	0	0.1	0.20	± 1	-0.1	Pass
1,000	0	0.1	-0.1	0.1	0.1	0.1	0.1	0.1	0.20	± 0.7	0.1	Pass
2,000	0	0.1	-0.1	0.1	-0.3	0.1	0.4	0.1	0.20	± 1	0	Pass
4,000	-0.1	0.1	-0.2	0.2	-0.1	0.1	0.7	0.1	0.26	± 1	0.3	Pass
8,000	0	0.1	0	0.2	0.1	0.2	0.1	0.2	0.36	+1.5, -2.5	0.2	Pass
16,000	0	0.1	0.6	0.3	0.2	0.2	-0.5	0.3	0.48	+ 2.5, -16	0.3	Pass

Data source key

Measured | Supplied by manufacturer | Actual microphone response

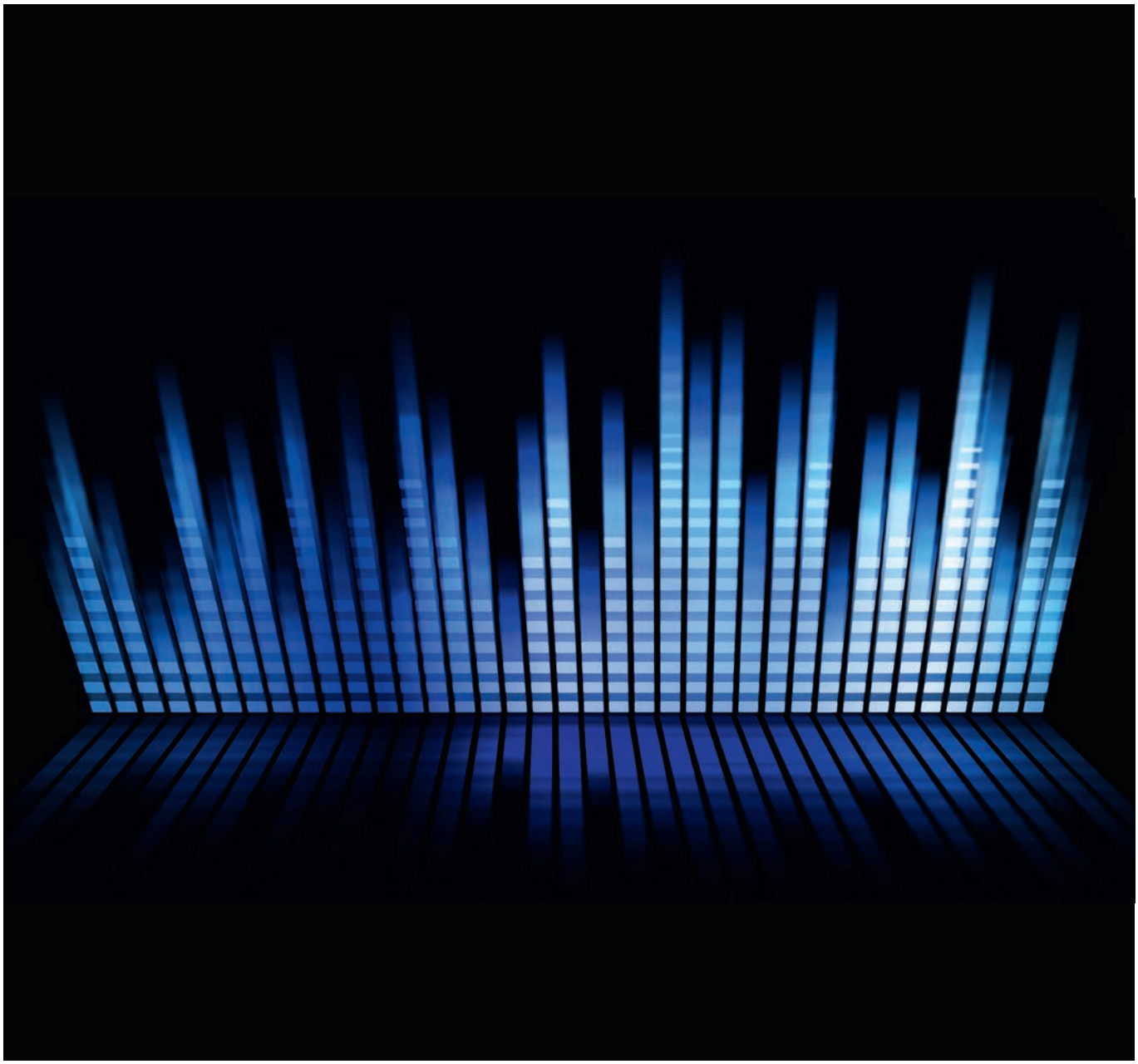
Combined response for BS 61672 Ed2 meter for A weighted response with nominal microphone data

Frequency Hz	SLM Electrical		Microphone		Case reflection		Weather protection		Comb. Uncert.	Data Limit	Deviation	Decision
	Meas.	U	dB	U	dB	U	dB	U				
	dB	dB	dB	dB	dB	dB	dB	dB	dB	dB	dB	
63	0	0.1	0	0.25	0	0.1	0	0.1	0.30	± 1	0	Pass
125	0	0.1	0	0.1	0	0.1	0	0.1	0.20	± 1	0	Pass
250	-0.1	0.1	0	0.25	0	0.1	0	0.1	0.30	± 1	-0.1	Pass
500	-0.1	0.1	-0.1	0.25	0.1	0.1	0	0.1	0.30	± 1	-0.1	Pass
1,000	0	0.1	0.01	0.1	0.1	0.1	0.1	0.1	0.20	± 0.7	0.21	Pass
2,000	0	0.1	-0.03	0.25	-0.3	0.1	0.4	0.1	0.30	± 1	0.07	Pass
4,000	-0.1	0.1	-0.12	0.25	-0.1	0.1	0.7	0.1	0.30	± 1	0.38	Pass
8,000	0	0.1	0.4	0.2	0.1	0.2	0.1	0.2	0.36	+1.5, -2.5	0.6	Pass
16,000	0	0.1	1.25	0.45	0.2	0.2	-0.5	0.3	0.59	+ 2.5, -16	0.95	Pass

Data source key

Measured | Supplied by manufacturer | Nominal microphone data

Above: Figure 2
Typical summation of individual elements of the calibration to get the overall response of the meter using either actual or nominal data



The electrical and acoustic tests on the sound level meter are performed by the calibration laboratory, while the case reflections and windscreen data are provided from the pattern evaluation. In respect of the microphone data, if a full microphone calibration has not been performed there is the option to use a comparison coupler or an electrostatic actuator to make bench measurements of the microphone response at the other six octave centres.

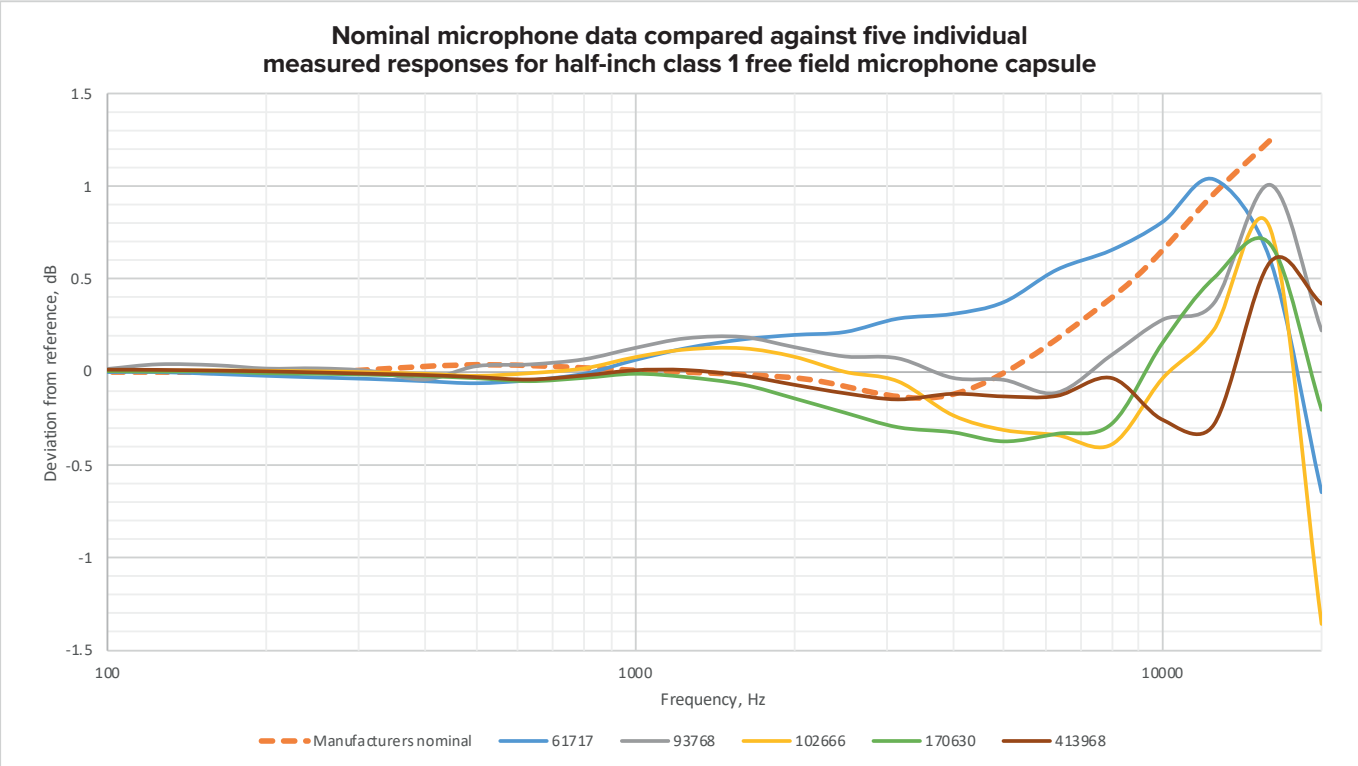
There is a further option for just the results at 125, 1k and 8k Hz to be made acoustically with the other six octaves reported as nominal values. This will allow the three mandated acoustic tests to be measured with a standard multi-frequency sound calibrator, this would be a lower cost option for the laboratory. This nominal data can be provided by the manufacturer or determined by the calibration laboratory.

The procedures here vary between the original 2006 (Edition 1) version of the standard and the revised 2013 (Edition 2) versions. For Edition 1 instruments, the nominal data should be provided by the manufacturer along with uncertainties. But for Edition 2 meters, the standard requires these six additional octave band points to be measured by the calibration laboratory, only if they cannot be measured may nominal values be used.

If the laboratory has to use this concession, then the nominal data must be determined as specified in BS EN 62585:2012. This requires measurements to be made on at least five samples of the microphone to determine the nominal responses along with their associated uncertainty. The results therefore need to be qualified by a statement of either:

1. The actual frequency response of microphone (manufacturer, model and serial number) has been used for the calculations to confirm compliance with BS EN IEC 61672-3 for a class 1 meter, or

2. Nominal frequency responses determined as per BS EN 62585-2012 have been used for the calculations to confirm compliance with BS EN IEC 61672-3 for a class 1 meter. P50



Above: Figure 3
Nominal microphone response with actual response of five randomly selected microphones of the same type

It is possible therefore for a calibration and conformance certification to only require acoustic calibration at three frequencies with the others based on estimated data. If, however, the laboratory includes a full calibration of the microphone as part of their calibration procedure then it is a simple matter to include actual measured data in the computation of the complete instrument; this will reduce the overall uncertainty of the results to be included in your projects.

In the case of nominal results being used, it would be advisable for the user of the instrument to keep a close eye on the 8k Hz result to detect any changes that may be symptomatic of movements in the microphone response at other frequencies that would not be reflected when using nominal results.

In the example above, comparing the nominal response with five randomly selected samples of the same type of microphone, we see differences over the samples of 1.1 dB at 8k Hz and with a maximum difference of 0.8 dB between the nominal and the samples. All of this is within the requirements of the standard, but use of nominal data does require the user to make some technical assessments on how the microphone may well be performing.

If you have an Edition 1 meter, the decision regarding the use of nominal or measured microphone responses is at the discretion of the user or the calibration laboratory. However, with Edition 2 meters; it states that measured data will be used, unless it cannot be measured. Not quite so clear here as to what that means: laboratory does not have the facility, or it does but the client thinks it is too expensive, etc.?

In the next issue

The next contribution to this series of notes (May/June 2022 issue) will look at the use of the associated calibrator along with the use of offsets to centre the microphone response in the permitted tolerance band. That will give still more food for thought about the use of nominal microphone performance.

IOA 'Transport Noise' publication

Part of the IOA's charitable remit is to promote and advance the art, science and technology of acoustics in all their aspects.

To this end, we produce magazines aside from the members' Acoustics Bulletin to engage with a wider audience comprising:

- those whose careers touch on acoustics, but is not their primary occupation;
- students who may be considering acoustics as a career; and
- members of the public who just want to find out more about the science.

These publications are available to members, but in the main, are written with a light touch with only necessary technical details. They are all clearly IOA branded and also serve to promote the Institute and its members.

Our latest publication, 'Transport Noise, how it affects our health and wellbeing' has just been issued online and it will be printed as required to be available at industry and public events where appropriate. This magazine includes articles by noted industry experts and explores noise from road, rail and air transport, how it is measured, predicted, managed and mitigated.

This publication follows IOA's careers supplement and innovations supplement both published in 2019. The success of this series of IOA publications indicates a strong audience and the plan is to publish more on different acoustics topics in due course.

Contributors

We are very grateful indeed to all the contributors to the Transport Noise publication, our thanks also go to all our advertisers. Without the unwavering support from writers and advertisers, this project would still be on the drawing board.

The contributors are:

- Cameron Salisbury (Sound arguments: the wonder of acoustics, and The future of mobility)
- Stephen Turner (How we manage transportation noise – policy and legislation)
- Matt Muirhead (Managing road traffic noise
- Dr Antonio J Torija Martinez (E-mobility: challenges and opportunities for environmental acoustics
- Adam Thomas (Auralisation – applications, then and now)
- Alex Southern (What will it sound like? Immersive sound demonstrations)
- Dr Oliver Bewes (Noise control measures for HS2)
- Nicole Porter, Robin Monaghan, Chris Wood and Jamie Easton (Aviation noise management and research)
- James Block (On the right track – the European Environmental Agency 'Environmental Noise in Europe' report
- Professor Keith Attenborough (IOA education and training in transport noise)
- Vicky Wills and Matt Muirhead (The road to a career in transport acoustics)
- Lisa Lavia and Daniel Goodhand (Salutogenic living: moving from noise control to soundscape design)
- Dr Calum Sharp and Professor Charlotte Clark (Noise and public health)

Read the publication here **https://www.ioa.org.uk/news/ioa-publishes-new-transport-noise-supplement**

WHAM:
TO ASYMMETRY AND BEYOND!

An on-going project at the University of Derby into Ambisonics to head-tracked Binaural rendering transparency was at the point of 'in-person' listening tests at the start of 2020 and involved custom software combined with wearable headtracking technology[22]. The restrictions soon to be imposed by the pandemic thwarted the continuation of these tests. It raised the question, "How do we maintain our essential test features using remote systems?" Many people had access to webcams, laptops, and headphones due to remote working, so we sought to tap into this!

By Mark Dring and Dr Bruce Wiggins,
College of Science and Engineering, University of Derby, UK

The WHAM (Webcam Head-tracked Ambisonics) website (www.brucewiggins.co.uk/WHAM) takes the approach of using a webcam to measure head rotation via the browser to provide auralisation using Binaural Room Impulse Response (BRIR) or anechoic Head-Related Transfer Function (HRTF) data; visitors to the site can experience very high order horizontal only Ambisonic to asymmetric binaural presentation of captured room responses.

This article documents the developments and improvements in functionality made to the WHAM website and open-source JS Ambisonics software library beyond its creation during lockdown in 2020[1], enabling the wider community to benefit from this work for acoustic auralisation purposes.

Spatial auralisation

Spatial hearing is our ability to make sense of the complex and multiple acoustic cues provided to our ear/brain system. Sounding objects have a direction, location and sound of the place where they occur and, combined with the dynamic nature of our constantly changing position, give a rich source of data for interpreting the world around us. The reproduction of sound can benefit greatly from an accurate dynamic simulation of this complex acoustical scenario, or auralisation. To provide a truly representative result, the systems used must capture and deliver critical, dynamic, psychoacoustic cues that react to the listener's head position whilst avoiding the listener becoming more aware of the 'system' than the audio experience.

When it comes to the measurement of rooms for auralisation over headphones, there are currently two options:

OPTION 1 – AMBISONIC MICROPHONES

A 360 degree (periphonic) acoustic signature of a room or environment can be measured using specialist Ambisonic microphones, capable of capturing a spherical harmonic representation of the sound field[2]. Invented by Gerzon and Craven in 1975, the first SoundField microphone was launched[3], constructed using spaced subcardioid microphone capsules to receive four signals (known as A-Format). These input signals were transformed using dedicated hardware into four channels of B-Format also known as First Order Ambisonics (FOA), able to reproduce the complete sound field with a minimum of eight speakers[4]. Upon reproduction, unlike some other audio conventions, Ambisonics can be decoded to different speaker layouts and be manipulated to provide rotation, tumble and tilt of the 3D scene after recording. Furthermore, Ambisonics can be efficiently converted into a binaural signal, suitable for headphone listening, through convolution with Head Related Transfer Functions (HRTFs)[5,6].

Ambisonics, being a hierarchical format, means that both the number of inputs for signal capture and the number of outputs for reproduction can be expanded. Higher Order Ambisonic (HOA) microphones are now commercially available, examples include the Zylia ZM-17 (3rd order) and the MH-Acoustics Eigenmike[8] (4th order). P54

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An increase in channels and, therefore, the subsequent order of spherical harmonics that may be captured is associated with an improvement in spatial resolution and the effects of spatial aliasing. The perceptual impact of a reduced spatial resolution will be a smearing of the sound source over a wider range of directions[9]. Spatial aliasing will limit the frequency bandwidth (3rd order, approximately 1.2kHz) over which correct interaural cues will be reconstructed, used to determine direction of arrival but also the spatial attributes of the environment in which the sounds have occurred[5,10]. Whilst current HOA microphones make for a quick and convenient method to capture the sound field, the low spatial aliasing frequency and maximum microphone order render this method sub-optimal for the intentions of this project.

OPTION 2 – HEAD AND TORSO SIMULATORS (HATS)

To extend beyond the currently limited Ambisonic microphone orders the sound field or BRIR can be captured using a dummy head or head and torso simulator (HATS) in two ways. The first, is by keeping the head static and measuring multiple source positions around the head. The second, is by maintaining a static source position and rotating the HATS. In anechoic situations, rotating the head or rotating the source around the head result in the same filters. In echoic situations, however, they will not be the same. Using either of these methods means the HRTFs associated with the dummy head cannot be separated from the room response and the reported benefits of HRTF personalisation cannot be applied at a later stage in the binaural reproduction process. However, with head-tracking devices, rotation, tumble and tilt can be implemented; research shows that this negates the cone of confusion issues and supports externalisation[11,12].

When transforming HRTF or BRIR data into the spherical harmonic domain, the higher the angular resolution of measurements taken, the higher the order of spherical harmonics that can be leveraged to encode the sound field. As an example, for spherical reproduction at orders up to and including 35th (highest order utilised in our wider research project), then 1,296 Ambisonic/spherical harmonic channels would be required according to equation (1), with binaural presentation doubling this value for a left and right pair.

$$HOA\ Signals=(Order+1)^2 \quad \textbf{(1)}$$

HOA presented binaurally can be computationally intensive, due to the number of convolutions needed which can lead to slow render times and audio presentation errors, such as glitches or distortion if sufficient computing power isn't available. Various researchers seek techniques that reduce the order yet maintain the desired spatial attributes without generating perceptual errors. One approach, used in this project, is to limit the dynamic nature of the system to the horizontal plane so only head rotation is processed, which greatly reduces the number of Ambisonic channels needed to 2N+1 where N is the Ambisonic order. The binaural data is still full 3D with the Ambisonic order set to a maximum of 15th, which is the maximum possible due to the Web Audio API limit of 32 channels per stream. Another commonly considered technique is to observe the resolution required for the direct sound differently from that required for the reverberant field, adopting a 'hybrid' approach[13]. Whilst these techniques capitalise on the studied perceptual thresholds of the reverberant/diffuse field through separation at a determined 'mix time', there is admission that in real rooms, ideal diffusion (and therefore a perfect mixing time) will never occur due to known occurrences of modal behaviour, proximity to room boundaries and non-uniform distribution of absorption[14].

The Reverberant Virtual Loudspeaker (RVL) technique documented by Engel and Henry[13] offers a solution to minimise the number of required convolutions for head tracked BRIR presentation. However, the room and room reflections are 'head-locked' and don't track with head rotations which leads to misaligned auditory cues between the direct and reverberant sound fields. Room positions which exhibit significant diffusion may mask this misalignment and Engel and Henry conclude that RVL, which renders the reverberation at low orders (max 4th order), is subjectively comparable to 'less flexible Ambisonic approaches'. However, this study positions the head in the centre of the room where generally sufficient diffusion and room symmetry is likely due to maximum path differences from all boundaries.

If the aim is to generate auralisations that aren't compromised in any detail for any listening position in the room and to provide dynamic rendering that ensures early and late reflections are truly relative to the source position and position of the head on playback, then Very High Order Ambisonics (VHOA) can be implemented. As an audio format analogy, it is the equivalent of rendering a WAV file compared to an MP3; the complexities of perceptual thresholds for each individual recording cannot be determined with absolute certainty. Therefore, we should avoid making any compromise when striving to present as accurate as possible an auralisation to the listener, when determining what maximum order is needed. P56

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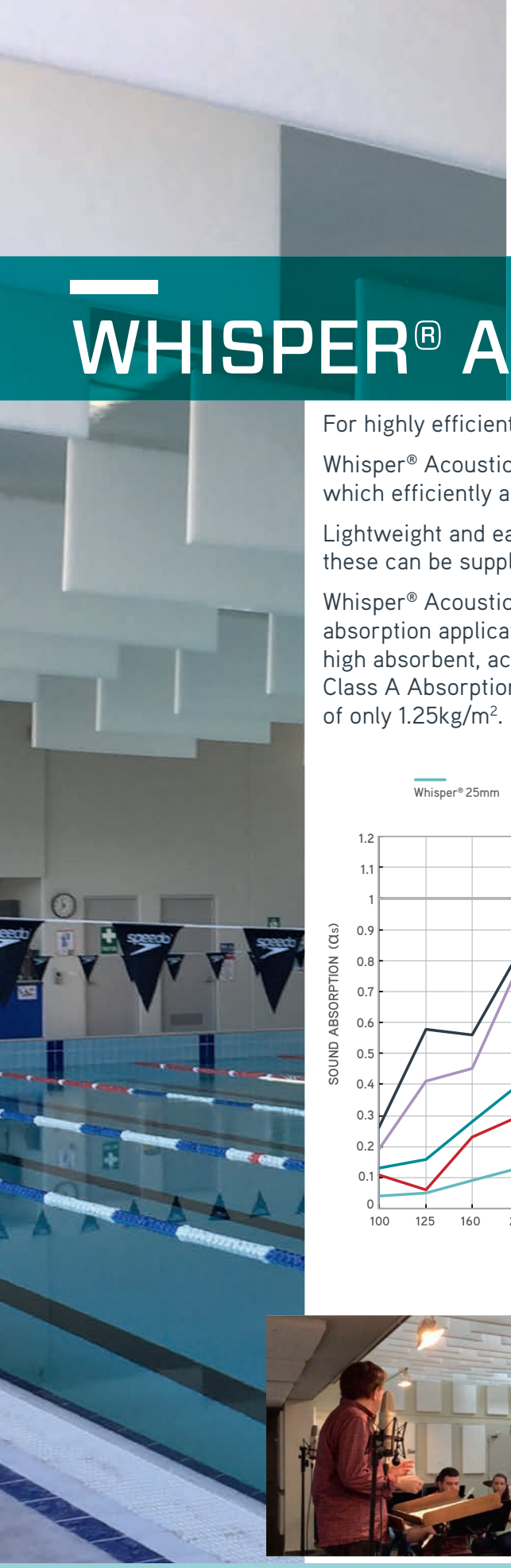

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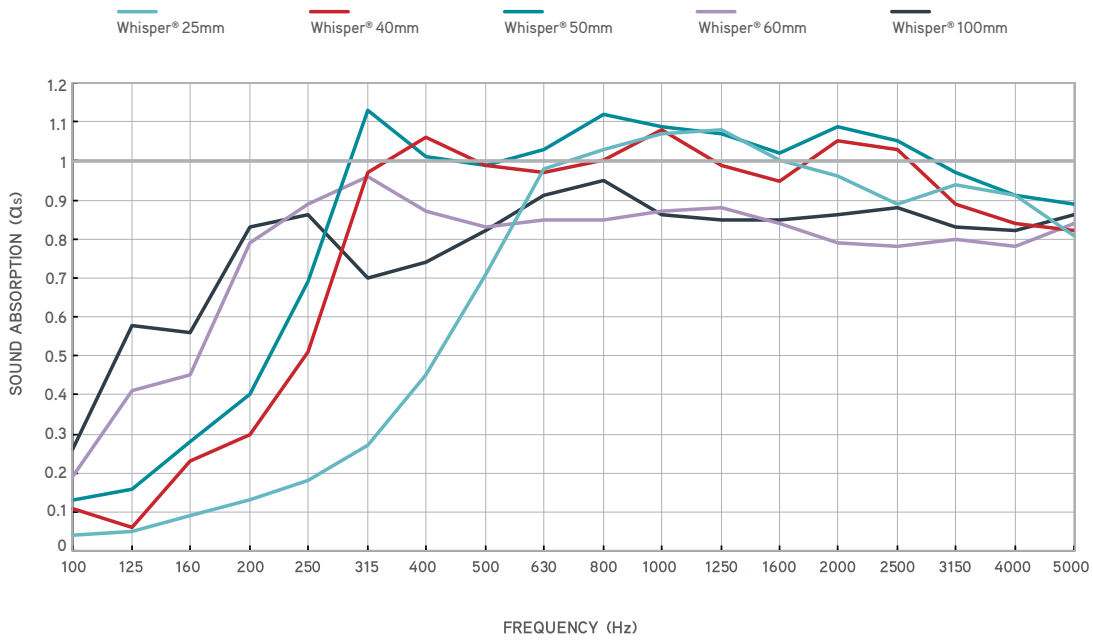

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For this project the KEMAR[15] head and torso simulator was employed to capture one hemi-anechoic environment (Hemi-anechoic chamber, University of Derby) and two reverberant environments (MS015, University of Derby and St. Paul's Church, Derby) in the horizontal plane only. The HATS was rotated on a turntable every 2.5 degrees for a single loudspeaker position (144 BRIRs), which allowed for a possible 71st order of circular harmonics for binaural rendering. The automated capturing process known as Dynamic Binaural Reverberation Acquisition Technique (D-BRAT), previously referred to as 'Binaural Scanning', has been documented by the authors previously[1]. Whilst limited to a fixed position of a single sound source and generic HRTFs, this technique ensures listeners will experience a sound field that accurately reflects the dynamic cues experienced in real life.

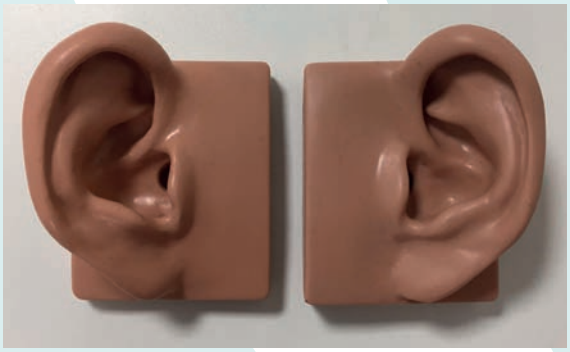
The Importance of Asymmetry

A typical criticism of binaural rendering is having sound sources located 'in the head' or poorly localised (mainly front/back confusions), which is often attributed to non-individualised HRTFs[16]; a known limitation of D-BRAT. It is therefore important that other processes, namely natural reverberation[17], dynamic cues, and asymmetrical pinnae[18] are capitalised upon to maximise the auralisation accuracy; put simply we need to ensure correct, and dynamic decorrelation of signals arriving at the left and right ear occurs.

Another technique adopted to increase computational efficiency of binaurally reproduced signals is to assume HRTF (and by extension BRIR) left and right symmetry[5]. When this assumption is made the number of convolutions per spherical harmonic is halved, as front/back filter pairs are identical, and left/right pairs are simply phase inverted[19]. This is a reasonable assumption for HRTF data, but room responses, and hence, BRIRs, will rarely, if ever, be left/right symmetric. Any assumption of symmetry will erode the desired decorrelation and is unrealistic for most real rooms when considering all the impacts on ideal diffusion mentioned previously. It is therefore of importance, as will be discussed later, that signals fed to the left and right ear are presented identically to how they have been captured.

In addition to the asymmetrical convolution processes at the end of the signal chain, research shows the utilisation of asymmetrical pinnae will have a positive effect on 'externalisation'[18]. D-BRAT makes use of the KEMAR HATS which utilises pinnae that are not symmetrical as they are based on real measurements of human dimensions. Figure 1 and Figure 2 show the pinnae used for this project and provide clear evidence of the differences that will lead to decorrelation of not only the reverberant field but also the direct sound source.

Below:
Figure 1:
Front profile of the KEMAR pinnae



Below:
Figure 2:
Side profile

JS Ambisonics: Developing 15th Order Asymmetry

JSAmbisonics, created by Politis and Poirer-Quinot, is a *'JavaScript library that implements a set of objects for real-time spatial audio processing, using the Ambisonics framework. The objects correspond to typical Ambisonic processing blocks, and internally implement Web Audio graphs for the associated operations.'* It's maturity, features, and the fact that it is open source, made it an ideal candidate for use in the WHAM project. JSAmbisonics is designed to work using the WebAudio API, a specification developed by W3C describing a high-level JavaScript API for processing and synthesising audio on the web, which is supported by major browsers on computers and mobile devices, allowing for a low barrier to entry for users.

The JSAmbisonics library already included much of the functionality and classes needed for the project with the main classes of interest being:

- monoEncoder2D: used to encode a sound source into an Ambisonic stream of a set order, with real-time control of the panning direction;
- binDecoder2D: implements an Ambisonic to binaural decode, using user-defined HRTF-based filters up to 15th order (horizontal only and assuming left/right HRTF/head symmetry); and
- orderLimiter2D: takes a Higher Order Ambisonic stream of order N and outputs the channel-limited HOA stream of order N'<=N (up to 15th order, 2D only). P58

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Efficient isolation solutions for light wooden structures.

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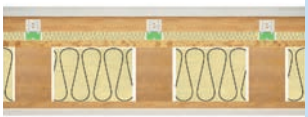
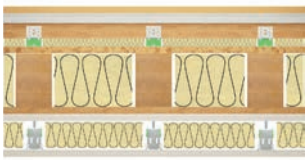
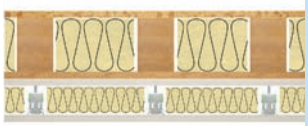
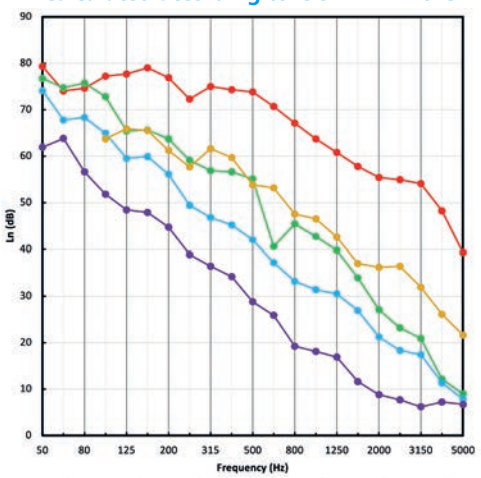
REFERENCE CONFIGURATION RC	 • 22mm Chipboard • 120x180 mm section wooden beams (100mm mineral wool between) • 24 mm wooden battens • Plasterboard
SYSTEM 1 S1	 • 22mm OSB • 50mm wooden battens (45mm mineral wool between battens) • **Akustik + Sylomer® floor mount 25** • 22mm Chipboard • 120x180 mm section wooden beams (100mm mineral wool between) • 24mm wooden battens • Plasterboard
SYSTEM 2 S2	 • Rigidur plate H13 BR - 13mm (cement board) • Rigidur 20mm • 50mm wooden battens (Mineral wool between battens) • **Akustik + Sylomer® floor mount 25** • 22mm Chipboard • 120x180 mm section wooden beams (100mm mineral wool between) • 24 mm wooden battens + 1 gypsum board
SYSTEM 3 S3	 • Rigidur plate H13 BR - 13mm (cement board) • Rigidur 20mm • 50mm wooden battens (Mineral wool between battens) • **Akustik + Sylomer® floor mount 25** • 22mm Chipboard • 120x180 mm section wooden beams (100mm mineral wool between) • 24 mm wooden battens + 1gypsum board • **Akustik + Sylomer 30** Acoustic Hanger with a 280 mm plenum (90mm of mineral wool) • 2 laminated 12,5 mm thick plasterboard
SYSTEM 4 S4	 • 22mm Chipboard • 120x180 mm section wooden beams (100mm mineral wool between) • 24 mm wooden battens + 1 gypsum board • **Akustik + Sylomer 30** Acoustic Hanger with a 280 mm plenum (90mm of mineral wool) • 2 laminated 12,5 mm thick plasterboard

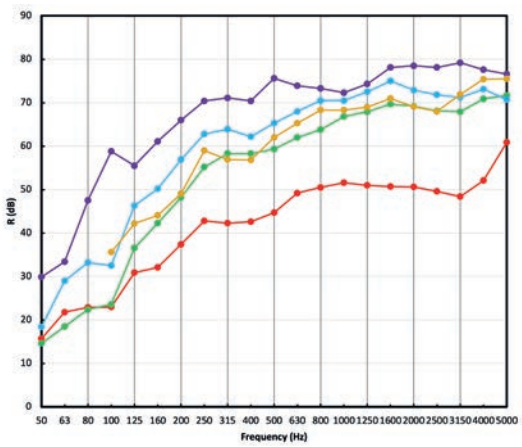
RESULTS OF THE LABORATORY TESTS

IMPACT NOISE RESULTS
Calculated according to ISO 717-2: 2013



RC Reference - 70,6 (0) dB
S1 System 1 - 57 (3) dB
S2 System 2 - 50,2 (2) dB
S3 System 3 - ≥38,3 (2) dB
S4 System 4 - 55,8 (1) dB

AIRBONE NOISE RESULTS
Calculated according to ISO 717-1: 2013



RC Reference - 48 (-2;-7) dB
S1 System 1 - 59 (-7;-16) dB
S2 System 2 - ≥67 (-7;-15) dB
S3 System 3 - ≥74 (-2;-7) dB
S4 System 4 - ≥63 (-3;-10) dB

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Modern browsers currently support 32 channel streams (the Web Audio API dictated minimum) and is where the 15th order limitation for horizontal decoding comes from (15th order needing 31 Ambisonic channels and the highest order that can be implemented below 32 channels). As mentioned above, all binaurally decoded implementations of Ambisonics assume that the head and ear are left/right symmetric. This reduces the number of convolutions needed to one per spherical harmonic. However, for this project, where BRIRs are captured and utilised, left/right symmetry cannot be assumed as the room response will not exhibit this feature and, as discussed above, asymmetry has been shown to be of importance even for anechoic HRTF data. If the HRIR/BRIR data isn't left/right symmetric, then the resultant spherical harmonic filters will be different for the left and right ear streams. For this reason, several JS Ambisonics' functions needed to be updated to allow for the processing of two 31-channel convolution streams simultaneously.

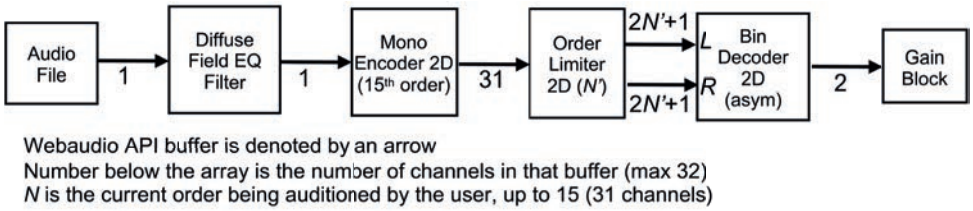
When the website is accessed, a number of audio files and filters are pre-loaded for use:

- an audio file used in the auralisation (a mono .wav file);
- diffuse-field equalisation filters relating to the order of Ambisonics to be used (a 2 channel .wav file); and
- Binaural Room Impulse Response JavaScript Object Notation (JSON) files which contains 144 two-channel BRIR data for a fixed source position, but multiple head rotations of the KEMAR HATS (every 2.5 degrees).

Once loaded, the JSAmbisonics library uses the BRIRs, coupled with the order of Ambisonics to be used, to create the filters needed for the binaural decoding of the audio (which will be Ambisonically encoded by the library). This results in two 31-channel filters (if 15th order is the maximum order to be used); one 31-channel set for the left ear and one 31-channel set for the right ear. The functions that needed to be expanded to allow for asymmetrical filter processing, necessary for correct reproduction of the room response with head tracking, are those associated with the calculation of the filters and the decoding of the Ambisonic audio, binaurally, which occur in the binDecoder class. In the forked version of the JSAmbisonics used for this project, this has resulted in two extra classes:

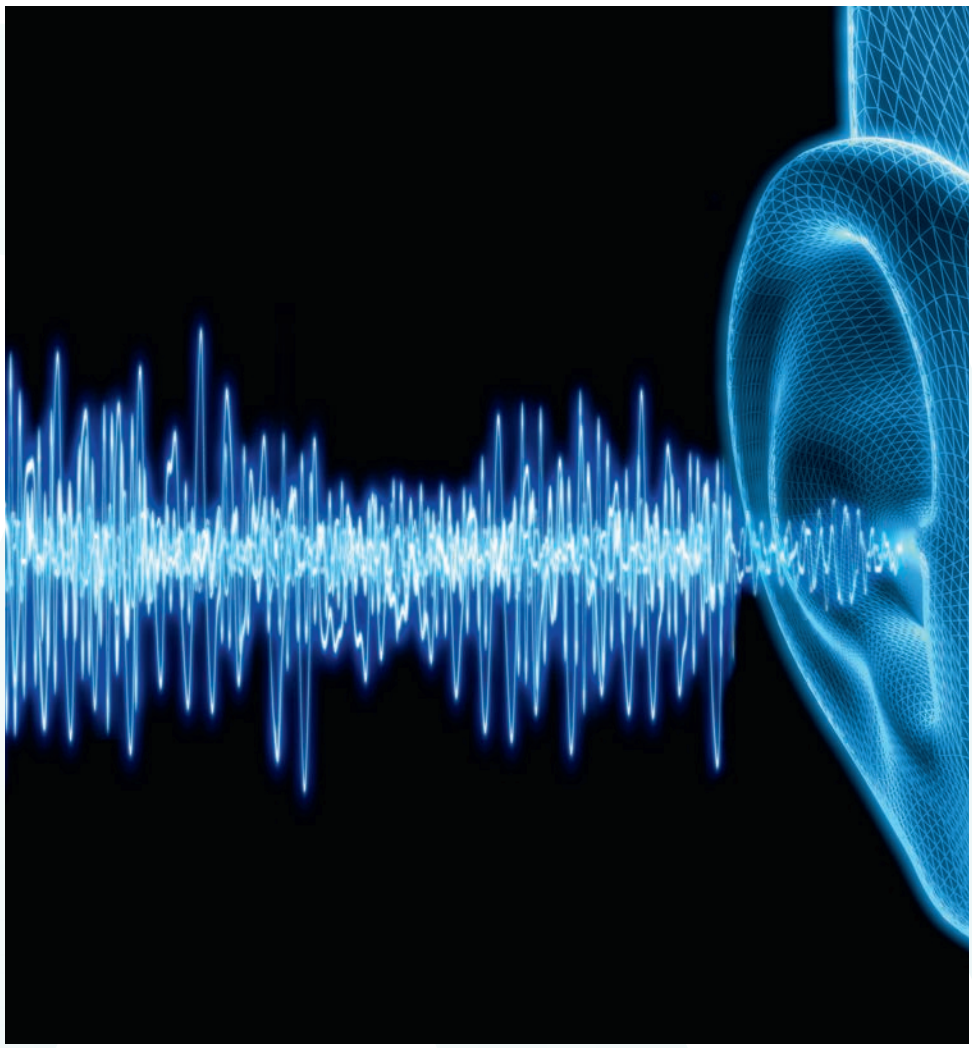
- HRIRloader2Dasym2 – a class that loads the BRIR data and calculates the filters needed for binaural decoding of the Ambisonic audio without symmetry assumed; and
- binDecoder2Dasym2 – a class that implements the Ambisonics to binaural decoding using the filters calculated using HRIRloader2Dasym2 above and implementing the two parallel 31-channel convolution streams needed.

A block diagram showing the WHAM Webaudio API and JSAmbisonics elements as implemented on the WHAM website are shown in Figure 3.



Below: Figure 3: Block Diagram of the D-BRAT processing on the WHAM website

Webaudio API buffer is denoted by an arrow
Number below the array is the number of channels in that buffer (max 32)
N is the current order being auditioned by the user, up to 15 (31 channels)



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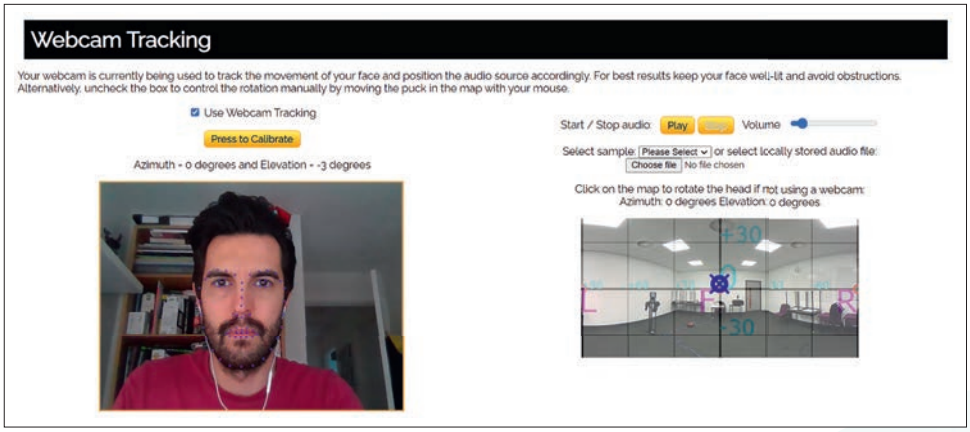
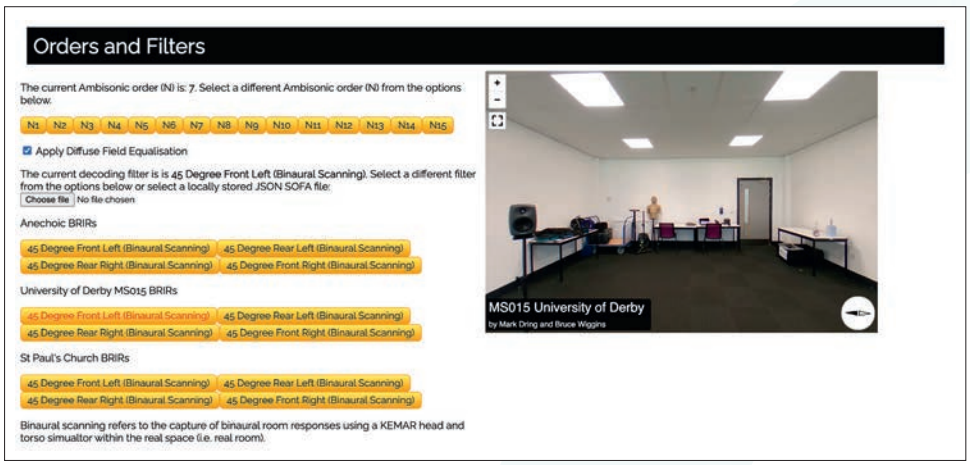
Website Features

The site has several interactive elements located under the headings, 'Webcam Tracking' (Figure 4), 'Orders and Filters' (Figure 5) and 'Listening Surveys'.

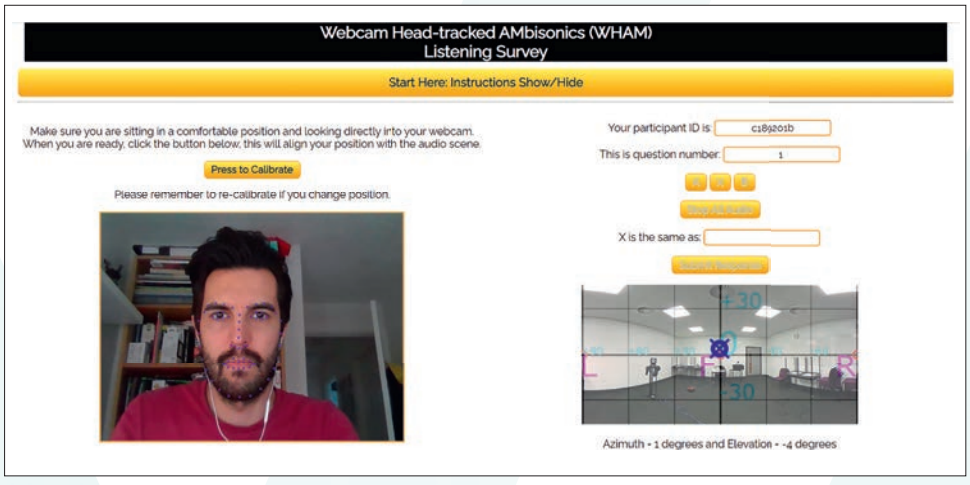
The webcam image is returned on the screen with the overlay of 68 facial points tracking the user's head orientation. The azimuth is used to determine the mix of filters required to match the head position for correct audio reproduction. A visual indicator of the determined angle is shown using a 'puck', positioned over a map. Webcam tracking can be disabled, with head rotation being made possible through direct control of the puck. Users can listen to locally stored audio files as well as two samples already available on the site. When the site loads the default BRIRs are set to MS015 (a University of Derby classroom) with a sound source positioned at 45 degrees azimuth and binaurally rendered using 7th order circular harmonics. Users can select up to and including 15th order for three acoustically different environments. For each environment, four different loudspeaker positions have been captured at distances of 2m from the HATS, offset by ±45 degrees to the front and rear. This provides users with some interesting audible interactions. It is also possible to load locally stored filters for auditioning with the webcam tracking, where available, in a JSON.SOFA file format.

Below:
Figure 4: Webcam tracking section of the WHAM website





Above:
Figure 5: Orders and filters section of the WHAM website



Above:
Figure 6: WHAM ABX listening survey

Using the Pannellum JavaScript plugin[20], an equirectangular image of the two reverberant spaces can be seen. The images switch according to the selected filter and the image follows the orientation of the head. Providing the user with the correct visual scene during the binaural reproduction of the same space is beneficial to ensure the phenomena of room divergence, which has a negative effect on externalisation[12,21] is minimised and therefore the auralisation is 'accurate' to the space being visualised by the listener.

Two well-known listening survey methodologies for perceptual audio studies (ABX and MUSHRA) were implemented on the site; both have an operational limit of 15th order. Listeners can lower the maximum order prior to starting the test; this was employed as a precaution to counter the occurrence of audio playback errors experienced on less powerful computers.

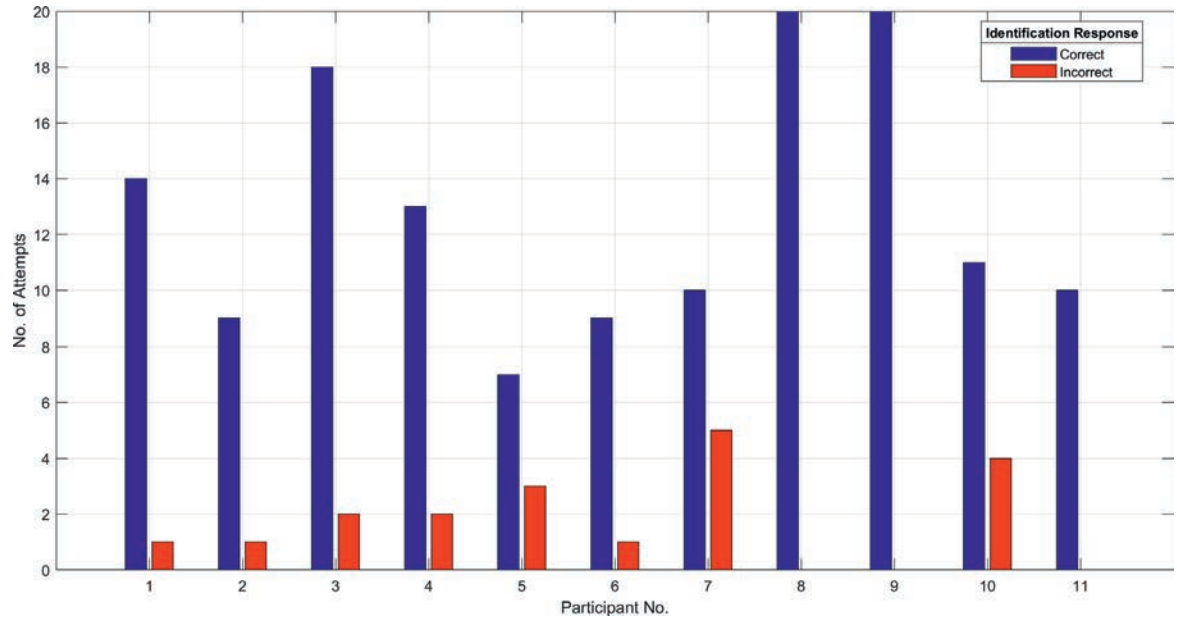
It is accepted that not all results will be immediately comparable, however it is hoped a significant number of participants will conduct the surveys to meet statistically significant thresholds.

The ABX survey (Figure 6) aligns most closely to the work conducted by the authors looking into perceptual thresholds of circular harmonic orders[22]. A single environment (MS015), single loudspeaker position (45-degree azimuth) and single audio type (drums) is presented for randomised orders against the maximum order determined by the user's selection for a minimum of 10 questions. Results obtained from this study will determine if listeners were able to either correctly or incorrectly perceive a difference in the spatial attributes between the 15th order reproduction and the other order presented for each question. P60

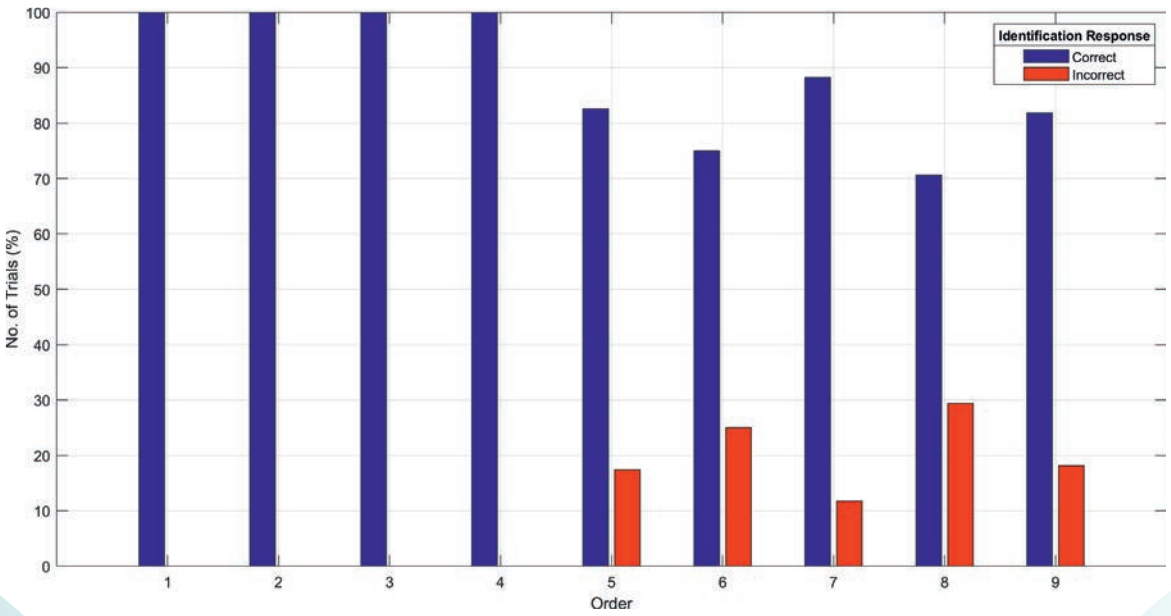
Preliminary Findings

Figure 7 and Figure 8 show the results from an early ABX listening survey where the site was operating with a 10th order limit.

It is evidenced in Figure 7, that eight (~73%) participants had a minimum of one incorrect response in the trials presented, with a maximum of five incorrect responses for any individual recorded within this data set. From the results there is an indication that a perceptual difference exists between 10th order and lower orders. This data alone does not support any meaningful conclusions, although is an indicator of sensitivity variations which supports the need to pursue a larger number of participants. This can be used to augment the data obtained using face to face tests which are now able to resume at Derby using a more powerful, non-web-based, and dedicated head tracked solution.



Right:
Figure 7:
Individual ABX responses per participant for all orders attempted



Right:
Figure 8:
Combined ABX participant responses (in %) for each order vs. max. order of 10

Order	1st	2nd	3rd	4th	5th	6th	7th	8th	9th
Total in Survey	21	16	14	17	23	24	17	17	11
Correct (No.)	21	16	14	17	19	18	15	12	9
Incorrect (No.)	0	0	0	0	4	6	2	5	2
Correct (%)	100	100	100	100	83	75	88	71	82
Incorrect (%)	0	0	0	0	17	25	12	29	18
P-Value	0.000	0.000	0.000	0.000	0.001	0.008	0.001	0.047	0.027

Above: Table 1: ABX Responses Separated per Order

As the orders are randomised for each question it is possible that some participants will be presented a greater number of lower orders. Table 1 breaks down the number of times each order was presented across all participants. For all attempts 6th order shows the greatest number of occurrences (24), with 9th order the lowest (11). Percentages are also given in Table 1 and visually presented in Figure 8 for a clearer contrast of 'success', here it is shown that 8th order was perceived the same as 10th order on more occasions (i.e. higher percentage incorrect) compared to other orders, including 9th.

Observing that 4th, 7th, and 8th order have identical number of attempts (17), a direct comparison of the percentage correct values show only 4th order to be determined 100% perceptually different to the 10th order reference. Perceptual similarities are shown to occur from 5th order and above against the 10th order reference, with a greater number of incorrect responses, however this trend isn't consistent.

For statistical validation the p-value is presented in the last row of Table 1. Whilst none of the orders exceed the 0.05 significance level determined for 50% forced choice response test method, the 8th order attempts come very close. From these preliminary results we are unable to statistically confirm that no difference between the 10th order reference and all lower orders were perceived (i.e., we accept that a difference can be determined).

Ideally an infinite order would be used as the reference, however pushing the maximum order within the limits of the system will hopefully reveal more about our spatial perception thresholds.

Conclusions

This article has researched the current techniques being used to binaurally render reverberant sound fields from Ambisonic signals. The techniques are either of limited order, render the spatial resolution required for the direct and reverberant sound field separately, or apply a left/right symmetry simplification. Whilst a reduction in computational load is achieved, they are not robust to the physical complexities of real rooms that impact on ideal diffusion or left/right variations from relative proximities between sound source and reflective surfaces.

A clear argument has been put forward in this paper to binaurally present sound fields with asymmetry using VHOA within the capabilities of the system. Application of this logic saw developments of the JS Ambisonics framework, which were then employed in the WHAM website to deliver horizontal only BRIRs to a current maximum of asymmetric 15th order.

Although the WHAM website was initially created to enable head-tracking without the need for dedicated head tracking peripherals, to allow our continued research into perceptual order thresholds, its development over the last year has opened the possibilities to this being a powerful auralisation tool.

Preliminary (10th order limit) ABX listening survey data taken from 11 responses, whilst not statistically valid, does indicate the platform reveals perceptual differences, especially at low orders, and therefore reinforces the need for continued research to compare against much higher orders.

Resources

- WHAM website: **https://brucewiggins.co.uk/WHAM/**
- Automated Sweep and Turntable Rotation Python ReaScript: **https://bitbucket.org/DrWig/wigware-reaper-scripts/src/master/WigET250-3D_Turntable.py**
- Forked JSAmbisonics supporting 15th Order 2D Ambisonics with Asymmetrical Filters: **https://github.com/DrWig/JSAmbisonics**

International Conference on Underwater Acoustics

ICUA2022 International Conference on Underwater Acoustics | Institute of Acoustics | acoustics.ac.uk THE UK ACOUSTICS NETWORK | ASA ACOUSTICAL SOCIETY OF AMERICA | Office of Naval Research Science & Technology

The IOA is holding the International Conference on Underwater Acoustics 2022, on 20-23 June 2022 at the Leonardo Royal Southampton Grand Harbour, West Quay Road, Southampton SO15 1AG. Following on from our ICUA2020 virtual conference, we are very much looking forward to holding an in-person conference this time.

The conference will comprise a series of oral sessions covering a broad spectrum of international underwater acoustic research. We have also planned these two plenary sessions:

- Philippe Blondel will be talking about remote sensing; and
- YT Lin will be talking about underwater propagation.

During the conference, Megan Ballard will receive her AB Wood Medal.

On the Monday evening there will be an Early Careers Group event where several companies working in underwater acoustics will be giving a series of short presentations. Conference papers are being submitted to POMA and the IOA to allow timely, editor-reviewed and open-access for delegates.

Social events

We are planning several social events for some informal and relaxed times. These include the conference dinner on the HMS Warrior in Portsmouth Dockyard, and tours around NOCS and ISVR, which provides a great opportunity to see their facilities and hear about some of their world-leading research.

The conference hotel is centrally located close to the main historic area of Southampton and many restaurants. The nearby ferry port offers regular sailings to the Isle of Wight.

We look forward to welcoming our friends and colleagues from all over the world.

https://icua2022.org/

Below: HMS Warrior in Portsmouth Dockyard, venue for the conference dinner

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BRANCH NEWS

Southern Branch

Christmas lecture

By Conor Tickner

The Southern Branch had the pleasure of welcoming Professor Paul White of the ISVR to deliver the Branch's Christmas lecture event, entitled: 'Wail in the Ocean', on 16 December 2021.

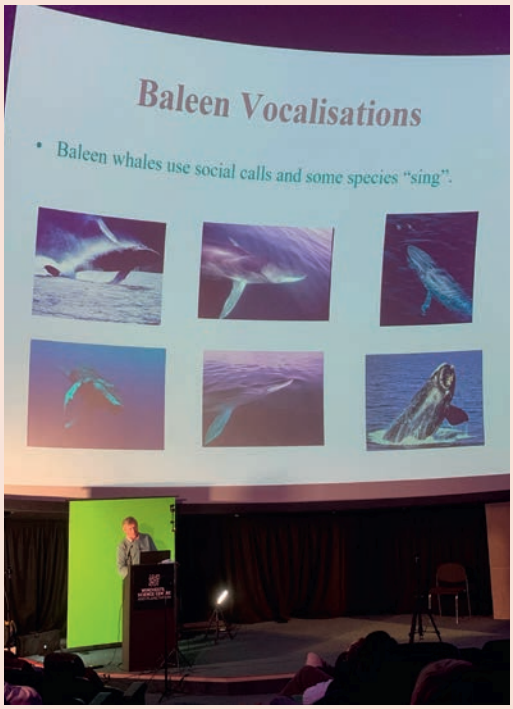
The event was held within the Planetarium at Winchester Science Centre, with members receiving full access before the talk to enjoy refreshments and explore the Centre's excellent Sound, Hearing and Vibration exhibition; inspired by the International Year of Sound 2021.

Professor White gave a wide exploration of the diversity of marine animals and their fascinating use of, and relationships with, various kinds of sounds in the ocean, from both natural and human sources. He also shed light on some of the potential impacts of humans on these animals, including the ways in which sound from human activities can affect these creatures in ways that are not immediately obvious.

Professor White identified many of the gaps in scientific knowledge around this topic, highlighting how relatively little is known in this area, describing some of the practical difficulties of studying these animals. Afterwards, the audience was treated to a 360° Planetarium show by the Centre's staff. The event was well attended by both Southern Branch members as well as a large audience from the wider public.

Professor White stepped in for Professor Tim Leighton, who could not be present due to health issues. The Southern Branch wants to give special thanks to Professor White for giving up his evening to share his research with us.

Below: Professor Paul White at the Southern Branch Christmas event at Winchester Science Centre



London Branch

IOA Diploma best final project course 2020-21 at London South Bank University, receives NTi-Audio award

By Dr Luis Gomez-Agustina

As it is becoming traditional now at the January London Branch meetings, some of the best IOA Diploma student final projects undertaken at the London South Bank University (LSBU), were presented by their authors.

In addition, the NTi Audio LSBU IOA Diploma Student Final Project award competition takes place during the January London Branch meeting. This award was set up in 2019 by LSBU Diploma Course Director, Dr Luis Gomez-Agustina, in collaboration with the sponsor of the award, acoustics instrumentation manufacturer, NTi Audio.

Due to the COVID-19 restrictions and recommended precautions, the 19 January 2022 London Branch meeting was held online via Zoom video conferencing. The three nominated finalists for the award presented their work undertaken at LSBU in the 2020-21 academic year.

James Gardner

James Gardner presented his final project report entitled '*Acoustic Quality and Comfort in Gymnasiums: A Case Study of Bob Prowse Health Club, Maidstone, UK*'. This research project discussed the current lack of standardisation in gym acoustic quality, and the relevant methods and criteria that could be used as part of an assessment.

Some of these methods were tested in a real-world and representative gym as part of a case study to assess their effectiveness. It was found that managing the ambient, occupied noise of the gym, was critical to ensure that occupational safe exposure action levels were not breached, particularly when the gym was busy.

Results showed that the ambient level was far in excess of any level required for effective speech transmission which is an

important consideration for practical and safe client/ personal trainer communication in the gym.

Toward the end of his talk, James provided a set of convincing recommendations and criteria levels that could be achieved from this representative case study.

Daniel Hare

Daniel Hare followed with the presentation of his work entitled *'The Acoustical Challenges of a Change of Room Purpose.'* His study investigated the hypothetical transformation of a public house into a recording studio incorporating live and control rooms.

The bulk of the project examined the acoustic challenges thrown up by such repurposing of a space. The study offered solutions to acoustical goals by presenting construction methods and materials for the shell and core of the building as well as looking at realistic means of acoustic control within rooms.

The work objectives and methods veered towards a more practical and affordable approach as opposed to the ideal methods presented in the literature, often not fully suitable for bespoke and unusual cases.

Daniel remarked that every studio build is unique and this is even more true when looking at changing the purpose of a room. He concluded by reflecting that there is no absolute standard when it comes to the design of a recording studio.

Gareth Hance

The last presentation was delivered by Gareth Hance introducing his work entitled *'C-Weighting Assessment for Environmental Low Frequency Control at Outdoor Concerts.'* He started off by acknowledging that low frequency noise pollution from outdoor concerts is a significant trigger for community complaints and, that the existing guidelines primarily specify consider noise limits criteria employing the A-weighted correction factors.

Gareth noted that although low frequency disturbance is also considered in the relevant guidance, a specific criterion is not offered. The associated supporting notes for an acceptable level in two low frequency octave bands are routinely applied out of context.

From this study and many other projects, Gareth commented that partly because of the lack of effective guidance on low frequency bands; compliance with the attached licensing conditions is rarely achievable and often simply ignored.

The practical part of the project aimed to investigate the benefits and limitations of using single figure C-weighted sound pressure level metric monitored at the source for effective low frequency nuisance control, and as an alternative to the current practice of tracking multiple parameters.

Extensive measurements were taken over three outdoor concerts in the same venue. The findings indicated that C-weighting assessment as the primary level parameter monitored at source provides several benefits over A-weighted alone. Presenting the front of the house (FOH) engineer with C-weighted overall levels (LC), facilitates assessment of A-weighted overall levels and low frequency noise in a single value.

LC tracking at FOH is fit for the purpose of providing useful information to the sound engineer for the simple binary criterion of compliant or not compliant with the PL conditions. Finally, Gareth offered a set of practical and compelling suggestions for consideration and valuable research ideas for further work.

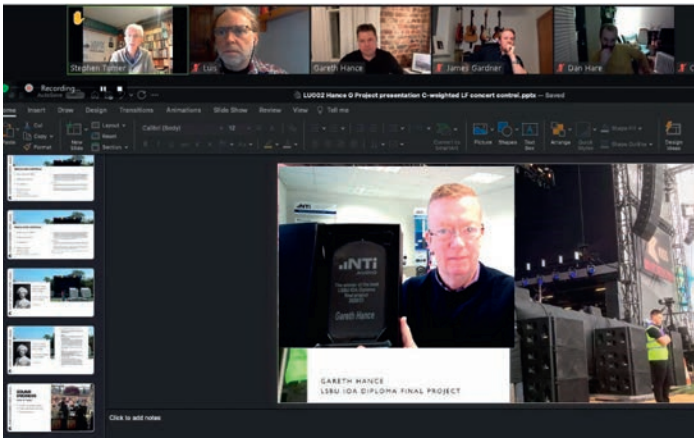
After the three presentations, Gareth, James and Daniel took a good number of questions from the interested online audience.

And the winner is...

Charles Greene, General Manager of NTi Audio UK and Luis, who hosted the event, presented the award trophy to the winner of the competition, **Gareth Hance**.

The IOA President, Stephen Turner and Luis congratulated Gareth and the other two finalist on the high standard of their projects.

Send your Branch reports for the next issue to editor, Nicky Rogers, at **nickyr@warnersgroup.co.uk** by 7 April 2022 latest please.



Above: The January London Branch meeting and awards

SPECIALIST GROUP NEWS

Senior Members' Group meeting – 3 February 2022

By Michael Sugiura

At a meeting open to all IOA members and non-members, Professor Trevor Cox gave an excellent presentation on work using scale modelling to assess the prehistoric acoustics of Stonehenge.

Trevor's talk covered the materials and methods to construct a 1/12 scale model of Stonehenge in an anechoic chamber, the measurement methods applied and the ensuing analysis.

Results were shown of reverberation and speech analysis, as well as the effects of discrete echoes, and the model was tested in different configurations.

Trevor discussed the modelling results and conclusions drawn.

In summary, with social rituals usually involving sound, an archaeological understanding of a site requires the acoustics to be assessed and this talk detailed how this can be done with acoustic scale models. Scale modelling is an established method in architectural acoustics, but it has not previously been applied to prehistoric monuments. The Stonehenge model described allows the acoustics in the late Neolithic and early Bronze Age to be quantified and the effects on musical sounds and speech to be inferred. It was found that the stone reflections create an average mid-frequency reverberation time of (0.64 ± 0.03) seconds and an amplification of (4.3 ± 0.9) dB for speech.

The model has a more accurate representation of the prehistoric geometry, giving a reverberation time that is significantly greater than that measured in the current ruin and a full-size concrete replica at Maryhill, USA. The amplification could have aided speech communication and the reverberation improved musical sounds. How Stonehenge was used is much debated, but these results show that sounds were improved within the circle compared to outside. Stonehenge had different configurations, especially in terms of the positions of the bluestones. However, this made inaudible changes to the acoustics, suggesting sound is unlikely to be the underlying motivation for the various designs.

The research is fully reported in the Journal of Archaeological Science and acknowledged contributors are Bruno M Fazenda, Applied Acoustics Group, University of Salford and Susan E Greaney of English Heritage.

The next Senior Members meeting will be held on 20th April 2022.

Above: Professor Trevor Cox with his scale model of Stonehenge

Deadlines for Branch news and Specialist Groups news

To help you plan your Branch news and Specialist Groups news reports for the magazine, here are the deadlines for all issues of Acoustics Bulletin for the rest of this year:

ISSUE	DEADLINE
May/June 2022 (published 9 May)	7 April 2022
July/August 2022 (published 7 July)	9 June 2022
September/October 2022 (published 7 September)	9 August 2022
November/December 2022 (published 7 November)	10 October 2022

Please send your reports and images (if any) to editor, Nicky Rogers at nickyr@warnersgroup.co.uk

NEWS

Susan Witterick named one of 2022's most inspiring female founders

Susan Witterick, founder of Manchester head-quartered acoustic consultancy, dBx Acoustics, has been named as one of the UK's most inspirational and dynamic female entrepreneurs by the f:Entrepreneur '#ialso100' campaign.

Susan, who started dBx Acoustics in 2013, is being profiled alongside 100 female entrepreneurs from across the country, as part of a campaign to celebrate the multi-achievements of women running businesses in the UK today. Now in its fifth year, the growing campaign attracted a record number of applications for this year's '#ialso100' line-up.

The *f*:Entrepreneur '#ialso100' sets out to showcase trailblazing female founders who lead businesses alongside a roster of other responsibilities, such as volunteering, mentoring and community support. Susan has been selected for her work around inclusivity and diversity, and for her efforts to destigmatise neurodiversity, she is an advocate for autism awareness and sits on the IOA equality, diversity and inclusivity committee.

Susan said: "It's important to me that nobody should feel excluded from a career because they don't feel like they fit the mold. I hope the success of dBx Acoustics will encourage others to create a workplace in which they can thrive."

To see the full line-up of the 100 women featured in this year's f:entrepreneur #ialso100 campaign visit **https://f-entrepreneur.com/ialso-100-2022/**

Biomedical acoustics

The biomedical acoustics (BA) network needs a reboot. therefore, the BA Special Interest Group (SIG) would like to arrange a meeting with SIG members to discuss the future of biomedical acoustics in UK, activities/events that we would like to organise and to find a way forward for BA-SIG.

Contact Professor Anna Barney (**ab3@soton.ac.uk**) or Dr Haydar Aygun (**aygunh@lsbu.ac.uk**) to find out more about the event.

Tracking mosquito species with large-scale acoustic data

To tackle diseases like malaria, yellow fever and dengue, researchers have been studying the distribution, diversity, and abundance of mosquitos

With more than 3,000 species, mosquitoes pose numerous risks to humans through disease and these are increasing with the threat of climate change.

The HumBug project, developing methods to identify different species of mosquitoes, used the acoustic signature of their flight tones. As captured on a smartphone, over five years' worth of research was released with the data of acoustic mosquito flight tones of 36 different species, in over 20 hours of audio recordings that the team labelled and tagged precisely.

The study used sound to categorise different species, generating unprecedented levels of necessary high quality, spatially accurate mosquito occurrence and abundance data without any risk to survey participants.

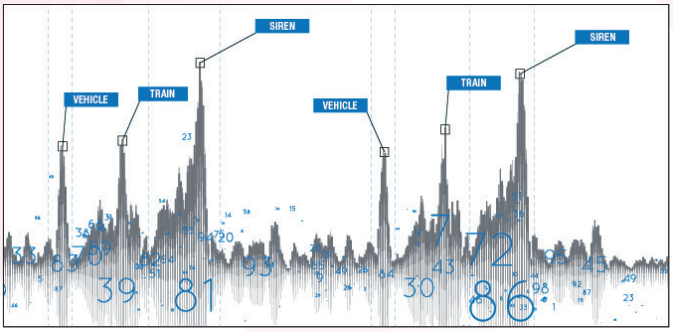
The Humbug system takes the recordings, with their location and time, and uploads them on the app to a server which detects the sounds of the mosquitos and thus, identifying their species.

Co-Principal Investigator, Professor Stephen Roberts, said: "Making our extensive dataset openly available will prove hugely beneficial to entomologists and mosquito domain experts. The scale of the data and associated algorithms is unique.

"We hope it will enable a better understanding of mosquito behaviour, distribution and help manage the threat they pose to humans."

This is the first large-scale multi-species dataset of acoustic recordings of mosquitoes tracked continuously in free flight.

NTi Audio introduces AI for noise classification



To help identify the cause of a noise level alarm, NoiseScout now provides a text description of the content of the wav files that are recorded during an alarm event. This is achieved using AI analysis and noise classification.

The text indicates what the possible cause of the alarm could have been and therefore, reduces the necessity to listen to the actual wav file.

Audio pattern matching

In NoiseScout, wav files of audio samples from intervals where levels were high, are compared to a library of classified sound samples with a pretrained audio event classifier that predicts audio events based on a dataset on the NTi Audio internal servers.

The functions of this classifier form the central part of this AI system. These functions use pattern matching to determine the closest matches between the current audio sample and the library. The result is then weighted according to the sound pressure levels within the wav file. Each pattern is assigned to predefined classes, and the class labels of the closest matches chosen.

A score value is assigned to each match. The score is a measure of the accuracy and precision of a best-match classification aggregated across the whole wav file. Scores are higher when there is less background noise. The text description and associated score are displayed when the score is greater than 20.

As this AI analysis and noise classification reduces the necessity to listen to the actual wav file (so saves time), the files remain available for a more in-depth analysis.

See the demo here **https://www.noisescout.com/demo1/**

ChovA's sound insulation solution

As the need for greater sound insulation in homes has become more important, especially since more workers are now home-based, acoustic insulation expert, ChovA has created a new range of systems to improve sound insulation levels between enclosures.

In order to guarantee a sound insulation system is up to the requirements of a refurbishment project, a number of essential conditions must be met: easy, reliable and flexible measurement and data analysis. To boost its capabilities in these areas, ChovA turned to Hottinger Brüel & Kjær (HBK) for the solutions, which would meet the latest regulations.

Following a consultation, HBK supplied ChovA with a full kit including, a class 1 Hand-held Analyzer Type 2270 for carrying out measurements that would comply with the latest standards. A Sound Calibrator Type 4231 for checking the calibration of the Type 2270 before every test, plus an OmniPower Sound Source and Power Amplifier. And a 1/3-octave graphic equalizer for ensuring the pink noise emission from the OmniPower had the flattest response possible in all the frequency bands in a free field.

The procedure that ChovA follows to launch a new system (which includes its products) leaves no room for uncertainty: starting from a specific sound insulation system, the company makes a series of measurements and then analyses the resulting data.

Read the full case study here: **https://www.bksv.com/en/customers/construction-consultants/chova**

HBK's spring webinars

HBK has launched its webinar training calendar for 2022, offering a range of topics from general acoustic, environmental and occupational noise to more specialised product training.

For acousticians seeking guidance on sound and impact insulation measurements that meet current standards, HBK will run building acoustics webinars, to cover this topic in March.

Users of HBK's B&K 2245 sound level meter can benefit from a series of webinars dedicated to helping them get the most from this tool. The sessions include Environmental Measurements with 2245 and Noise at Work Measurements with 2245.

ACQUA 5.0.100 provides great flexibility

ACQUA 5.0.100 is the first iteration of the new generation of the analysis software, ACQUA, from HEAD acoustics. The significantly reworked structure of ACQUA provides even greater flexibility for future applications than the previous version.

There are new features, most notably the 'Workplace Settings' – where the user can configure and define their local workplace, including HATS (head and torso simulator), microphones, loudspeakers or radio testers used. This intuitive structure provides greater clarity.

The analysis possibilities have been extended by the new loudness calculation according to Recommendation ITU-T P.700. The new psychoacoustic-based loudness calculation allows a more realistic calculation of the speech loudness perceived by the user. Even non-LTI systems such as AGC and compression schemes can be evaluated. This provides an analysis of all measures integrated by manufacturers targeting the increase of the subjectively perceived loudness without producing excessive sound pressure levels.

With ACQUA 5 the new perceptual based audio quality measure, MDAQS, is integrated in HEAD's analysis portfolio for the first time to provide unique audio quality evaluation for all types of audio equipment.

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Members are reminded that **ONLY** Sponsor Members are entitled to use the **Sponsor IOA logo** in their publications, whether paper or electronic (including web pages).

Committee meetings 2022

DAY	DATE	TIME	MEETING
Wednesday	**16 March**	**10.30**	**Council**
Tuesday	22 March	11.00	CPD Committee
Wednesday	6 April	10.30	Engineering
Thursday	7 April	10.30	Engineering
Thursday	21 April	1030	Meetings
Tuesday	3 May	10.30	CCWPNA Examiners
Tuesday	3 May	13.30	CCWPNA Committee
Thursday	5 May	11.00	Publications
Thursday	12 May	10.30	CCHAV Examiners
Thursday	12 May	13.30	CCHAV Committee
Thursday	19 May	10.30	Membership
Tuesday	24 May	10.30	Research Co-ordination (London)
Thursday	26 May	10.30	Executive
Wednesday	**15 June**	**10.30**	**Council**
Tuesday	21 June	10.30	ASBA (Edinburgh)
Tuesday	12 July	10.30	Distance Learning Tutors WG
Tuesday	12 July	13.30	Education
Wednesday	13 July	09.30	CCBAM
Wednesday	13 July	10.30	CCENM Examiners
Wednesday	13 July	13.30	CCENM Committee
Tuesday	26 July	10.30	Engineering
Wednesday	27 July	10.30	Engineering
Thursday	28 July	10.30	Meetings

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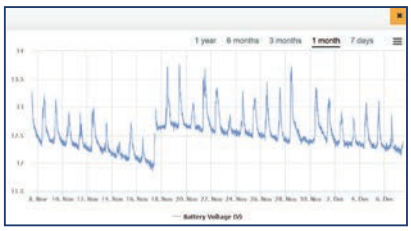

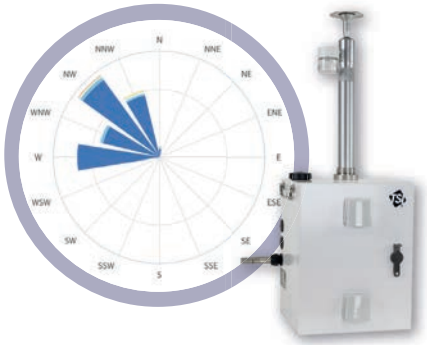

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