

Volume 50 No 2 March/April 2024

Introducing the new IOA Research
Member grade
Page 12

Archive section :
IOA in the 1980s
Page 38

Auditorium Acoustics provided
something for everyone
Page 52

Technical:
Sound insulation of suspended
ceilings: A finite element
method-based comparison of
suspension systems
Page 58

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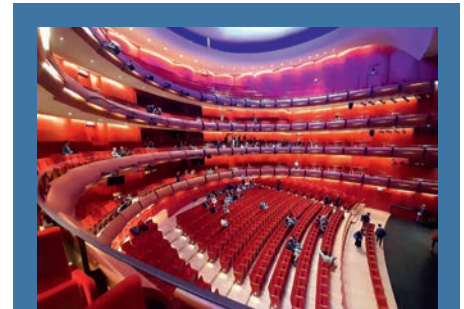
Acoustics Bulletin Volume 50 No 2 March/April 2024

Institute affairs

- 5 President's letter
- 6 Engineering Division
- 10 New members
- 12 Introducing the new IOA Research Member grade
- 14 IOA Education update
- 24 IOA Bursary Fund update
- 38 IOA 50th anniversary special feature
- 50 IOA consultations report

Features

- 18 STEM – Inspiring pre-university students
- 20 IOA Early Careers Group recent activity
- 22 IOA Student Representatives
- 26 Reproduced Sound 2023 report
- 36 Environmental Sound Group Winter meeting report
- 52 COVER STORY: Auditorium Acoustics 2023 report
- 58 Technical: Sound insulation of suspended ceilings: A finite element method-based comparison of suspension systems



Cover image: Hosted by the IOA in collaboration with the Hellenic Institute of Acoustics in Greece, the 11th International Conference on Auditorium Acoustics was held at the Stavros Niarchos Foundation Cultural Center in Athens on 28-30 September, 2023. Read the full report on page 52.

Regular

- 8 2023 events
- 46 Research: Aeroacoustics of propellers on novel electric propulsive configurations for urban air mobility vehicles
- 67 IOA Branch news
- 70 Institute diary

Technical articles review procedure

All technical contributions are reviewed by an expert identified by the IOA 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

In my last letter I took the opportunity to wish you all a happy new year. However, for our Asian colleagues and members, every year the holiday (also known as the Spring Festival) begins on the second new moon after the winter solstice, this year on Saturday, 10 February. As I write this, the celebrations are just starting, so once again at the start of my letter, I'll take the opportunity to wish all our East and South East Asian colleagues and members a happy new year! This is the start of the year of the dragon, a year of luck, strength, ambition, and charm – so definitely a year to look forward to!

Housing policy and political engagement

We are in a general election year and it is clear that policies to address the housing crisis will figure high up the agenda of all party manifestos. This being the case, it has been very useful to attend a couple of the All Party Parliamentary Group (APPG) meetings related to this issue. Extending our sphere of influence in relation to government policy is an important priority in our Strategic Plan, and such meetings provide us with opportunities to emphasise the importance of considering noise impacts on health and wellbeing in relation to policy decisions on housing design standards and planning development.

The first was the APPG 'for healthy homes and buildings' and was entitled *A manifesto for a healthier Britain*. This session had the aim of calling on politicians and policy-makers of all parties to commit to positive policy change to tackle the huge problem of unhealthy homes and buildings across the UK. Their *Healthy Homes Healthy Britain* campaign and *Healthy Homes Manifesto* are about embedding the right to live in healthy homes, recognising that there is an inextricable and undeniable link between our homes and our health and wellbeing.

We also attended a joint North West Parliamentary Forum and Debate: *Unlocking great homes and places, keys to investment, innovation, inclusive growth – What will fix the housing crises in our cities, towns, and region?* This was the first time, the Liverpool City Region APPG and Greater Manchester Westminster Group joined together with Greater Manchester Housing Providers and Liverpool City Region Housing Providers, to highlight the common barriers to housing and the problems being created. I was grateful for the help of James Healey, Chair of our Building Acoustics Group, for participating in this major session on behalf of the IOA.



Did you know?

As Past Presidents, Chris Rice, and Geoff Leventhall, continue with our 50th anniversary reflections, I thought I would look back and provide some random, non-acoustics context to what else was going on in the year we were formed. So here goes: A three-day week was introduced to conserve electricity; petrol was 11.8 p/litre; BBC2 showed the first early morning Open University programming; ABBA won the Eurovision Song Contest in Brighton with the song 'Waterloo'; Five all-male Oxford University Colleges admitted women undergraduates for the first time; McDonald's opened its first UK restaurant in Woolwich; the final episode of *Monty Python's Flying Circus*, 'Party Political Broadcast', was broadcast; and the Mr Men TV series was first broadcast – but we had to wait until series two in 1977 for Mr Noisy!

Warm regards,



Alistair Somerville, IOA President

Engineering Division



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.

By Blane Judd BEng FCGI CEng FIET FCIBSE, Engineering Manager

This is a special year for the IOA, and I am sure you will be reading a lot about the 50-year celebrations.

We are also very pleased to see that one of our successful CEng applicants has been featured on the Engineering Council website. Harout Taghilian initially went through IEng with the IOA, and I recall him approaching us back in 2017. He came back in and gained CEng in 2023.

It is always great to see someone progress in their career and gain the recognition along the way. If you want to find out more about Harout, his story can be accessed here: <http://tinyurl.com/CEngHarout>

Assessors

The training of new assessors is going well but we can never have enough, so if you want the chance to be part of the progression of other engineers, please let us know. If you have experience in a specialist area of acoustics, we'd love to hear from you so that we can broaden our offering to new candidates. Being an interviewer is a great CPD activity and it's good to know you are supporting engineers of the future.

Professional review reports

The redacted version of a good professional review report is helping people to put a good first draft forward. We have also had some interviewers personally mentor candidates who have been struggling to get their professional review report in a good shape.




Above:
Harout Taghilian

Below:
We are now interviewing using the Engineering Council UK SPEC version 4

The better you demonstrate the competencies the more likely you are to get to interview quickly. We still get a few candidates who, once they have paid their invoice, ask what the next steps are. These are all clearly laid out in the guidance so please take the time to study it as it will tell you what documents are needed, and which items need to be endorsed by your sponsors. It also explains what to do if you cannot find IOA members to act as your sponsors.

We are always ready to comment on the content of your professional review report prior to submitting the final draft. We are grateful to



the volunteers who take the time to comment on submissions and give feedback to candidates. We will always comment on submissions and ask for re-drafted versions, but to avoid an iterative process; try to include evidence that shows you have the underpinning knowledge related to the projects you have submitted. For example, if you have selected a particular software to conduct modelling, explain why you chose it, what the shortfalls are, what results you were expecting and how you validated the outputs. These are all part of the A and B competencies and will save you having to do several rewrites.



The UK Standard for Professional Engineering Competence and Commitment (UK-SPEC)

Fourth edition

Published August 2020

Emma Lilliman is working hard to encourage those who have paid their invoice and then stalled to get going again. There is no time limit but the sooner you start the sooner you can take advantage of being professionally registered. We have seen candidates progress in their careers as a result.

Neil Ferguson still helps 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 Engineering Council website <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 the article).

Interviews

We hold several interview events through the year, depending on the number of candidates we have coming forward for registration. Our set in February have already taken place so we will be looking for applicants to sit their interviews in June. If you are interested in taking the next step to becoming a professionally registered engineer, contact 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 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 above).

The **individual assessment** route, for applicants who do not have the

Recognised qualifications

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.

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 self-directed learning. In many instances, it is likely to be a combination of some or all these options.

Remember 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.

The Institute recognises the IOA Diploma course and the several Master's courses linked to it as providing evidence if you are looking to gain CEng registration.

You could also offer a PhD qualification, depending upon the content of the associated taught element. We can also offer support for registration via a 'technical report' route, if you do not have the relevant qualifications to help 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 and provide the essential peer review process that affirms that you are at the appropriate level for recognition as an Engineering Council Registered Professional Engineer. 🗳️

Our video explains how members can gain professional recognition and Engineering Council registration through the IOA. <https://www.ioa.org.uk/video/recognising-your-professionalism-0>

IOA EVENTS FOR 2024

Organised by the Early Careers Group
Supported by UKAN+
THE ART OF BEING A CONSULTANT
21 March 2024
National Oceanography Centre, Southampton

Organised by the Early Careers Group
Supported by UKAN+
THE ART OF BEING AN ACOUSTICIAN
22 March 2024
National Oceanography Centre, Southampton

Organised by London Branch
Supported by UKAN+
ARTIFICIAL INTELLIGENCE FOR ACOUSTICS
22 May 2024
London South Bank University, London

Organised by the Underwater Acoustics Group
ICUA2024
International Conference on Underwater Acoustics
17-20 June 2024
University of Bath
(See below for more details of this event)

ACOUSTICS 2024 - 50TH ANNIVERSARY CONFERENCE
12-13 September 2024
Manchester Metropolitan University

Organised by the Electroacoustics Group
REPRODUCED SOUND 2024 – 40TH ANNIVERSARY
12-14 November 2024
The Bristol Hotel, Bristol

OTHER EVENTS

ICSV24
22-23 April
Boston, USA

IPGRC CONFERENCE
28-30 May 2024
University of Salford
<https://hub.salford.ac.uk/ipgrc-conference/>

NOISE-CON
10-12 June
USA

INTERNOISE
25-29 August
Nantes, France

PERCEPTION INFLUENCED DESIGN FOR AIRCRAFT NOISE WORKSHOP
8 September
Manchester

QUIET DRONES
9-11 September
Manchester

ISO WORKING GROUPS AND PLENARY MEETINGS
21-25 October
Berlin, Germany

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

International Conference in Underwater Acoustics

The Institute of Acoustics is holding the International Conference in Underwater Acoustics (ICUA2024) from **17-20 June 2024** at the University of Bath.

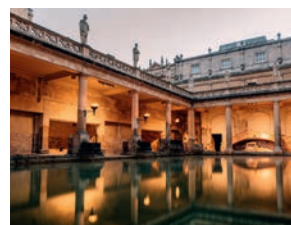
The University of Bath is at the forefront of international research in many fields including underwater acoustics.

The conference will take place in the Chancellors' Building on the University's main campus, Claverton Down.

The conference will have a series of oral sessions covering a broad spectrum of international underwater acoustic research, and will also include environmental acoustics, platform acoustics, acoustic



Above: Brunel's SS Great Britain (image courtesy of Brunel's SS Great Britain)



Above: Roman baths (image courtesy of Visit West)

propagation, sonar systems, and signal processing.

There will be two keynote speakers and the A B Wood Medal Lectures.

Conference social events include:

- Welcome reception
- Early Careers event
- SS Great Britain. A visit to the historic SS Great Britain in Bristol
- Reception and Conference Dinner at the Roman Baths and Pump Room.

<https://icua2024.org/>



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Approved Membership Applications

The Membership Committee reviewed 63 application forms on 18 January 2024 at their first Committee meeting of the year, held at IOA HQ in Milton Keynes. 16 corporate applications have recently been approved by the Council following the recommendations of the Membership Committee. The Committee saw 40 new candidates joining the IOA, 17 of whom had completed the IOA diploma. The remaining applications came from members upgrading.

MIOA

Aaron Andrews	Lewis Kelter
Nick Bruce	Andrew Knight
Gemma Clark	Conor McLean
Conor Gorman	Kane Mitchell
Sean Graham	Evangelos Ntotsios
Leo Hawkins	Nathan Parker
Elliot Hurst	Monica Saralertsophon
Chris Jordan	Ilaria Chiara Sartori

TechIOA

Philip Campbell	Donogh Casey
-----------------	--------------

Affiliate

Hiba Aijaz	Holly McCarthy
Maria Fedyszyn	Phoebe Pearce
Daisy Flatters	Joe Skilbeck-Dunn
Kosmina Koumi	Benjamin Briggs

AMIOA

Rebecca Anderson	Rhiannon Hawkins
Nicolas Assiotis	Joshua Humphris
Matthew Baines	Thomas Jebson
Adam Baylis	Harry Johnson
Gus Campbell	Ruan Joubert
Harry Coles	Serena Joynes
Lucy Connor	Daniel Lilley
Gunes Dincer	Alex Lovell
Donel Dippi	Georgina Mackworth
Wayne Eastwood	Tanya Mileusnic
Hugo Evans	Morgan Quarless-Oates
Christopher Fisk	Megan Samuel
Feargus Flanagan	Joseph Twentyman
Emily Forster	Vivek Vasudevan
Iain Gregory	Nilgyul Yozgyur
Vinusree Gurusamy Vivekanandan	



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- Regulation and Assessment of Noise
- Environmental Noise: Measurement, Prediction & Control
- Noise and Vibration Control Engineering

Established for more than 50 years, the Institute provides graduates and those with a proven interest in acoustics, the chance to become a recognised member of a vibrant and active global network with regular UK meetings and CPD. The Diploma is taught to candidates in centres across the UK and via distance learning tutorials, also facilitating candidates abroad – find out more at: www.ioa.org.uk/education-training

FOR MORE INFORMATION:
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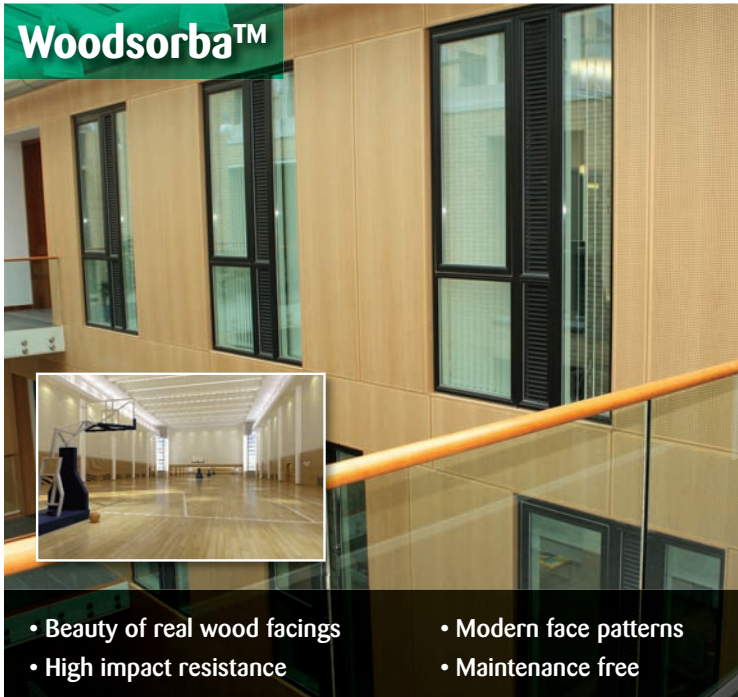
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Introducing the new IOA Research Member grade

Looking back at the Acoustics Bulletin articles covering the history of the IOA it becomes obvious that when the Institute was formed there was interest mainly from manufacturers, consultants, environment health officers and academics. In recent years, the IOA has focused more on industry and consultancy.

By Professor Stephen Dance

In 2014, the Research Coordination Committee under Professor Horoshenkov created the UK Acoustics Network (UKAN) to provide a forum to link industry with academia.

In 2017, this led to a successful Engineering and Physical Sciences Research Council (EPSRC) grant bid which was followed by more success in 2021 with UKAN+. UKAN now has 1,800 members split 50/50 between academia and industry, approximately half are also members of the IOA. Currently, UKAN membership is free for all and you can apply at www.acoustics.ac.uk The long-term plan is for UKAN and the IOA to develop a forum for everyone with an interest in acoustics-related science.

In 2022, again thanks to the work of the Research Coordination Committee, the idea arose of creating a new membership grade, which would be attractive to potential members who were early in their academic career. This would provide a new pathway between

Student and Associate Membership that would allow in time full corporate status. This idea was formally put forward at the IOA AGM in August 2022.

In 2023, the Membership Committee created a simplified application form which covered all non-taught students i.e. MRes, MPhil, PhD and EngD programmes for students in a field directly associated with acoustics. As with the Associate Membership status, a five year limit was deemed to be appropriate. This prohibits part-time PhD or EngD students but of course their main job could be in acoustics and hence AMIOA or MIOA would still be open to them. Hence, it was decided to recommend to Council that the Research Member grade should be a specific subset of the Associate Membership grade. The key difference being that all communication will be by electronic means, to be more sustainable, as well as to lower operational costs, thus allowing the fee to be significantly reduced compared to that of those with AMIOA status.


Above:
UKAN members at the recent UKAN annual conference at the University of Sheffield

Apply now

The application form is now live, and the applications are being reviewed by the Membership Committee. It is hoped that with the right promotion (e.g. at *Art of Being a Consultant* and *Art of Being an Acoustician* meetings, the support of the Early Careers group, as well as through UKAN) this new grade will, in time, provide a new revenue stream to the IOA, but more importantly create a conduit where once again industry and academia are working together to benefit the acoustics community.

To apply you just need a thesis title, a proposer, and an academic email address.

The benefits of being a Research Member

- membership certificate (electronic copy);
- membership number;
- reduced fee (currently set at £30);
- attend at meetings/conference at the student fee price;
- free access to Acoustic Bulletins (PDF);
- free access to I-NCSE Journal – Noise Control Engineering Journal;
- free access to Acta Acustica / Acustica Journal;
- free access to I-NCSE Proceedings (1972 onwards); and
- all the other benefits an AMIOA member would receive. 

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IOA Education and Training news

The Institute offers a range of professionally recognised courses for those interested working in any aspect of acoustics.

By Helen Davies, IOA Education Officer

Information on accredited centres and the IOA certificate courses they are delivering in 2024 is available on the IOA Training webpage at <https://www.ioa.org.uk/education-training> Please contact your preferred centre directly for information on course dates, delivery methods, course fees and to register for the course. For any other enquiries contact education@ioa.org.uk

IOA Certificate courses 2024

Typically certificate courses run once in the Spring and again in the Autumn, with a practical assessment and a written examination on the final day. Some centres may only run one delivery per year and offer a slightly different format.

Also, subject to acceptance of the arrangements by appropriate management committees, and a sufficient number of candidates, certificate centres may be able to

deliver bespoke courses on site, on request.

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

Subject to recruitment, the IOA will be offering the following Certificate courses in 2024:

Certificate of Competence in Workplace Noise Risk Assessment (CCWNRA):

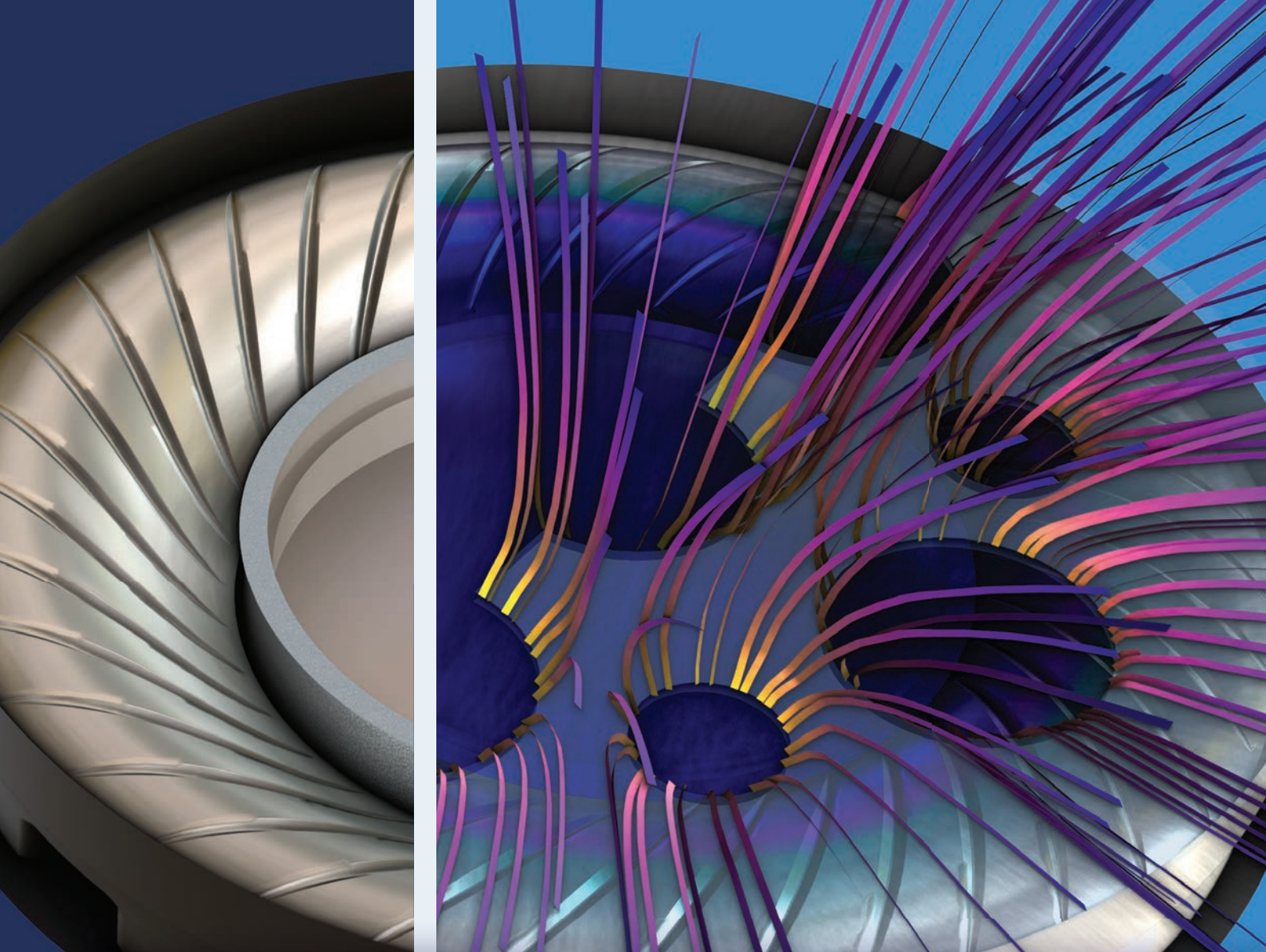
This five day course aims to provide the education and training needed to carry out workplace noise assessments in a competent manner, as required by the Control of Noise at Work Regulations 2005. Demand for competent

noise exposure assessments is increasing and this course provides those registering with the latest information and training to meet the demands of the legislation. It is designed to provide a background of basic acoustics combined with 'hands on' practical experience of industrial noise measurements and associated assessment of workplace noise exposure.

Centres: *Blue Tree Acoustics, (Sheffield), KP Acoustics Research Labs (Southampton), Moloney and Associates (ROI), Make UK (Birmingham), Shorcontrol Safety Ltd (ROI), University of Derby.*

Examination dates: **8 March and 27 September.** P16





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Advanced Certificate Course in Report Evaluation (ACCRES):

This 2.5 day course will provide the more experienced practitioner with the knowledge and skills to critique the technical written work of others effectively. It will help to build the skillset for those in (or moving up to) supervisory roles to check and sign off on reports prepared by others and will also help regulatory officers to know what to look for in a technical report which they may receive. The course involves two days of learning and an assessment on the morning of the third day.

Centre: KP Acoustics Research Labs (Southampton).

Examination date:

Summer date to be confirmed.

Certificate of Competence in Building Acoustics Measurement (CCBAM):

This five day course provides a basic knowledge of the methodology for measuring and reporting sound insulation and aspects of room acoustics, together with relevant provisions of key standards and guidance.

Centre: KP Acoustics Research Labs (Southampton).

Examination dates:

19 April and 1 November.

Certificate of Competence in Irish Building Acoustics Measurement (CCIBAM):

The aim of the five day CCIBAM course is to give the necessary training for candidates to carry out and report on sound insulation tests on walls and floors, in accordance with relevant standards and regulatory instruments **in the Republic of Ireland.**

For more information contact info@soundtestingireland.com

Examination date:

12 April.

Certificate Course in the Management of Occupational Exposure to Hand Arm Vibration (CCMOEHAV):

This five day course seeks to enable course delegates to appreciate the nature of hand-arm vibration hazards in the workplace and the need to protect employees from hand-arm vibration syndrome and to advise and assist employers to meet their legal duties under relevant health and safety law, in accordance with current guidance from the Health and Safety Executive.

Centre: Institute of Naval Medicine (Gosport).

Examination date:

19 April.

Certificate of Competence in Environmental Noise Measurement (CCENM):

This five day course seeks to provide delegates with a basic knowledge of the methodology of environmental noise measurement, including the use and accuracy requirements of sound level meters and analysers and to enable them be aware of the significance of measurement data against the framework of standards and legislation for environmental noise.

Centres: Acoustic Associates (Peterborough), Bel Noise Courses (Scotland), Blue Tree Acoustics, (Sheffield), Colchester Institute, KP Acoustics Research Labs (Southampton), London South Bank University, Moloney and Associates (ROI), Shorcontrol Safety Ltd (ROI), Ulster Environmental (NI), University of Derby, University of Liverpool.

Examination dates:

17 May and 4 October.

Certificate of Proficiency in Anti-Social Behaviour (Scotland) Act 2004 – Noise Measurements (CPASBA):

The three day ASBA course is approved by the Royal Environmental Health Institute of Scotland (REHIS) and the Institute of Acoustics and relates to the implementation of the noise provisions of the Anti-Social Behaviour Act in Scotland. It is designed to enable successful candidates to make and report the required noise measurements in a competent manner.


Centre: Bel Noise Courses (Scotland).

Examination date:

For more information contact Bel Noise Courses.

IOA Diploma 2024-25

Enquiries and expressions of interest in studying the Diploma at an accredited centre or via tutored distance learning for academic year 2024-25 are welcome. Application and registration forms for distance learning will be made available in April 2024.

Accredited centres will include London South Bank University (LSBU), the University of Derby and KP Acoustics Research Labs, who will offer the Diploma in Southampton and Manchester (Salford University). 

Please refer to the accredited centres list on the IOA website Diploma page (<https://www.ioa.org.uk/diploma-acoustics-and-noise-control>) for contact details of your preferred centre and enquire directly for more information on course dates, delivery and course fees.

For tutored distance learning, please direct enquiries to education@ioa.org.uk until the 2024-25 application link opens on the IOA website education and training page in April 2024.

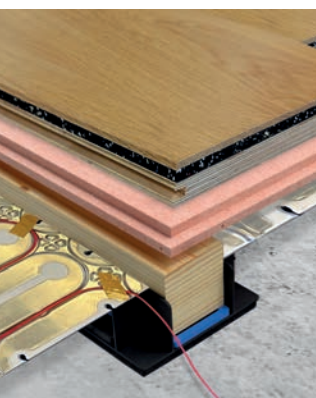


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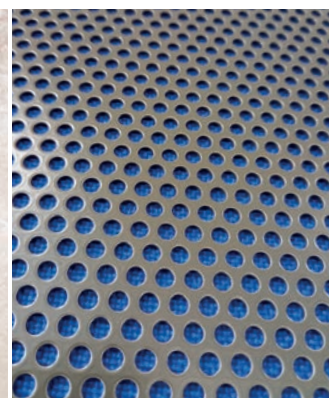
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Inspiring pre-university students

In this article Simon Perry (Sigicom) reports on IOA STEM's very well received activity at the recent College of Richard Collyer sixth form careers fair.



Vicky Wills (AtkinsRéalis) and I attended the Collyer's career fair in Horsham to represent the IOA; this was the second year that representatives of the IOA attended. The IOA was unique at this event representing an industry rather than a specific firm, but our attendance was important to raise awareness of the career choices available through studying acoustics. Past experience of similar events had highlighted the narrow range of career options often presented to STEM students (typically mechanical or chemical engineering).

The IOA provided early careers material and videos along with 'the Wheel of Acoustics' which visually demonstrated the broad range of career paths available.

Above left: Mother and daughter confused by confusophones

Above right: Simon and Vicky man the stand

Engagement and feedback from the Collyer's students was very encouraging; helped by the great write up we got in the promotional email sent by the college. There was a lot of positive interaction and interest in the field but perhaps more importantly, a lot of students went away understanding that their options are far broader than they had previously imagined. The interest ranged from the automotive engineering cross-overs through to musical acoustics. Excitingly, we also got to catch up with past winners of the IOA's Secondary School competition from St Oscar Romero School, who now attend Collyer's for sixth form studies. It was fantastic to

see the enthusiasm for acoustics that the competition had sparked in them.

Raising the profile of acoustics

The overall response we received at this event was highly positive but, unsurprisingly, very few students were aware of acoustics as a discipline. For acoustics to compete in the very competitive jobs market, it is important that we attend these events to raise the profile of our industry with the students who could be our future acousticians. In addition, we should further invest in materials and outreach programmes to engage with pre-university students and continue to look at apprenticeship programmes. 🗣️

If you have attended similar events or are interested in doing so, please reach out to the IOA STEM committee at stem@ioa.org.uk

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IOA Early Careers Group recent activity: CPD and why it matters

The Early Careers Group (ECG) aims to bring together a diverse network of acoustic professionals in the early stages of their career and at the December 2023 meeting, Rachel Canham (member of the IOA CPD Committee) gave an informative presentation on the philosophy of the IOA continued professional development.

By Aaron Tomlinson, member of the IOA Early Careers Group

The takeaways were plentiful, however there are some stand out aspects which could help those planning to apply for membership, or are looking to upgrade their membership.

Applying for membership is simple but there is a process to follow. Broadly, the steps will involve demonstrating your qualifications, experience, and continued professional development.

Depending on your current status, you may qualify for one or more different types of membership, whether this be corporate (Fellow, Member) or non-corporate (Associate, Research, Student, and Technical). Examples of the corporate memberships include:

- Fellow (FIOA) – Minimum seven years' experience and have made significant contributions to the field of acoustics (must also meet the requirements for Member); and
 - Member (MIOA) – Either suitably qualified in acoustics and with a minimum of three years' experience or can demonstrate equivalent knowledge of acoustics and have a minimum of seven years' experience
- The CPD aspect is not only

necessary but an important part of your career. Not only that, but once you become a member of the IOA, you must continually update your professional skills i.e. you must undertake CPD. The requirement is to undertake a minimum of 20 hours per year on professional development.

CPD could be anything from:

- relevant training courses (in house or external);
- work-based learning;
- distance learning programmes;
- self-directed private study including reading Acoustics Bulletin;
- preparation and delivery of papers, lectures, and presentations;
- attendance at relevant meetings (e.g. IOA Branch meetings), lectures, seminars, and conferences – including this one!
- relevant voluntary work – e.g. STEM ambassadors, sitting on an IOA or ANC committee; and
- reviewing technical publications, relevant standards, and guidance documents.

But it also may not be specifically about acoustics, as long as it's related to your job, e.g. keeping up to date with health and safety requirements, and regulations.

Examples are also given on the IOA website: <https://www.ioa.org.uk/professional-development-scheme>

In her presentation, Rachel explained how the real intent around CPD is to achieve goals, or at least to always be working towards something. Some goals may take years; such as obtaining professional registration (CEng, IEng), whereas others may be simple in their time-frame. However you set your goals, it's important to make sure they are SMART (sensible, measurable, attainable, realistic, and timed). The IOA CPD spreadsheet template (see previous link) is a great way to organise your goals and track your progress towards them.

You should habitually track your time spent on CPD. Even if you don't currently have any specific goals, you must still demonstrate that you are developing.

The IOA annually reviews 10% of all members' CPD records.

Some of the important questions and answers from Rachel's talk include:

• **Seeking upgrades to membership whilst abroad?**

The process is the same as within the UK. You will still need to have two proposers/sponsors as part of your membership upgrade.

- **In regards to FIOA applications, what constitutes a significant contribution to the field of acoustics?**

It entirely depends on the contribution and this will be decided by the committee themselves.

- **Can weekly CPD meetings within a company, whether you're attending in real time or catching up count?**

Yes, if it is relevant to CPD meetings certainly can be included within your CPD records.

- **Do you need a certificate to demonstrate CPD?**

No. Certificates can be useful for other professional institutes though, hence why they are provided by some events.

- **If your goals change before you are upgrading your membership, how does this affect your CPD records?**

CPD plans are not set in stone, and you have the agency to review and update it as you wish. If your goals change before you have completed your previous goals, this is fine, but you may wish to simply amend the goals text to say this.

- **Does the 20 hours relate to specific membership types?**

Yes, all. Except for the TechIOA membership, for which concessions may be made for non-acoustics related CPD.

Any queries can be forwarded to the IOA, whose volunteers will endeavour to answer. You are encouraged to read the IOA website via the links provided first, but in doubt, please email membership@ioa.org.uk

Upcoming ECG events:

By Josie Nixon

- Becoming an Expert Witness (hybrid), 20 March 2024 (jointly hosted with Central Branch)
- The Art of Being a Consultant, 21 March 2024
- The Art of Being an Acoustician, 22 March 2024

The two-day 'Art of Being...' conference is being held at the National Oceanography Centre in Southampton this year, jointly organised by the IOA ECG and UKAN+ SIG.

The Art of Being a Consultant

(AOBAC) is aimed at future acousticians looking to join, or who have recently joined the acoustic consultancy world. The day will explore what being an acoustic consultant is, how to do the job and the rules around consultancy. It has been 20 years since the first AOBAC day was launched!! Come and see what all the fuss is about.

The Art of Being an Acoustician

(AOBAA) is aimed at acousticians remaining in acoustics academic, research, and policy making. This is the second year the AOBAA has run and is a great addition to AOBAC. The day is also beneficial to consultants as it looks at how the different parts of acoustics interconnect.

If you register to attend the Art of Being a Consultant you can attend the Art of Being an Acoustician for FREE on Friday 22 March.

The ECG is open to all members of the Institute (both corporate and non-corporate) who shall normally be under 35 years of age or within the 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>

If you would like to present a webinar, or have a topic suggestion please get in touch directly with us: earlycareers@ioa.org.uk

Register for all events on the IOA website: <https://www.ioa.org.uk/events> and make sure you have also registered as an ECG to find out about all our upcoming webinars and events.

IOA Early Career's Award for Innovation in Acoustics

By Diogo Pereira

The IOA Early Career's Award for Innovation in Acoustics is sponsored by Cirrus and awarded every year. It is designed to recognise excellence and achievement within acoustics among those who are aged under 35 or early on in their careers in industry. It departs from the usual format in that it is also intended to increase awareness of the value of acoustic engineering and technology to the community at large. It is available for backgrounds such as research, public service, or private consultancy. The award has recently changed its name from 'Young Person's Award' to 'Early Career's Award' and is now also awarded annually to reflect a more inclusive and up to date approach for our ECG members.

The deadline for nominations for 2025 is 30 October 2024.

The application form can be downloaded directly at <https://www.ioa.org.uk/about-us/awards> or by accessing the awards page at (<https://www.ioa.org.uk/about-us/awards>) and clicking the link on 'The IOA Early Career's Award for Innovation in Acoustical Engineering (sponsored by Cirrus)' section. A proposer is required for the award and two candidate referees should be included. ☺

IOA Student Representatives

The IOA Student Representative group is a new Sub-Committee dedicated to encouraging greater engagement between university students and the wider UK acoustics community.

By Alec Korchev

The group currently has student members from across the country, but we are looking to expand further with new members. The programme is open to any university student studying acoustics, or in an acoustics-related field, who is keen to represent their cohort and have their voices heard at the IOA.

We are currently organising a trip to the IOA headquarters for our next meeting, to learn how the IOA operates and to meet with the various people who manage the many engagements of the Institute, including IOA President, Alistair Somerville and IOA President Elect, David Waddington.

The Student Representative Sub-Committee is currently chaired by Alec Korchev, who is the ECG committee member for the Research Coordination Committee (RCC). Alec is ideally placed as he is undertaking his PhD part-time while working as an acoustic consultant.

Meet our longest serving Student Rep:

Ellen Crockett joined the Student Representative Sub-Committee when it was launched in 2022 under Tomasz Galikowski, the previous ECG Chair. Ellen has attended the meetings, promoted the IOA and feeding back suggested comments from students on how the IOA might improve. She has been a fantastic asset to the Student Representative Sub-Committee.

Ellen is currently an assistant engineer at Sandy Brown while completing her BEng acoustical and audio engineering degree at



Salford University. She first became interested in acoustics through her performance experiences for the City of Birmingham Symphony Orchestra Youth Chorus, performing in many top venues such as Symphony Hall, Bridgewater Hall, and the Royal Albert Hall. This inspired an interest in concert hall acoustics and subsequently architectural, and environmental acoustics.

She joined the IOA in her first year and attended the Art of Being a Consultant online series in 2021.

Above:
IOA Student Rep.
Ellen Crockett

At the end of 2022 she then became part of the first cohort of Student Representatives for the IOA to try and encourage students to get involved with the opportunities available to them.

Ellen is currently in her final year of her degree and her final year project is on 'Improving the acoustic performances of Greek and Roman theatres through acoustic modelling software'. After graduation Ellen will be continuing with Sandy Brown as an Engineer. 🎧

Get in touch

If you are interested in participating, wish to join the Sub-Committee or simply want more information, please contact Josie Nixon or Alec Korchev at earlycareers@ioa.org.uk

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IOA Bursary Fund update

In this issue, the Bursary Fund update includes the experiences of two applicants who have obtained funding for different activities related to acoustics. The first one is Vladimiras Malyskinas, who travelled to Greece for the Auditorium Acoustics conference. The second is Bala Sarma, who has started studying the IOA diploma and gained employment in an acoustic consultancy.

By Reena Mahtani, Chair of the IOA Bursary Fund

As Chair I find it encouraging to see young people benefiting from funding to be able to enter the industry and contribute to it.

If you know of someone who could do with funding for acoustic related activities (attending a conference, studying, or even starting a STEM project), please remind them to apply! All the details and the application form are readily available on the IOA website at <https://www.ioa.org.uk/can-we-help/bursary-fund-application-form>

Vladimiras Malyskinas

We first met Vladimiras in the September/October 2023 issue of Acoustics Bulletin, where he wrote about how he applied to the IOA Bursary Fund to help fund some of his learning. He is studying a BSc in music technology at Coventry University and used his bursary to attend Auditorium Acoustics conference in Greece. This is his report:

“Thanks to the IOA bursary, I was able to attend the 11th International Conference on Auditorium Acoustics. The conference took place at the SNFCC in Athens, Greece – a stunning cultural space and I was very excited to learn that the architect, and the Arup team behind this space were present and open to discussions about the space.

“As a final-year student, it was thrilling to attend this conference. Everyone was friendly and open

to questions, and although the first moments there were scary, I was greeted by one of the members of the organising committee, Anne Minors, who introduced me to other delegates and thanks to that, I was quickly able to find company.

“This was my first professional conference and the organising committee created an outstanding experience; the presentations were all very interesting with topics ranging from very scientific and research-based to reports of acoustic work processes that groups have accomplished when building (or renovating) auditoriums recognised across the globe. As I came to the conference to learn more about acoustic simulation software and its advancements, I was pleased to find several

like-minded professionals who presented their works on this topic. After listening to their presentations and having further informal discussions, I was happy to have learned about new tools I hadn’t had the opportunity to use before.

“The poster sessions involved very interesting works, such as acoustic measurements and analysis of ancient Greek theatres and even disapprovals of ISO standards. A good change of pace was provided by the interactive posters, where the users could put on VR glasses and experience famous opera houses through virtual reality and spatial sound.

“Although most of my day was spent at the conference, there was plenty of time for cultural experiences. Since Athens offers

Below:
Vladimiras
Malyskinas



free entry into cultural sites to people from the EU under the age of 25, I used this to explore old Greek ruins and museums. Being a big fan of Greek culture and architecture, so it was good to be able to combine my professional trip with a culturally exciting one.

“One of the most exciting parts of the conference was the conference reception atop Lycabettus Hill, from which you could see all of Athens. During that dinner, there was a great opportunity to talk to acousticians from all around the world in a relaxed setting. After talking about my professional journey and what I do, I was encouraged to show my portfolio of works to others present at the conference to gather valuable feedback.

“The end of the conference was an outstanding experience – a film screening of *Koyaanisqatsi: Life out of Balance* with a live performance from the Philip Glass Ensemble in the Odeon of Herodes Atticus. After reading many posters detailing the acoustics of Roman theatres, it was stunning to experience them firsthand. The view of the Acropolis complimented the evening, creating the perfect ending to my trip to this Auditorium Acoustics conference.

“Overall, the experience was so fantastic that I felt inspired to continue my professional development in acoustics with an internship after the completion of my bachelor’s. Going into the conference, I was worried that I would be lost or not understand the material being presented, but the language was brief, precise, and easy to understand. The community of acoustics is very open to new, young people attending, and I would encourage any young person who is studying acoustics or is thinking of studying them to attend this conference and experience firsthand the tight-knit connections that the community shares. I do hope to visit the conference again both as a listener and maybe one day as a presenter. Thank you to the Institute of Acoustics for providing this opportunity, it provided me with an opportunity for professional advancement that I could not have achieved otherwise.”

Turn to page 52 for a full report of Auditorium Acoustics.



Above:
Bala Sarma

Bala Sarma

“Securing a grant from the IOA Bursary Fund proved to be a seamless and straightforward process. Accessing the application form on the IOA website, I followed the instructions, ensuring the completion of the application with all relevant details.


“A crucial component of the application involved explaining the purpose for which financial support was sought, accompanied by a concise description of the mutual benefits accruing to myself, the IOA, and the broader acoustics profession.

“The Bursary Fund played a pivotal role in allowing me to enrol for the IOA Diploma in Acoustics and Noise Control. This programme has been instrumental in fostering my competence as it awards a qualification endorsed by an internationally recognised professional acoustics body. Furthermore, the diploma has given me the opportunity to establish connections with industry experts, so is contributing significantly to my professional growth.

“Integrating the knowledge gained from the course with my work experience as a mechanical

engineer, I secured a position as a trainee acoustic consultant with Spectrum Acoustic Consultants Limited. This dual engagement enables me to assimilate core concepts from the diploma while simultaneously interacting with leading professionals in the acoustics field, thereby gathering invaluable experiences pivotal to my ongoing professional development.

“The IOA Bursary Fund served as a springboard for launching my career in acoustics. I am determined to use this opportunity to actively engage, collaborate, and devise solutions for real-world challenges faced by the acoustic industry. My commitment extends beyond personal growth, as I want to use my acquired knowledge and expertise to educate communities, policymakers, and stakeholders on the significance of acoustics, adherence to noise control regulations, and the impact of sound on overall wellbeing.

“I’d like to thank the Institute of Acoustics for being a constant support in every possible way for everyone seeking professional development in the field of acoustics.” 



Reproduced Sound 2023:

Audio accessibility – The ingredients for success

The 39th annual Reproduced Sound conference, organised by the IOA's Electro-Acoustics Group (EAG), took place in Bristol from 14-16 November 2023. 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

Above: EAG Chair, Ludo Ausiello, presenting an overview of Prof Angelo Farina's career

Organisation of the conference was led by EAG chair, Ludo Ausiello (University of Portsmouth, UK), supported by the 13 committee members and the IOA's Linda Canty.

Complete audio-visual support was coordinated by EAG committee members, John Taylor, and Andrew Horsburgh, along with students Morgan Durnin, Lili Rees, and Molly Newcombe from dBs Institute of Sound & Digital Technologies, Bristol. d&b audiotechnik have generously provided technical support for Reproduced Sound for many years, to the great benefit of the conference.

The conference was held both in person at the Bristol Hotel and online. There were 62 delegates (55 in person and seven online), representing a healthy balance between industry and academia.

Pre-conference activities

Reproduced Sound often includes a special event the evening before the conference, consisting of informal talks and demonstrations from members of industry or academia. This year's Tuesday evening workshop was presented by Audioscenic, a spin-out from ISVR, University of Southampton. The main course of the event was a practical interactive demonstration.

A laptop and a large sound bar were included, with attendees offered the chance to experience the intriguing virtual 3D technology developed by the company.

Participants were presented with different tracks and musical genres to listen to, with the signal processing involving specialisation of the original musical sources and instruments in an enveloping and engaging three-dimensional scenario, thanks to head tracking and bespoke signal processing. This showcased, with well-chosen examples, how engaging specialisation can be, especially with the correct algorithms and theories applied.

Conference day one

The first formal day of the 39th Reproduced Sound conference was launched by EAG Chair, Ludo Ausiello. Ludo expressed his gratitude of having the honour to chair the conference for the first time and also expressed his thanks to the technical team for their hard work preparing for the conference in order to deliver excellent audio and video support, something RS delegates have benefitted from for many years.

Awards

Peter Barnett Memorial Award – Angelo Farina

This year's Peter Barnett Memorial Award recipient was Professor Angelo Farina (University of Parma, Italy). Due to unforeseen circumstances, Professor Farina was unable to attend the conference to accept his award. In his absence, his former student and current EAG Chair, Ludo Ausiello, accepted the award on his behalf. IOA President, Alistair Sommerville, was on hand to present the award.

The award presentation was followed by a short talk by Ludo, highlighting Farnia's career to date. His research has spanned virtually all of audio engineering



and acoustics, with many projects resulting in useful signal processing plug-ins and independent projects. Overall, he has published more than 300 papers, but possibly the most impactful work was that detailing his approach to swept sine measurements, which is now commonplace in the industry.

Above: Jamie Angus-Whiteoak receiving her Honorary FIOA from IOA President, Alistair Sommerville

Below: Jamie Angus-Whiteoak giving a retrospective of her 'life electroacoustic'

Honorary IOA Fellowship – Jamie Angus-Whiteoak

Following Ludo's presentation, Alistair Sommerville presented an Honorary IOA Fellowship to Professor Jamie Angus-Whiteoak. Alistair expressed his gratefulness to have Jamie on hand to receive this award, as she has been a stalwart of the RS conferences since their beginning in the 1980s. He reminded the delegates of the wide range of subjects covered during Jamie's career, often embracing new ways of thinking and presenting such ideas with her typical fun and engaging manner. Her insightful questions at conferences always benefit the audience and presenters. Alistair concluded by making clear just what a treasure Jamie is to the IOA and the field, which resulted in a large round of applause from the audience.

Following the award presentation, Jamie delivered her talk: *A life electroacoustic: From Altec to Array Loudspeakers and AI; A time of change*. This was an autobiographical talk, which Jamie made clear was out of her comfort zone, as she typically sticks to technical subjects. Jamie provided a detailed account of how she [P28](#)





Above:
Attendees
chatting during a
coffee break

ended up working in electronics, computing, and audio engineering. She came up in the field at a time of huge technological advances, specifically in digital electronics, requiring her to stay up-to-date on recent advancements and to be comfortable with changes in the field. She concluded her talk with a very relevant piece of advice: “Change happens, learn how to change.” There were many questions for Jamie from the audience. One asked about her thoughts on AI in which she explained that it’s not magic and it can’t generalise to all problems. There are also considerable ethical considerations that remain unresolved. Another question brought up the fading expertise in analogue electronics. Jamie agreed with this, saying that much of the analogue know-how is getting lost as the older generations of engineers reach retirement age, which is bound to cause problems in the future.

Session 1: Live sound/venues (Chair, Glenn Leembruggen)
Inaudibility criteria and alternative methods for controlling music noise levels

The first paper presentation of the conference was jointly delivered by James Gardner (JG Acoustics, UK) and Gareth Hance (Electric Star, UK). James provided a brief history of the use of inaudibility criteria in environmental noise regulations in the UK, noting that this is particularly difficult for music venues, as the sound in this case isn’t a byproduct – it is the product. Gareth highlighted a recent case study involving a 1,500-capacity indoor venue which operated from 11pm-4am and had inaudibility criteria imposed within the local noise regulations. He explained how, in such a situation, achieving inaudibility was virtually impossible due to residential buildings in close proximity to the venue. The pair concluded that inaudibility criteria

pose significant challenges to acoustic consultants, especially due to the difficulty in actually monitoring noise levels with this ambiguous target in mind. While no firm conclusions were presented, there was clear motivation for further research to be conducted in this area.

The effect of purported acoustically transparent materials on sound propagation




The next paper in the live sound/venues session was delivered by Adam Hill (University of Derby, UK), who was presenting in the absence of the paper’s lead author, Zsombor Szoke, who recently graduated from Derby. Adam detailed an investigation into the acoustical transparency of scrim materials used as banners at large-scale events and high-specification LED video walls. Results from the small-scale experiments indicate that the **P30**

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scrim was mostly acoustically-transparent, but the video wall was not. The video wall resulted in a significant lowpass filtering effect in the forward-moving direction and diffusion for the rear-going reflected sound. The conclusion was that engineers must be careful when using products marketed as 'acoustically-transparent'. In some cases, as was shown here, the claim is likely to be misleading.

Subjective quantification of noise annoyance due to outdoor events

The final paper in this session was delivered by Charbel Hourani (University of Derby, UK) detailing early results from his PhD research on annoyance due to large-scale outdoor events. He began by making the point that we need to look beyond SPL and properly define the key factors resulting in annoyance. Charbel detailed an experiment he conducted where participants were placed in a simulated living environment experiencing various amounts of

noise pollution due to an outdoor music event. Psychological, physiological, and acoustical data were captured in an attempt to better understand how music-based noise can impact people. The results provided some clues in terms of the most important factors in such annoyance, but there is much more work left to do. There were many questions from the audience, indicating a considerable amount of interest in this subject.

Electroacoustics Group AGM

The AGM of the Electroacoustics Group (EAG) was held prior to lunch on the first day of the conference. The meeting was chaired by Ludo Ausiello, who gave an overview of the activities of the group over the past year, the central focus being the organisation of this conference. He thanked the committee members for their efforts with the conference planning and specifically, John Taylor and the rest of the technical crew for their excellent support on the technical side of the conference

delivery. Discussions were held regarding the current committee composition as well as the possibility for new members to join.

Session 2: Measurement (Chair, Bob Walker)

Extending the acoustic centre concept to directional loudspeakers

The first presentation of the afternoon was by Jon Hargreaves (University of Salford, UK), where his work took the seminal research by Vanderkooy on omnidirectional loudspeaker acoustic centres and extended the concept to work with directional loudspeakers. Jon's approach involved a thorough mathematical treatment of the problem, which was then modelled for validation purposes. He used a spatial search to identify the acoustic centre of a given directional source in tandem with a residual error metric, which is minimised at the acoustic centre. This was shown to be of use when optimising cardioid loudspeaker directivity.

Below:
James Gardner presenting his work on inaudibility criteria



Variable bracing patterns to tune soundboard and membrane speakers

Ludo Ausiello delivered the next paper in the session, which was a further instalment in his ongoing series of Reproduced Sound papers on the optimisation of acoustic guitar performance. In this work, Ludo explored how varying the internal bracing pattern on the soundboard of a guitar can help in tuning the instrument. He demonstrated how this can be experimented with using real-time measurements. Again, he emphasised that much of the acoustic guitar market is driven by marketing language, without objective measurements published. Questions from the audience focused on understanding the variables of the experiment and whether laser vibrometer measurements would be useful.

An improved omnidirectional sound source for room acoustic testing

The final paper of this session on measurement was given by Reproduced Sound regular, Glenn Leembruggen (Acoustic Directions, Australia). He explained recent work on the development of an improved so-called omnidirectional sound source for use with acoustical measurements. It is well known that typical dodecahedral loudspeakers aren't omnidirectional above around 1.5Hz and the relevant ISO standard is therefore very generous for the resulting errors. This work proposes an icosahedral loudspeaker with signal decorrelation applied to groups of transducers to minimise coherent interference of direct sound. A prototype was built and tested in direct comparison to a comparable dodecahedral design. Results indicated that the prototype provided more even coverage to a higher frequency, but there is more work to be done to optimise the performance.

Session 3: Transducers 1 (Chair, Ludo Ausiello) Adventures in high intensity acoustic testing

The conference's first paper session on transducers started with a presentation from Jon Hargreaves (University of Salford, UK) and James Hipperson (Funktion One, UK), where they detailed their recent work on a practical method for high intensity acoustic testing, largely driven by the aerospace industry. The motivation for this work was that bespoke facilities were very expensive and difficult to build. The focus here was on developing a way to carry out small scale, high SPL component testing. As there were quite stringent SPL and coherence targets, a bespoke loudspeaker was designed to deliver 140 dB RMS at 1m between 200Hz and 7kHz. Various loudspeaker configurations were tested, with all generally facing inwards, surrounding the test area. Challenges were encountered, primarily due to vibration of the test environment. Mutual acoustic coupling was also considered, as this has the potential to cause significant issues with the testing. It should be noted that delegates were informed prior to the commencement of the presentation that it had been certified 'integral-free'.

An investigation into the effect of sweat and moisture on the performance of in-ear monitors

The next paper focused on transducers a couple orders of magnitude smaller in scale, specifically in-ear monitors (IEMs). Adam Hill (University of Derby, UK) presented this paper as the lead author and recent Derby graduate, Ross Gilmour, was out on tour (as a lighting engineer, Adam was sorry to report). The research focused on the effect moisture from sweat had on in-ear monitor (IEMs) performance at live events. A series of experiments was conducted on a 3D printed model of a human ear with a bespoke IEM. Each experiment had its own challenges, many of these were highly relevant to real-world applications, such as the continual removal and re-insertion of IEMs during a performance. It was found that even a small amount of moisture introduced to the pinna can cause wide variations in magnitude response. [P32](#)

SAVE THE DATE Conference & Awards 2024

Wednesday 3rd July 2024

The 2024 Awards will take place at the Annual Conference, where the shortlisted entrants will give presentations about their entries.

The results will be announced at a dinner that evening.

The awards promote and recognise excellence among UK acoustic consultants and look for examples of work that displays innovation, and originality in acoustic design or approach to a particular project.

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Detailed analyses were presented looking at frequency-specific effects as more artificial sweat solution was introduced to the experimental setup. An informal subjective test was used to supplement the objective results, providing a strong indication that a performer's IEM experience has the potential to drastically change over the course of a performance.

The advancement of ceiling array technology

The final presentation of the day came from Matthew Fisher and John Ellis (Shure, UK) as well as Matthew Koschak (Shure, USA), who dialled in remotely. The focus of the paper was on the history and recent advancements in conference room technology. They specifically focused on the challenges presented by attempting to build a relatively compact ceiling unit containing both loudspeakers and a microphone array. The presenting trio dedicated a good deal of time explaining how they overcame issues such as acoustic echo cancellation, mechanical isolation, and power limitations. Questions from the audience focused on the specifics of the signal processing algorithms used in the system.

Above:
Ludo Ausiello receiving the Peter Barnett Memorial Award on behalf of Professor Angelo Farina

Conference reception and dinner

Reproduced Sound's reception and dinner were held at the Mud Dock Cafe. Delegates enjoyed an evening of networking and catching up with each other. In place of the traditional after dinner speech, conference Chair, Ludo Ausiello, instead brought his guitar (which we assume was appropriately optimised) to provide an enjoyable musical accompaniment for the evening.

Conference day two

Session 4 –

Speech intelligibility

(Chair, Paul Malpas)

Speech metrics in reverberant environments

Day two of Reproduced Sound began with a paper from Hugh Hopper looking at how speech metrics perform in highly reverberant environments. The study examined three objective speech quality estimators alongside subjective testing. The findings revealed that all three metrics were highly sensitive to changes in reverberation time, much more so than the subjective results. This led Hugh to suggest that we need to be careful when using such metrics and

should consider developing a more suitable far-field metric that is more robust and in line with perception.

Sound quality during video conferences in corporate meeting rooms

The second paper of this session on speech intelligibility was delivered by Glenn Leembruggen (Acoustic Directions, Australia). The work was based on practical challenges encountered by Glenn and his team when designing and implementing conference systems in corporate meeting rooms. Glenn touched on key principles of acoustic design that he's presented previously and which he encountered in this particular instance such as distribution of absorption and frequency response anomalies (which aren't picked up with STI). The team faced a challenge due to the echo-cancellation in the video conferencing systems often eliminating most of the test signals. They ended up using coherence to assess speech degradation, where the ratio of window length to file length was key. Results showed considerable high-frequency roll-off in the tested systems, causing significant intelligibility issues, although Glenn noted that he's still unsure exactly what coherence is telling us in the results.

Session 5 – Signal processing (Chair, Ludo Ausiello)

Using sparse sampling to reduce aliasing in array loudspeakers

Jamie Angus-Whiteoak returned to the stage to deliver the first paper of the signal processing session. Jamie discussed an approach to loudspeaker array design to overcome the issues of side lobes due to aliasing which can cause increased reverberation and lower speech intelligibility. Her proposed approach was to use non-uniform element spacing in arrays to reduce the aliasing lobes. The specific spacing of the elements was drawn from the idea of sparse sampling, understanding that real signals contain redundancy. The question was, what are the minimum number of samples needed to represent a polar response while not using uniform sampling. With the use of so-called 'incoherent positions', the more destructive interference can be expected, reducing the prevalence

of strong lobing patterns. Jamie walked the delegates through the process to define such an array and the talk was followed by many questions from the audience, who showed considerable interest in the concept.

Objective measurement for evaluation of haptic audio signals and transducers

The final paper of the session was presented by Stephen Oxnard (Meridian Audio, UK) detailing research into the analysis of transducers used to deliver haptic responses in audio applications. The project inspected three commercially available transducers in a controlled environment. The preliminary results showed that as

transducer size increases, temporal response worsens, as expected. Signal processing was then applied with the aim of microdynamic modification, both for transient and steady-state components. The results were encouraging, but Steve noted that there was a need to determine the just noticeable differences for haptic responses to better focus the signal optimisation.

Session 6: Transducers 2 (Chair, Adam Hill)

Correcting aberrations in audio systems with acoustic metamaterials

The second session on transducers started with a paper from EAG member, Letizia Chisari (Metasonixx and University of Sussex, UK).

Below:
Dan Pope chairing a paper session

Letizia outlined an approach which employed an acoustic lens made out of an acoustic metamaterial mounted to a transducer. The lens was compact (smaller than one wavelength in the target frequency band) and allowed for both magnitude and phase manipulation, which can be seen as complimentary to DSP. The ideal characteristics of the metamaterial were determined through an optimisation routine, which was a six dimensional search problem. The results were encouraging, with a clear path for further research identified.

Active unimorph controlled diaphragm

The morning was concluded with a paper from Kelvin Griffiths (Electroacoustic Design, UK), where he was looking into the problem of modal control for transducers. In many cases, breakup modes spoil the wideband response of a device. Kelvin proposed a novel solution to this problem which involves using a second active transducer to counteract the dynamic bending of a flat diaphragm loudspeaker. In this instance, a piezo unimorph transducer was used. Both modelled and experimental results were presented, where the experimental results were promising, showing a reduction in breakup modes, but Kelvin indicated that there was further work to be done in this area.

Session 7 : Modelling Chair, (Andy Horsburgh)

Optimal voltage correction for a unimorph transducer

Reproduced Sound regular, Patrick Macey (PACSYS, UK), presented the first paper of the afternoon, which tied into the previous paper where Kelvin Griffiths looked into the use of unimorph transducers. Patrick went into detail in describing his approach to determining the optimal drive signal related to the secondary transducer used to minimise breakup modes on a flat diaphragm transducer. The key takeaway was that modes can't be dealt with in isolation – a more holistic approach is required. The presentation led to a number of questions from the audience, primarily exploring ways to further improve the process. [P34](#)



Experimental and theoretical investigation of an unusually shaped horn

The next paper was jointly delivered by Joerg Panzer (R&D Team Software Development, Germany) and Patrick Macey (PACSYS, UK). This project started with an unusual horn design by Patrick, where the pair of researchers wondered how accurately this could be modelled. To begin with, the horn was measured in an 'infinite' baffle configuration. Then two pieces of commercially available software were used to model the horn. The results from both pieces of software gave relatively good agreement where it was found, as expected, that smaller elements led to more accurate results. Patrick went through the detailed modelling procedure and went into further detail about impedance from the mouth to the throat of the horn.

Diversity presentation and discussion (Chair, Mark Bailey)

Mark Bailey (Harman Professional, UK) lead a session on diversity in the industry, reminding the audience that the conference was a safe place, and to be kind. Various examples of the championing of diversity were presented, drawn from various initiatives at Harman, with Mark explaining how such programmes could be implemented elsewhere. Audience members suggested that neurodiversity must not be overlooked – perhaps this should be a focus for next year's diversity element of the conference. Others noted that unconscious bias can diminish diversity and we all need to be mindful of this and work to overcome such issues.

Session 8 – Hearing impairment (Chair, Dan Pope)

Hearing health for audio professionals

The final presentation of Reproduced Sound 2023 was given by Ian Wiggins (University of Nottingham, UK) and Rob Shephard (NHS, UK). This talk grew out of Philip Newell's talk at Reproduced Sound 2022, detailing his personal experience of hearing loss during his career. Ian began the presentation reminding the audience that our ears are

the most important tools we have in this industry, but there are no regulations in place to specifically protect audio professionals (as highlighted many years ago by Floyd Toole). He provided an easy to follow explanation of how our ears work and how elements of our hearing system can be damaged over time. In one relevant study it was found that by mid-life people with significant noise exposure have hearing as if they were 20 years older, although the general population 'catches up' in terms of hearing loss later in life. Both Ian and Rob emphasised that audiograms don't pick up on so-called 'hidden' hearing loss, which many of us are likely to suffer from (such as struggling to follow a conversation in a noisy environment).

Ian talked through how we, as audio and acoustics professionals, can protect our hearing. He likened this to taking care of a new car. Just as you wouldn't run a car into the ground by not servicing it, you should get your hearing tested regularly – both with audiometric and otoacoustic emission (OAE) tests. You also would never put the wrong type of fuel into your car and similarly you should avoid putting harmful substances into your body which could affect your hearing. Investing in suitable hearing protection should be something we all do to protect our hearing. We also should avoid any exposure above 140 dB LCpeak. Ultimately, we shouldn't leave things until it's too late. At present, once our hearing is damaged, there's no way to repair it.

Finally, Ian highlighted the key features in the WHO Global Standard for Safe Listening Venues and Events. The standard focuses not only on overall sound level, but also on aspects of acoustic and sound system design that can avoid overexposure to sound at music events. Ultimately, we need to be good audio citizens, remembering that everyone's hearing is different and changes all the time. As we can easily be fooled by perceptual biases, we should know when to trust measurements (consistency, absolute levels) and when to trust our ears (when it sounds 'right').

Open discussion on hearing impairment

Ian and Rob fielded numerous questions from the audience during and after their talk. Rob helped to clarify why pure tone testing is used – audiologists are used to it and legislation is very slow in changing (it has been used since the 1940s, but it doesn't provide the complete picture). He also alluded to ongoing research to develop new and improved testing methods, but re-emphasised the usefulness of OAE testing to reveal early signs of hearing damage, particularly concerning hidden hearing loss.

Ian was able to provide a more detailed explanation of the current understanding of the cause of tinnitus as well as the reason for discrepancies between sound exposure exchange rates (some places use 3 dB, while others use 5 dB) – it's a long (and imperfect) story. Finally, there were questions on low-frequency sound exposure. Ian explained that there is currently no robust answer, but noted that our hearing system isn't less sensitive at low frequencies when we consider typical concert levels, so care should be taken.

The audience was extremely engaged with Ian and Rob's presentation, with almost the entire group opting to stay beyond the formal end of the conference to hear more on the subject.

Conference closing

Reproduced Sound 2023 was formally closed by Ludo who expressed his gratitude to all the presenters, session chairs, committee members and, of course, to the IOA's Linda Canty. The papers were interesting and informative, resulting in a wonderful conference. He specifically thanked the technical crew from d&b audiotechnik and dBS, for their hard work throughout the event. We hope to see you all again in 2024 for our 40th anniversary of Reproduced Sound! 🌟

All images courtesy of Paul Malpas.



architectural acoustic finishes

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OSCAR
acoustics

Environmental Sound Group (ESG) Winter meeting

The Environmental Sound Group (ESG) Winter meeting, held on 13 December 2023, was a resounding success, attracting 264 attendees. The online event, hosted by the University of Salford and chaired by Professor David Waddington, was titled *Sound Advice: Explore BS 4142 and the Environment Agency*.

It provided a unique opportunity for attendees to gain insights into the practical application of the BS 4142 Method for rating and assessing industrial and commercial sound, and the highlight of the event was a presentation by Jon Tofts MIOA, the National Environment and Business Technical Advisor for Noise at the Environment Agency (EA).

With a full-time role as a specialist industrial noise advisor, Jon is responsible for training and mentoring EA staff in noise regulation and assessment across the country. His expertise and dedication to the field were evident throughout his presentation.

Jon explained how to use the BS 4142 Method when monitoring sound for an environmental permit. He discussed the recently published Method Implementation Document (MID) for BS 4142, designed to improve the quality of environmental measurements and assessments of noise impact received by the EA. The presentation highlighted the most misinterpreted elements of BS 4142 and areas of concern. Jon also shed light on how the MID is used to deliver the requirements for noise management plans. The

success of the MID was evidenced by the reduction in the number of reports that have needed to be returned with requests for further information from 75% to less than 25%.

Discussing practicalities

Following the presentation, Jon opened the discussion to the attendees for a lively Q&A session. A concern raised by many was the perceived rigidity of requirements for a BS 4142 report conflicting with the practicalities of industrial noise surveys. For example, it may not always be possible to align a long period to switch off an industrial site with consultant availability and good meteorological conditions. Jon reassured the participants that so long as these factors have been considered and that suitable, practical alternatives have been arranged to gain data, that the EA will fairly consider their reports.

Lucie from GSAD raised an insightful question about the impact of rainfall on sound measurements, asking whether results should be discounted during wet weather and if data should only be used from dry weather conditions. This query was addressed by another attendee, David Sproston, who clarified that

specific, residual, or background sound measurements should not be taken during or immediately after rainfall. He advised that the sound level meter operator must wait until any standing road water has disappeared before starting acoustic monitoring. In addition, Alex Wyatt enquired about the availability of a CPD Cert link, highlighting the professional development opportunities associated with the event.

Learning from experts

The session concluded with thanks to Jon for his informative presentation, with attendees such as David Sproston and Halcrow Lyall commending Jon's contribution. The ESG Winter meeting was not only informative but also fostered a sense of community among attendees. The friendly and welcoming atmosphere of the ESG meetings, coupled with the opportunity to learn from experts and share experiences, made this event a must-attend for anyone interested in the field of environmental and industrial acoustics.

We look forward to future ESG meetings and the continued advancement of acoustics research and practice.

Environmental Sound Group Spring meeting

How do we apply soundscape in practice? An introductory discussion on taking soundscape research into industry practice. Monday 11 March 2024, 12:30-13.45

Speakers: Francesco Aletta – UCL, Martin McVay – Welsh Government, Peter Rogers – Sustainable Acoustics, and Jack Harvie Clark – Apex Acoustics

Since the release of ISO 12913 (Acoustics – Soundscape, Parts 1-4), soundscape research has flourished, and there is a growing interest in understanding how soundscape research can be applied in practice. The desire to better comprehend the positive impact of acoustic environments on humans has never been more pronounced. Its practical implementation holds the promise of creating more pleasant surroundings and significantly enhancing our overall health well-being within

the built environment. While research findings are gradually influencing policy, the practical integration of these insights into assessment and design remains relatively uncharted. In this discussion, IOA members will explore the associated challenges and potential solutions. Our speakers will present an overview of the latest relevant research, delve into how soundscape considerations are shaping policy, and share examples of their application in project work by UK acoustic consultants. We warmly welcome your participation in this discussion.

The session is a joint venture by the IOA's Environmental Sound and Noise and Health Groups and will be chaired by Adam Thomas (Arup).

No need to register just use this Teams link to join <https://www.ioa.org.uk/civicrm/event/info?reset=1&id=876?> ©



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A decade of development – the 1980s

This year, we celebrate the 50th anniversary of the Institute of Acoustics. So in each issue of Acoustics Bulletin during 2024, we will travel back in time to see how we progressed over the decades to become the highly topical, balanced, impartial, and respected institution we are proud to be members of today. In this issue we embrace the '80s.

This is the second in our series of celebratory issues of Acoustics Bulletin to mark the IOA's 50th anniversary.

This time, we have reproduced some excerpts from the 1980's archives, and we also have contributions from two more IOA Specialist Groups; this time, the Electroacoustics Group, and the Environmental Sound Group, where we even have a couple of brave predictions for the next 50 years, thanks to Rupert Thornely-Taylor of the Environmental Sound Group.

We are very fortunate too, to hear from Geoff Leventhall, President from 1984 to 1986 and from Chris Rice, who was President towards the end of the decade.

Are we getting WISE in Acoustics?

1984 was WISE year. WISE stands for Women Into Science and Engineering, and is a campaign organised by the Engineering Council and the Equal Opportunities Commission to encourage more girls and women to take up careers in science and engineering.

As WISE year comes to an end, I feel it appropriate to spend a short time considering the situation of women in Science and Engineering, and more especially in acoustics. Many of you may feel that the WISE initiative is not of particular interest to you, as a cursory glance at the IOA membership shows that most of you are men. Women do not form a very large proportion of this Institute, and indeed the women members probably do not consider that being a part of the female minority is very important one way or another, but because of this low percentage, it can be seen that the WISE initiative is highly relevant to the Institute.

In his letter in the last issue of the Bulletin, the President outlined the structure of the membership, and expressed a hope that in the future we can attract more members. I would suggest that attracting more women firstly into science and engineering and secondly into acoustics is one way of going about this. One fact left out of the President's letter is that out of the total membership of the Institute, 4% are women. This is a pretty abysmal figure, but not unusual in scientific or engineering professions, which are still having trouble recruiting women in this

country despite equal pay and anti-discrimination legislation. Obviously training for science and engineering starts very early on at secondary school and, by the time subject choices are made in the third year, most girls have already decided that science and mathematics are not for them. The Women's Engineering Society gives many careers talks at schools, and finds in many cases that fifth year girls begin to show an interest, but have already dropped maths and physics. It is very difficult to get them back into science at this stage. However, it is likely that problems start much earlier in life, and the attitude of parents is of paramount importance.

So what of the Institute? Are we too far along the system to have any influence? I suppose the immediate answer is yes, but unless we are aware of the situation, and monitor it, we may be unaware of the needs of women in the Institute. It must be borne in mind that by only having a 4% female membership, we are ignoring a large pool of possible talent, which the acoustic profession cannot afford to pass over. This is one area where we should look for our new members.

One bright spot — 1% of Fellows are women (if you see what I mean — and as for sexist nomenclature, well that's another matter!), 3% of Members, and 9% of Associates. This does look as if numbers are increasing as time goes on, as by and large the Associates are younger than the Members, who are younger than the Fellows. On the other hand, there is the possibility that

numbers decrease after women leave work temporarily to have children, and cannot get back into the industry, hence the shortage of Members and Fellows. This is something the Institute and membership can do something about, by encouraging colleges and polytechnics to run refresher courses should the need arise, and by realising that working hours and the length of the working week are not eternal verities laid down by God (or science) and can be flexible enough to meet all needs. Some consultancy work can easily be done at home, and much of the practical side of it does not take place during normal working hours anyway. The industry may have to change to attract more women, and the methods may be different but no less valid than in the past. (Just think, the men may have been wrong for all this time!)

In the last Bulletin, the editor wrote that one reason why acousticians may be unavailable to write articles is because they are otherwise engaged having babies. It's encouraging to see that women are sometimes remembered. However, this must be balanced against the President saying that retirement 'may be at age 60, if present trends continue', 4% of us have to retire at 60 now (although few if any would consider these double standards desirable) and we do, sometimes, get a bit tired of being overlooked.

I hope that all the membership will think positively about this subject, because it can only benefit all of us in the end. □

Sue Bird

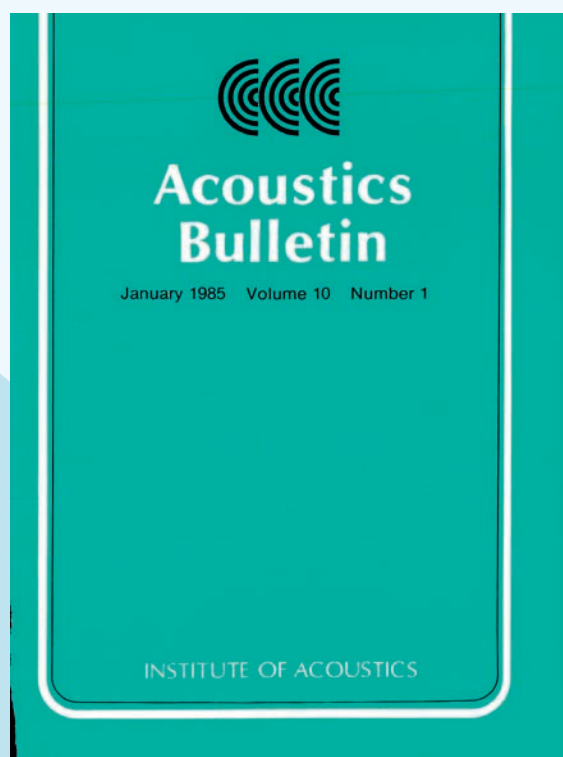
Articles from the archives

During the 1980s Acoustics Bulletin was published four times a year, and edited by Mrs F A Hill. In the January 1985 issue, Sue Bird wrote an article

(shown above) about women in engineering and specifically, in acoustics, and the need to attract more women members into the IOA. One of the stumbling blocks, Sue thought, was that by the fifth form, most girls had dropped maths and physics and then their potential as engineers was lost. You can read here original article here <https://www.ioa.org.uk/catalogue/publication/acoustics-bulletin-january-february-1985> and her update to that article is below:

Sue's update to her 1985 article

'The WISE' in the article I wrote referred to Women in Science and Engineering, and WISE year had occurred in 1984, when a number of activities and information was produced throughout the year for the purpose of informing the public, employers, education institutions, and everyone else as far as possible that science and engineering was an interesting, important, and well paid career for women. It was a successful campaign. So I was asked on





Left:
The caption provided for picture number 4 (Coffee and tea breaks provided a welcome counterpoint to the formal sessions, some well-known figures being seen attempting to lend some additional stability to the corridor walls) is a bit mind-blowing isn't it?



Reproduced Sound

WINDERMERE: 6-9 NOVEMBER 1986

Photographs by Mike Askers.

1. We came to Windermere, to the Hydro Hotel, which lived up to its name — it rained outside almost all the time — but without the rain there would be no Lakes.
2. The captive audience inside hardly noticed the weather, so attentive were they and appreciative of the speakers during the sessions.
3. ... and, during the breaks, natural or otherwise, interested in the wide variety of hardware, software and software exhibited by our industrial and commercial supporters.
4. Coffee and tea breaks provided a welcome counterpoint to the formal sessions, some well-known figures being seen attempting to lend some additional stability to the corridor walls.
5. Even **Ken Dibble** (whose total contribution to the proceedings was nothing less than breathtaking) needed occasional lubrication and oral rest.
6. **Jeff Charles** receives the 1986 Young Medal from **Geoff Leventhall**, following his lecture on "Acoustic Consultancy: Aural Craftsmanship with Scientific Precisionism".
7. Eighty years young, but still remembering almost all of his (mostly business) encounters of the female kind during his long career in acoustics, **James Moss** is awarded an Honorary Fellowship after the banquet.
8. The staff looked after us attentively, although your correspondent found the odd unattended room.
9. Among the controllers and attenuators present, there were some pretensions, but no synthetizers, Ken is again high profile.
10. & 11. A surprising and spontaneous display of talent from people whose energies are normally directed into attempting to reduce the impact, if not the actual volume, of *Reproduced Sound* in the world outside this successful conference at Windermere.



Acoustics Bulletin January 1987

11

Advertisement from the archives

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Computed Parameters
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Company: _____
Address: _____

Above:
This Solartron 1200 advertised in a 1981 issue apparently weighed 34kg. It might be worth dropping them a telex to see if they have any in stock before you travel

Recollections of two IOA Presidents of the 1980s:

Geoff Leventhall, IOA President 1984-1986

The transition in 1974 from British Acoustical Society (BAS) to Institute of Acoustics was so smooth for BAS members that I have little recollection of it. One day I was in the BAS and the next day I was in the IOA. Then, when membership grades were issued, I became a Fellow. My first memory of an IOA event is the opening ceremony at the Albert Hall for the 1974 International Congress on Acoustics, listening to the speeches, sitting along with other organisers on the orchestra stage, and feeling a little exposed under the bright lights.

I became President of the Institute in the mid-1980s, but before this had the privilege of serving the Institute in other ways. I had been a Council Member, Chairman of the Meetings Committee in the 1970s, Treasurer at the end of the 1970s and Assistant Examiner for the Institute's Diploma, helping Chief Examiner, Ray Stephens. I became Chief Examiner myself when Ray's stint was over in the early 1980s. These positions, followed by the Presidency, took me through more than 10 years, from the 70s to the late 80s, which was an exciting period for the Institute's development. More recently, I helped on the CPD Committee,

checking members' progress through the documentation for their professional development, giving this up when I turned 90. As I look back from my 95th year, I remember much, have forgotten a lot, and there are some personal memories to share with you. These are, of course, coloured by my memory lapses and prejudices.

I had been a member of the Acoustical Society of America since 1968 and the Institute of Physics since my student days. These gave me a feel for what a learned society could achieve. I aimed to help develop our Institute so that it stood shoulder to shoulder with the long-established UK engineering and scientific institutes, for example, the Institute of Physics, Institution of Mechanical Engineers, and Institution of Electrical Engineers. One of the visible trappings of these Institutions' prestige was the ability to offer Chartered Engineer status to those of their members who were suitably qualified and experienced. We hoped to do the same for our own members so that they were not disadvantaged in their careers. A requirement for a professional institute to offer chartered status to its members was the award of a Royal Charter to that institute. One of my early steps as President was to investigate this for the IOA.

We formed a group of Past Presidents (Peter Lord and

David Weston), President at the time (me) and President Elect (Orhan Berktag), and off we went to meet the Clerk to the Privy Council, Sir Neville Leigh. It was made clear to us that for a professional body to receive a Charter, it should be able to demonstrate proactivity, leading to certain achievements, including service to the community. At that time we were on the verge of such developments, but not yet there. We decided to defer the Charter route for another 10-20 years! It is pleasing to know that, following a long wait and a completely new approach, our Charter application is now progressing.

The alternative route for the professional registration of members of an Institution which does not have its own Charter was through the Engineering Council in association with an appropriate Chartered Body. We were lucky to be able to progress under the wing of the Institution of Mechanical Engineers. After some to-and-fro contacts, the Engineering Council visited our offices in St Albans in August 1985 and subsequently gave us their requirements for the completion of the process. We followed through with these and all went well. We have a demanding, but smooth route to Chartered status for our qualified members, overseen by the Engineering Division.

One of the tasks we had in the run-up to ICA 1974 was to give a brief check on all the papers accepted for the conference. Not to referee them, but to ensure that they were not acoustical gibberish, a task that fell upon Ray Stephens and me. This was before the digital age, and was carried out with paper copies – piles of them – in the offices of the Institute of Physics, in Belgrave Square.

At that time, most UK electricity production depended on coal-fired power stations and the miners were threatening to strike. To conserve coal, the Government (Prime Minister, Ted Heath) introduced a three-day working week from the end of 1973, making it illegal for companies to use electricity on more than their three allotted days each week. The restriction was lifted in February 1974, but covered the time when the assessment of papers for ICA 1974 was scheduled, before assembling and printing the Proceedings. So, although we started reviewing the papers in

daylight, it became dark early, and we were told that we could not have lights on as this was one of the Institute of Physics ‘no electricity’ days, but candles were available! So that’s how we completed the task, acoustics by candlelight.

The IOA is not shielded from National trends and was hit by the high inflation of the 1970s. Annual inflation was over 24% at the end of 1975 and continued double-digit into the 1980s, which was not good for a small Institute that needed to finance its expansion. We had previously decided to hold down membership fees, and when I took over as Treasurer in 1979, I found a worrying problem with our finances. This could only be solved in the short-term by a significant increase in fees, which was unpopular, but necessary. It was pleasing that the great majority of our members stuck with us.

One way to increase income is to increase membership numbers. Another way is to further develop saleable products, such as conferences. We took both routes.

When I became President, I had access to membership records and did an analysis of member ages and grades, published in the President’s Letter, Acoustics Bulletin, October 1984. At that time we had the following members working in some aspect of acoustics.

Associates	318	approximate age of peak of distribution 25 years;
Members	667	approximate age of peak of distribution 35 years; and
Fellows	204	approximate age of peak of distribution 50 years.

Additionally, there were 17 student members and 40 others with a range of occupations, giving a total of 1,246. The age distribution emphasised the need to attract younger members to fill in the space left when existing members grew older and I set a target of 2,000 members by the year 2000. Back in 1985, we had 15 years to achieve this, but did so by the early 1990s, helped by some of the social and legislative changes which were occurring in the UK, especially in environmental noise and hearing protection in industry.

The Wilson Report on Noise, published in 1963, gave a boost to the developing interest in environmental noise. In parallel with this, the work on hearing damage from industrial noise was progressing, whilst building designers were realising the problems of amplified music. Noise was an unwelcome side effect of the UK’s growth, but with potential control through the Environmental Protection Act and the Health and Safety at Work Regulations. There was a problem in that we had the regulations but did not have sufficient skilled acousticians for enforcement. The IOA was able to come forward with its plans for the Diploma in Acoustics and Noise Control and took its first students in the late 1970s. The Diploma gave a boost to the Institute, both financially and in terms of new members. Many of the Diploma students worked in Environmental Health and became members of the IOA. They gave us a double financial stream: first from Diploma fees and then from membership fees.

Back in 1981, when I was at InterNoise in Amsterdam, Danish acoustician, the late Fritz Ingerslev, who was active in the 1974 founding of International INCE, asked me what the chances were of the IOA hosting an InterNoise conference. There was a spot available for 1983 and I said I would raise it with Council and the Secretariat. But when I did so shortly afterwards, there was a rather negative response from some Council members – in those early days, noise control interests were not very strongly represented on Council. However, when it was pointed out that the IOA could earn itself a significant surplus from an InterNoise conference, the discussion swung to positive and InterNoise 1983 in Edinburgh was the outcome. This was successful in delegate numbers and financial surplus and established the IOA as an international actor.

Our progress through the 1980s, and beyond, depended enormously on Cathy Mackenzie and the late Roy Lawrence. Cathy was a skilled and meticulous Chief Executive, who established good relations with members, whilst Roy encapsulated vision and energy, with just a sprinkling of the abrasiveness which gets things done.

We were a good team.

Thank you IOA for helping to make a career in acoustics so satisfying for me. [P42](#)

**Chris Rice,
IOA President 1988-1990**

Looking back on my term as President I can remember initially thinking how smoothly things were going until one evening I received a telephone call from Roy Lawrence informing me that the auditors had said that the Institute was on the point of financial collapse. Such events concentrated the mind and change was implemented immediately.^{1,2}

Dudley Wallis astutely recalled that this phase of the history of the Institute had been described by the then Secretary, Cathy Mackenzie, as the 'starvation phase'. As a team we pulled together and after many long hours managed to provide the foundation for the start of a new era in the history of the Institute. The Institute owes a great debt to the roles played by Cathie Mackenzie and Roy Lawrence during this period of change and in moving the centre of gravity of the Institute from Edinburgh to St Albans. Other achievements during this time are best recalled by quoting extracts from my last letter as President³.

'The period saw the formal signing of the institute-affiliated body agreement with the Institution of Mechanical Engineers and the subsequent processing of applications of a small number of members for CEng status. Coupled with this has been the introduction of the Associate Member Grade (AMIOA), which allows suitably qualified young members to start their careers as acknowledged professional acousticians. The status of the Diploma has been enhanced by its incorporation into the above initiatives, and introduction of the Certificate of Competence in Work-Place Noise Assessment has received encouraging acceptance. The results of the membership drive look promising and the number of corporate members is now expected to grow steadily. More

importantly, however, there has been an extensive revision of the industrial sponsorship scheme. It has been felt for a long time that there should be greater interaction with the industrial base and it is hoped that the new proposals will prove to be mutually beneficial.'

'In order to enhance the move to St Albans I would like to suggest certain goals which ought to be included in any business plan for our long-term future. Most important is the pressing need to increase the annual level of the fixed income. At present membership income on its own is not sufficient to meet establishment costs, which have to be supplemented with the profits obtained from meetings. Ideally such profits should be better used in support of speculative ventures. Could I again ask you to help in this venture by reminding you to think '*What can I do to help the Institute?*' rather than demanding '*What can the Institute do for me?*'

'What does the future hold? I am quite confident that we will continue to play a major national and international role during the 1990's but will need to make a conscious and determined effort to maintain and improve our corporate image'.

In the intervening period I think the Institute has excelled itself and is now well prepared to apply for Royal Chartered status. Good luck to all concerned.

Specialist Groups

As the IOA celebrates its 50th anniversary, its specialist groups have been looking back at key developments in their sectors over the past five decades and looking ahead to what the future might hold. In this first series of reviews, we look at the work within electroacoustics and environmental acoustics groups.

Electroacoustics Group

*By Ludovico Ausiello,
Electroacoustics Group Chair*

The Reproduced Sound (RS) conference has been an annual event since the first one held in Windermere, Cumbria, in 1984. It is organised by the IOA Electroacoustics Group (EAG) and is aimed towards all those who work in the multi-disciplinary world where electronics, acoustics, architecture, and intelligibility blend. Each year, the organisers set a core topic for technical contributions, then ask for contributions on more traditional areas of interaction of acoustical space with audio systems.

RS and the EAG continue to evolve and, during the pandemic, when we found ourselves locked down at home, struggling and fearing for our futures, the electroacoustic community (surely a peculiar lot, considering we come from all over the world and we generally dream of loudspeakers, microphones, and all the complicated systems in-between!) rose to the challenge and rapidly found the tools to maintain our plans and deliver the conference online.

When we were asked if it would be possible to transform Reproduced Sound into a virtual conference, and whether we needed some 'professional' to support us, we thought that we were the professionals! A small team of members volunteered to organise the online conference, and it is important here to mention the amazing support of dBTechnologies and John Taylor, especially when it came to setting up the system for the Q&A parts of every conference session.

This is where the EAG organisers succeeded in researching and establishing resources, which eventually became part of the standard operating procedure of the IOA for its committee meetings and conference sessions.

After many years of outstanding and dedicated work, Keith Holland stepped down from his role of

References

- 1 Chris Rice (2016) IOA The first 40 years; What financial crisis? p55
- 2 Dudley Wallis (2016) IOA The first 40 years; The role of finance and industrial collaboration and Sponsor members. p56
- 3 Chris Rice (1990) Acoustics Bulletin April. Presidents' Letter. p5

Chairman, and Ludo Ausiello was elected, showing once more the high level of openness and inclusivity of the EAG. Ludo had presented his first paper in 2018, became a member of the committee a couple of years later, and was then elected Chair.

The EAG continues to welcome new members, and discusses interesting and evolving topics such as new research into hearing impairments, as well as offering fundamental components for the education to electroacoustics professionals. This includes a series of new IOA videos to promote the world of electroacoustics in terms of transducer design.

It is interesting to note the fluidity with which delegates attending RS move from industry to academia, and vice-versa. A great example of this is the work done by Marcos Simón, who won the best paper award in 2013. Marcos now leads Audioscenic, a company dedicated to spatial audio, and was among the most interesting exhibitors at RS2023.

We know that 2024 is a year of celebrations for the IOA and for RS as well, since 'we' celebrate the 40th anniversary of the conference. The plan? We're already planning RS2024 by collecting suggestions from participants, and we anticipate that there will be even more musical involvement this time, with a 'bring your own instrument' session, which will be dedicated to a very special form of networking.

We are planning an evening event to pique the interests of

electronic musicians. The idea is to gather synthesisers of all eras and arrange the ultimate 'shoot-out', where attendees bring their own instruments (analogue or digital, real, or virtual) and demonstrate their passion for music and electronics to other delegates who are passionate about amplifying such magical sounds.

Environmental Sound Group

*By Rupert Thornely-Taylor,
Environmental Sound Group Chair*

The management of environmental sound involves four main areas of endeavour:

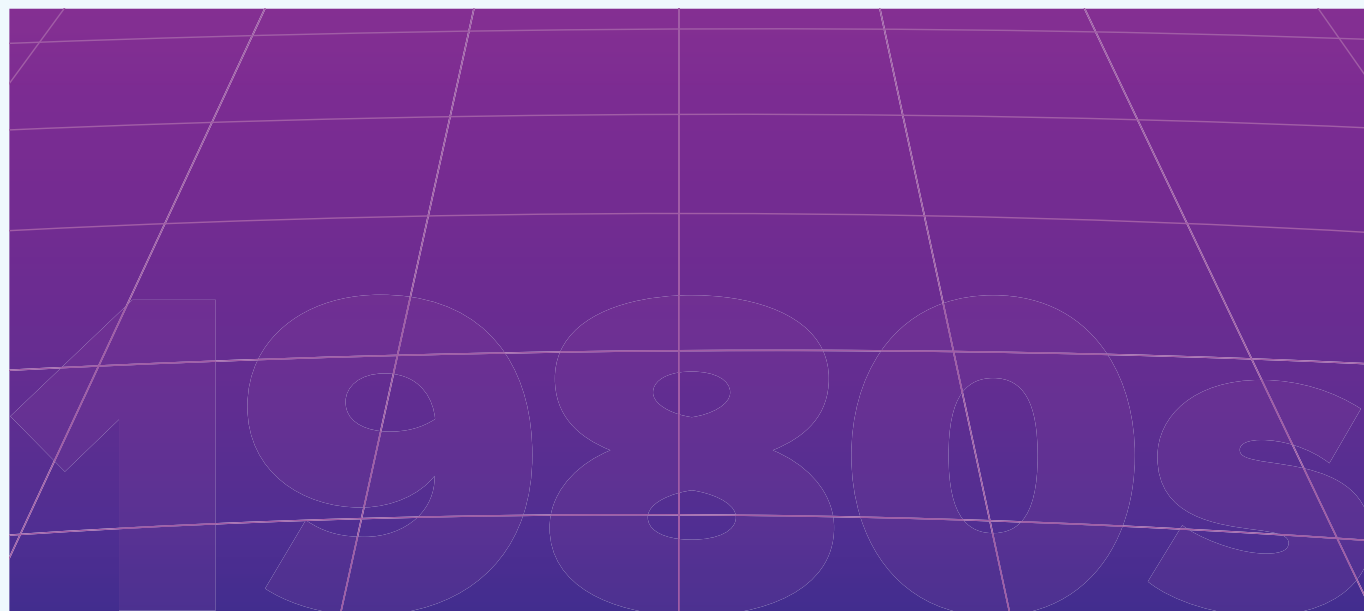
- measurement;
- prediction;
- assessment and
- control.

Over the past 50 years, the way these tasks have been carried out has changed enormously, both as a result of changes in technology and research into human response to sound, not only unwanted sound (noise), but also in terms of soundscapes.

The reasons for engaging in environmental sound management have also changed. Environmental Impact Assessment in 1974 was not a statutory requirement in the way it is now. Only in the case of developments where noise was a clear concern, such as new airports, was a formal assessment of noise carried out, submitted, and considered as part of the decision-making process. Noise measurement was done using battery-hungry analogue instruments, including

reel-to-reel tape recorders; some of which were themselves works of art. While the basic units of noise measurement had been established, environmental noise indices were in their infancy. In some ways, noise scales 50 years ago were more complex than they are now, in that analogue sound levels meters for a time had a 'D' weighting in an attempt to go some way towards replicating the complexities of the PNdB. Noise indices started with statistical distribution analysis, again carried out using electro-mechanical analogue equipment, and this was simplified with the greater use of L_{A10} and L_{A90} . L_{Aeq} , first used for hearing damage risk assessment, came into use as an environmental noise index without much justification, although it was not until 1985 with the publication of the CAA's Aircraft Noise Index Study that L_{Aeq} displaced the Noise and Number Index. Digital boxes for computing noise indices started to appear, sometimes with clattery printers that were noise sources themselves, and no permanent internal data storage. Real-time frequency analysis and data capture came much later. There of course was no internet for telemetry.

Noise prediction was also in an embryonic state. There were no software packages, not least because computing was in its infancy. The IBM PC did not appear until 1981. Significant tasks were done by mainframe computers or 'minicomputers' which were slow machines in large cabinets using magnetic tape reels. [P44](#)



I brought back my first copy of the Integrated Noise Model from a visit to NASA Labs on a 12” tape reel. There were effectively no standard noise prediction methods, and predictions had to be made using basic acoustical principles. Topics such as sound attenuation with propagation over soft ground had only partially been researched. This meant that practitioners really had to know their acoustics, and not just be readers of software instruction manuals.

Noise assessment was also quite primitive. Given that there were no environmental assessment regulations, there was no need to decide on frameworks for the ranking of impacts or assignment of levels of significance. We did have BS 4142:1967 with its then idiosyncratic system of on-time corrections and corrected noise levels, and also the Wilson Report, which introduced the Noise and Number Index and made tentative recommendations about noise levels inside living rooms and bedrooms in terms of LA10.

Noise insulation regulations for road traffic noise were introduced in 1973, so eligibility for insulation needed assessment, but it was measurement-based, and ‘Calculation of Road Traffic Noise’ did not come along until 1975. We had NC and NR curves, and they sometimes found wider application than they do now. There were motor vehicles construction and use regulations, but it was only practicable to enforce their noise limits for new vehicle types. Published originally in 1971, ISO R 1996 had a rating system with wider application than BS 4142 and was widely used. World Health Organization guidance did not start to emerge until 1995 (more formally in 1999). In the field of Town and Country Planning Circular 10/73, Planning and Noise in 1973 had introduced some guidance on ‘ways and means of taking noise from

various sources into account when making planning decisions’ but more a more formal procedure did not come until 1994 with Planning Policy Guidance 24 with its Noise Exposure Category system.

With regard to noise control, progress over that past 50 years has in some areas been dramatic:

- aircraft emit substantially less noise than they did 50 years ago, although their numbers have also greatly increased;
- road traffic noise has reached the point where tyre noise predominates, with the consequent rise in the importance of low noise road surfaces, which were unknown 50 years ago;
- the demise of many heavy industrial sites has means that a once widespread problem of industrial noise is less of an issue than it was; but
- on the other hand sources unheard then, such as heat pumps, have grown in significance.

The technology involved in noise control devices such as sound attenuators, acoustic enclosures and noise barriers has changed little, although noise barriers, for example, have found very widespread application in transportation projects such as High Speed 2 in order to give effect to the noise policies that have emerged following the issues of the Noise Policy Statement for England in 2012 and the consequent creation of the concepts of LOAEL and SOAEL.

In comparing environmental noise management in 2024 with that in 1974, the outstanding differences are firstly the great sophistication of instrumentation and of software for noise prediction that exists today, coupled with the highly detailed approach which is now taken to environmental impact assessment, as is witnessed by the enormous size of modern environmental statements compared to those

which sufficed when EIA was first required by law.

The profession of acoustics, particularly as it is applied to environmental sound, has grown in terms of the number of qualified practitioners in a remarkable way, and the standard inclusion of acoustical consultants in development teams for major and even quite minor projects has had as great an effect as have the technological and policy advances.

Where will we be going in the next 50 years?

Already we have started to look at sound which is not necessarily ‘unwanted’ in terms of soundscapes. We have had problems of safety due to the lack of noise from electric vehicles and a rise in the hazards of pedestrian conflict. We are still unsure how to define and quantify tranquility, and sources which were not high on the list of concerns such as fireworks and outdoor music have grown in importance. The World Health Organization’s Environmental Noise Guidelines for the European Region developed the link between noise and health in a way that certainly has led to a need for more work to improve understanding of the links between noise and health and implementable guidance on how to address health issues. The health issues that have been studied will be extended to mental health as well as physiological effects.

Whether we shall see new noise control technologies remains to be seen. There was a flurry of research activity in exotic areas such as meta-materials. We may have reached the limit of aircraft noise reductions as the noise of airframes passing through air is in some cases the main source of aviation noise. The achievements of low noise road surfaces needs to be followed by improvements in tyre noise, as internal combustion engines give way to electric motors, and we have not heard the last of heat pumps!

Some 1980s significant world events

- The World Health Organization declared that smallpox had been eradicated (8 May 1980)
- Prince Charles married Lady Diana Spencer (29 July 1981)
- The war between the United Kingdom and Argentina over control of the Falkland Islands began (2 April 1982)
- Michael Jackson released *Thriller*, one of the most successful albums in the world (30 November 1982)
- *Live Aid* was held simultaneously in London and Philadelphia (13 July 1985)
- Tenth mission of the space shuttle Challenger ended in disaster (28 January 1986)
- Chernobyl nuclear power plant in Ukraine nuclear accident (26 April 1986)
- Pan Am Flight 103 exploded over Lockerbie, killing all 259 people on board and 11 individuals on the ground (21 December 1988)
- A series of protests and demonstrations in China culminate with a government crackdown on demonstrators in Tiananmen Square, Beijing (3-4 June 1989)
- The Berlin Wall fell (9 November 1989)

You can read *IOA, The First 40 Years* here

<https://bit.ly/IOAfirst40>

Memories differ

All our contributors to this section will remember events differently and as we feature *their* memories, and they might not be exactly how others remember them!

Technical terms

In this archive section, we use technical terms 'of the day.' These terms may not be what we use now.

50th anniversary events

Acoustics 2024

12-13 September 2024

Manchester Metropolitan University

50th Anniversary Dinner

27 November 2024

Vintners Hall, London

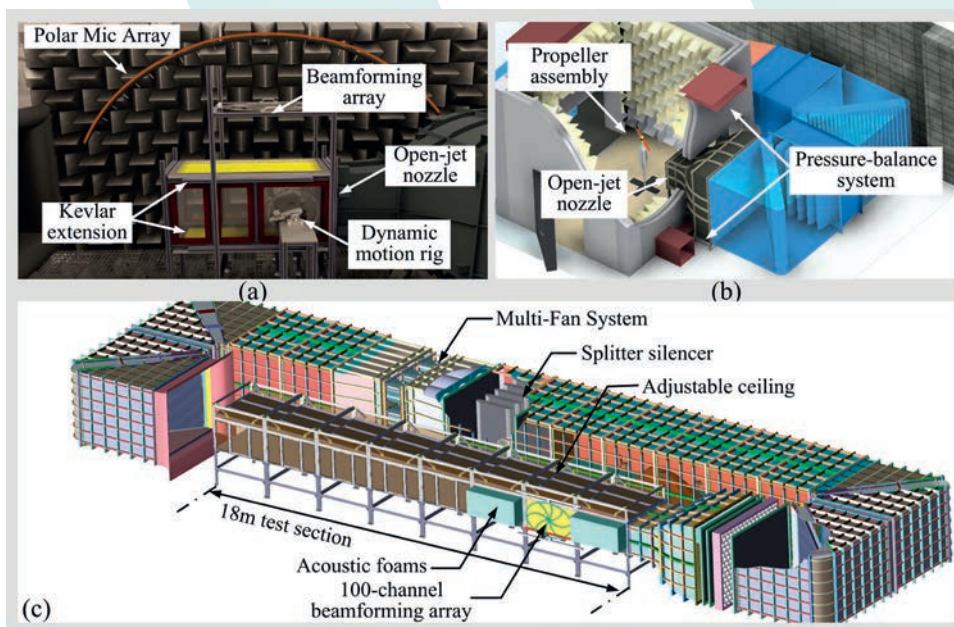


If you have any IOA memories or photos you'd like to share in future 2024 issues, contact the editor, Nicky Rogers at nicky@warnersgroup.co.uk

Aeroacoustics of propellers on novel electric propulsive configurations of urban air mobility vehicles

Towards better understanding of the noise characteristics for next-generation aerial vehicles.

By Nick Zang, Desmond Lim, Nur Syafiqah Jamaluddin, Ismaeel Zaman, and Mahdi Azarpeyvand, School of Civil, Aerospace and Design Engineering, University of Bristol



- **aeroacoustic wind tunnel (AAWT)** facility: a closed-loop, open-jet wind tunnel with a test chamber, anechoic down to 160Hz. The 775mm (H) x 500mm (W) open-jet nozzle delivers a low-turbulence, uniform free-stream of 5m/s to 40m/s (see Fig.1(a) and <https://doi.org/10.1016/j.apacoust.2019.06.005>).

The nozzle section can be modified to accommodate a larger range of free-stream velocities up to 120m/s;

- **pressure-neutral acoustic wind tunnel (PNWT)**: a purpose-built facility for propeller research. The PNWT has a 700mm (H) x 1000mm (W) open-jet nozzle which enables testing of propellers with larger diameters, at a free-stream velocity range of 4m/s to 35m/s. It is designed with a unique pressure balancing system (see Fig.1(b)) to minimise propeller-induced flow recirculation in the anechoic test chamber. This prevents the ingestion of self-turbulence from the propellers which would otherwise introduce spurious noise; and

- **boundary layer wind tunnel (BLWT)**: a multi-purpose facility with a 18m-long test section to naturally develop a turbulent boundary layer of $\sim \delta = 25\text{cm}$. Driven by nine axial fans, it can produce a steady flow velocity from 0.5m/s to 35m/s, and is equipped with boundary layer suction control and variable pressure gradient via a tilting ceiling. The first three test sections are acoustically treated and fitted with tensioned Kevlar test section and a 100-microphone, large beamforming array (see Fig.1(c)). P48

Disruptive technological innovations in the aerospace sector are critical to the timely delivery of the net zero 2050 target.

Hybrid/fully electric propulsion systems for urban air mobility (UAM) vehicles have huge potential to transform aviation, and have attracted significant governmental support and research efforts in academia and industry.

Yet, it comes with inherent technological challenges:

- an increasing design complexity of the propulsive configurations (e.g. tilted, distributed, boundary layer ingestion); and
- a growing level of operational complexity (e.g. atmospheric turbulence interaction, take-off and landing in complex urban environments).

Above: Figure 1: The three national wind tunnel facilities at the University of Bristol. (a) Aeroacoustic wind tunnel, (b) pressure-neutral wind tunnel, and the (c) boundary layer wind tunnel with far-field microphone and beamforming arrays for acoustic measurements

The design and operational complexities introduce new aerodynamic noise sources to UAM vehicles. Quieter vehicles are essential for ensuring community wellbeing and public acceptance. This necessitates a better understanding of the noise at source and the generation mechanisms, which is an important step towards the aircrafts' entry into service and thus, more sustainable aviation.

Wind tunnel facilities and measurement capabilities

The University of Bristol is an excellent environment for propeller aerodynamic and aeroacoustic research, and is home to three national wind tunnel facilities:

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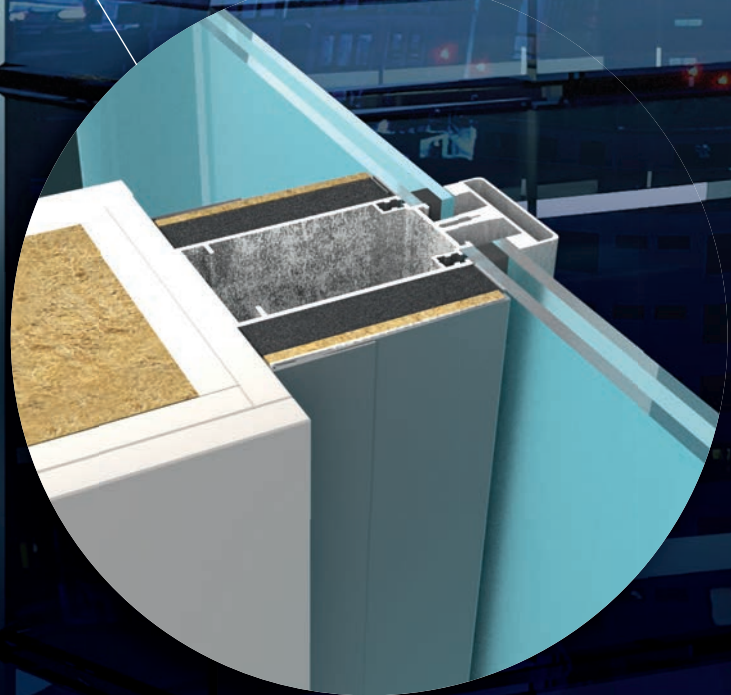


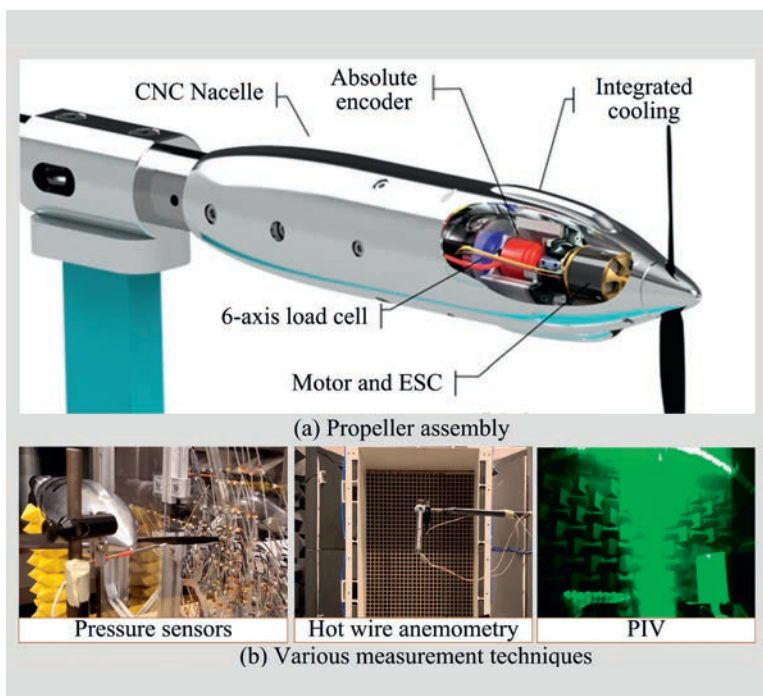
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Left:
Figure 2:
 (a) Propeller assembly with the various components for aerodynamic loading, blade phase angle and heat management, and the (b) various near-field measurement techniques used for identifying the noise sources and generation mechanisms

Accurate experimental study requires careful design and commissioning of the propeller assembly suitable for both far- and near-field measurements. Figure 2(a) shows a propeller assembly used across various configurations, which typically comprises of a motor coupled with electronic control unit, a six-axis load cell for aerodynamic loading measurements, and an absolute encoder to register blade phase information for phase-locked analyses. The integrated cooling system ensures relatively small temperature variations during the measurement duration, thus minimising uncertainties arising from temperature effects.

To quantify the far-field acoustics and directivity, the AAWT and PNWT aeroacoustic facilities are equipped with multiple polar microphone arrays. In addition, large, reconfigurable beamforming array can be mounted on top and at the sides of the test section to allow accurate noise source localisation. To further unravel the underlying noise generation mechanisms, near-field pressure and velocity measurements based on wall-mounted pressure sensors, hot-wire anemometry and particle-image velocimetry (PIV) can be performed (see Fig.2(b)), and are often synchronised with the far-field measurements to allow near-to-far-field correlation.

Research into propeller-turbulence interaction noise in edgewise flight

In an urban setting, UAM vehicles are likely to encounter flow with relatively high levels of turbulence, arising from the atmospheric flow interacting with buildings and street canyons. Therefore, understanding the effects of turbulence on the aerodynamic noise of propellers is crucial.


To investigate the effects of turbulence intensity and length-scales on the propeller acoustics, a passive turbulence grid was mounted to the contraction of the open-jet nozzle in the AAWT facility, as shown in Figure 3(a). The turbulence intensity and length-scale were controlled by the ratio between the opening of

the grid (M) and the diameter of the grid (d). In the present study, two distinct grids, (grid A and grid B) were used to produce turbulence intensities of 5% and 10% with corresponding length-scales of 13mm and 19mm, respectively. The propeller assembly is like that shown in Figure 3(a) in the edgewise flight condition, and the rotational speed is kept constant at 5500 revolutions-per-minute (RPM).

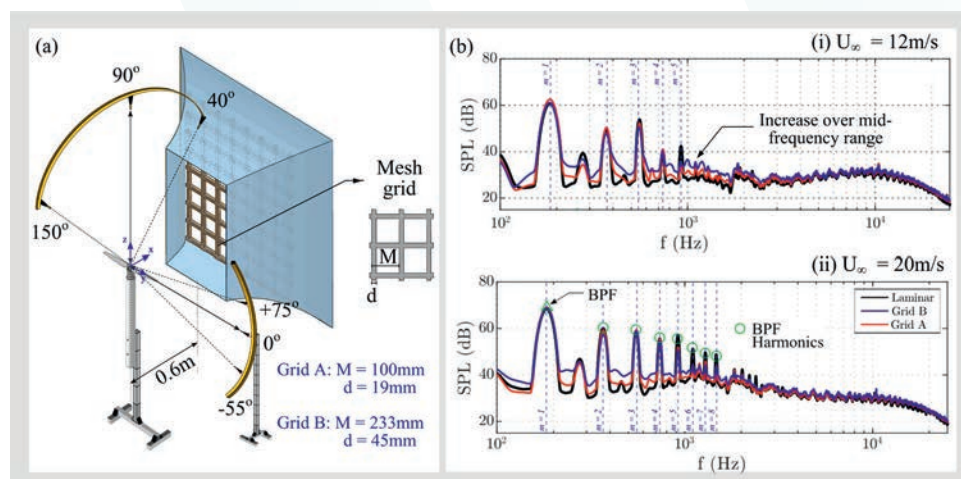
The far-field acoustic spectra, as shown in Figure 3(b), demonstrate a clear increase of the magnitude over a broadband frequency from approximately 200Hz (i.e. just beyond the first blade pass frequency, BPF) to 1500Hz, regardless of the inflow velocities. When comparing the effect of turbulence, grid B led to a noticeably greater noise increase than that from grid A. Having higher turbulence intensity and larger turbulence length-scale, grid B naturally produces an enhanced level of turbulence interaction with the blades.

Future work

As shown in the brief discussion on the propeller-turbulence interaction, the current understanding on the aeroacoustics of propeller operating at conditions typical for UAM vehicles is still relatively limited.

At Bristol, the dedicated facilities, measurement techniques and strong support from industrial partners are research enablers that will support extensive studies on the noise sources and generation mechanisms at source for various configurations, such as tilt rotors, distributed propulsion, ducted propellers, etc. These results will be shared with the community. 

Below:
Figure 3:
 Far-field acoustics of a propeller interacting with isotropic turbulence in edgewise flight. (a) Schematic of the experimental set-up with passive turbulence grid and (b) the sound pressure level spectra for two inflow velocities





SCAN ME

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Friday 22 March 2024

National Oceanography Centre, Southampton SO14 3ZH

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Current parliamentary and policy news

How we deploy air source heat pumps and the health impacts of noise have been a focus for recent policy discussion for the Parliamentary and Public Liaison Group.

The acoustics impacts of our energy sources – with consultations and research on heat pumps continue to engage the interest of many members. The House of Lords expressed disappointment with the Government approach to noise and health, and a new briefing note to help people understand the management of mysterious hums has been published.

Government urged to commit to action on noise

Last year IOA members presented evidence to the House of Lords Science and Technology Committee, during their investigation into environmental noise and human health. Their report was published in July, finding that noise remained a neglected pollutant. Recommendations included noise targets focusing on reducing the overall burden of disease with targeted interventions. The Government responded to the report in December, with their view that there is insufficient research available on which to base noise targets. Now, the Committee Chair, Baroness Brown, has issued a written reply. In a letter to Minister Rebecca Pow MP, Baroness Brown expresses disappointment that the Government has shown no commitment to taking any action to address the health impacts of noise. The letter points out that while further work by Defra and the UK Health and Security Agency (UKHSA) to improve noise mapping and estimate health impacts is welcome, *'mapping a harmful pollutant with no clear commitment to reduce it is a wasted opportunity'*. She added that identifying cost-effective interventions to reduce noise exposure should be properly resourced and published, *'given the growing evidence on noise*

pollution's impacts on public health.'

The letter asks Defra to set out what actions it is taking to use noise mapping information to reduce the disease burden from noise pollution in the UK, and to reconsider setting a national target. It also asks the Government to ensure adequate resources and guidance are available for local authorities to manage noise pollution.

Read the full letter here: <https://committees.parliament.uk/publications/43158/documents/214669/default/>

Response to MCS heat pump consultation

Many members of the IOA regularly carry out noise impact assessments of heat pump installations. This was reflected in the attendance of more than 120 members at two consultation workshops considering our response to the Microgeneration Certification Council (MCS) consultation on the MCS 020 Planning Standard for Permitted Development Installations of Air Source Heat Pumps (ASHP). Contributions from workshop attendees informed answers to questions raised in the consultation. These include expressing concerns that the existing permitted development noise limit (described as 42dB(A) at 1m from the nearest neighbouring habitable window) may be too high. IOA is encouraging further research to identify a 'permitted sound level' which would reduce the risk of any effects, including the effect of multiple domestic ASHPs in a residential neighbourhood. The IOA supports publication of additional guidance for installers that may help reduce ASHP noise at the nearest property, as well as guidance for the public illustrating what owners of ASHPs and their neighbours might expect to hear from a correctly installed ASHP.

Read the full consultation response here: <https://www.ioa.org.uk/publications/response-consultations>

Wales: ASHP and permitted development

The Welsh Government has published research examining air source heat pump (ASHP) noise and permitted development rights (PDR). Minister for Climate Change, Julie James, said: "We wish to encourage residents to transition from fossil fuel heating to low carbon alternatives, but without creating noise nuisance." Sustainable Acoustics and Apex Acoustics were commissioned to investigate this distance rationale. Currently in Wales, PDRs allow installation of an air source heat pump at a minimum 3m from a neighbour's boundary, to reduce potential noise impact. Phase 1 of the project found noise is a major factor affecting ASHP deployment. Phase 2 identified issues relating to noise hindering deployment of ASHPs. These included the lack of easily accessible noise data for homeowners and installers. Also, more assistance is required to facilitate installations for terraced and semi-detached houses, which represent the majority of housing. The reports state that further work is required to determine if the current permitted noise target is adequate to deal with protection of quality of life, examining factors like cumulative impacts of multiple units, and variation in noise generated over the seasons. At time of writing the Welsh Government are reviewing the reports.

Read the reports here: <https://www.gov.wales/air-source-heat-pump-ashp-noise-and-permitted-development-rights-wales-phase-1-report-redacted>

<https://www.gov.wales/air-source-heat-pump-ashp-noise-and-permitted-development-rights-wales-phase-2-report>

England/Wales: Energy National Policy Statements revised

The National Policy Statements (NPS) for energy infrastructure were introduced in England and Wales in 2011, to set out planning parameters for nationally significant infrastructure. These have now been superseded by revised versions which came into force on 17 January 2024. These NPS cover the overarching criteria for development of natural gas and electricity generation, renewable electricity generation, gas and oil infrastructure, and electricity networks. The IOA responded to the consultation last year on the revised statements, broadly welcoming the consideration of noise in the overarching statement, EN1. In our response we noted the exclusion of onshore wind from the statements, these are determined by the Town and Country Planning Act. The inclusion of health and wellbeing in relation to noise is particularly welcomed, as is the amended wording proposed by IOA at 5.12.6 to *'an assessment of the effect of predicted changes in the noise environment on any noise-sensitive receptors, including an assessment of any likely impact on health and quality of life/wellbeing where appropriate'* this brings the statement in line with policy in Wales. The 2011 version of the National Policy Statement for Nuclear Power Generation (EN-6) remains in force as DESNZ are consulting prior to drafting a new EN7 to cover nuclear post-2025.

Statements can be found here: <https://www.gov.uk/government/publications/national-policy-statements-for-energy-infrastructure>

England/Wales: Consultation on approach to siting nuclear power stations

The Department for Energy Security and Net Zero (DESNZ) is consulting on a criteria-based approach to new nuclear deployment, a new National Policy Statement EN7, which contains updated criteria that constrain where development can

occur. Alongside this consultation, a draft scoping report on the Appraisal of Sustainability (AoS) and draft methodology report on the Habitats Regulation Assessment (HRA) have been published – both of which cover noise considerations. The consultation closes on 10 March 2024 and we are considering any comments required.

<https://www.gov.uk/government/consultations/approach-to-siting-new-nuclear-power-stations-beyond-2025>

Revised standard for attenuation of outdoor sound

A revised standard for the attenuation of sound during propagation outdoors was published on 31 January 2024 by BSI. This new standard, BS ISO 9613-2:2024, contains updated technical guidance, and cancels and replaces the first edition ISO 9613-2:1996.

The standard is available from BSI and you can read it here: <http://tinyurl.com/bsistandard>

England: Consultation Permitted Development covering ASHP and home extensions

A consultation on changes to Permitted Development Rights in England is now open. This covers proposed changes to planning rules around air source heat pumps (ASHP) and home extensions. For ASHP proposals include removing the 1m rule for installation, increasing the maximum permissible size of an ASHP, and subject to the creation of a methodology to assess noise emissions, permitting two ASHP within the curtilage of a dwelling. Consultation closes 9 April.

<http://tinyurl.com/ashpdevelopmentrights>

WHO: environmental health inequalities and noise

As part of a series of fact sheets on environmental health inequalities, the World Health Organization (WHO) has published a fact sheet covering the unequal distribution of self-reported noise annoyance for the European region – including the UK. Key messages include that in western Europe poorer households suffer more often from environmental noise annoyance than rich ones,

and complaints about environmental noise from neighbours or from the street are a major problem. Rural households generally report fewer complaints than urban households. Suggested mitigation actions include promoting and adopting more sustainable forms of transport to reduce both noise and air pollution, increased implementation of the EU Environmental Noise Directive and WHO's environmental noise guidelines for the European Region, addressing socially disadvantaged groups, and ensuring that action plans to address noise issues at a regional level take potential social inequalities in noise exposure and different vulnerabilities into account.

Read the full report here: <https://www.who.int/europe/publications/i/item/WHO-EURO-2023-8027-47795-70570>

New Briefing: Low Frequency Noise Annoyance

Low Frequency Noise (LFN) issues are often reported in local and national press – hums we've heard of include those in Bristol, Holmfild, and most recently, Immingham. In many cases no source of the sound can be found, and those who hear it may suffer months or years of annoyance or disturbed sleep. Many turn to local councillors, MPs, or the press when the source of the sound remains unresolved. This briefing aims to help increase public understanding of low frequency noise and sets out processes for investigation and routes to finding mechanisms for coping with it where no source can be identified.

Read the new briefing note here: <https://www.ioa.org.uk/news/low-frequency-noise-annoyance-new-briefing-note> ©



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

Auditorium Acoustics 2023 report

Hosted by the IOA in collaboration with the Hellenic Institute of Acoustics in Greece, the 11th International Conference on Auditorium Acoustics was held at the Stavros Niarchos Foundation Cultural Center in Athens on 28-30 September, 2023.

By Raf Orlowski and session chairs.

Above:
Concert at the
Herodes Atticus
amphitheatre

The programme aimed to provide something for everyone. The first day focused on opera houses and in the afternoon, there was a visit to the main opera auditorium in the Stavros Niarchos Centre where delegates could listen to operatic arias by leading singers from the Greek National Opera.

The soprano, Vassiliki Karagianni, and the tenor, Giannis Kalyvas, kindly repeated their arias several times so that delegates could change seats and compare the acoustic quality.

The second day concentrated on concert halls and classical theatres and delegates were again treated to live music – this time by a jazz trio who not only played exciting music but explained the intricacies of playing in a jazz ensemble.

The third day covered auralisation, measurement techniques, theory, and active acoustics. And for those delegates still craving live music, in the evening there was a spectacular

concert at the Odeon of Herodes Atticus where the acclaimed film *Koyannisqatsi* was screened accompanied by a live score by the Philip Glass Ensemble and the Athens Youth Choir.

Special attention was devoted to the poster presentations and as well as providing ample time for reviewing the posters, delegates were invited to assess the quality of the posters by marking a form so that prizes could be awarded at the closing session for the most outstanding posters.

Notwithstanding the musical delights that the delegates enjoyed, there were also culinary delights, especially at the restaurant on the highest hill in Athens, the Lycabettus Hill, which has a wonderful view of the Acropolis. Here the delegates observed a great sunset followed by a full moon accompanied by traditional Mediterranean fare.

There now follows a summary of each of the conference sessions authored by the respective chairs.

Opera house acoustics Chair: Eckhard Kahle

Anders Christian Gade confirmed that the horseshoe-shaped Italian Baroque theatre is still the most common model for new opera halls and that most of its acoustical problems such as focusing have been solved. However, some shortcomings remain such as poor balance between singers and orchestra, and the need for better hearing protection for musicians.

Philip Wright described a series of subjective listening tests in a leading western opera house to establish the effect of key variables in the configuration of the orchestra pit. The results led to suggestions about optimal pit settings for the opera house taking account of repertoire, creative approach, and musician personality.

Gustavo Basso discussed the anomaly experienced in the Teatro Colon in Buenos Aires where the low frequency response is subjectively excellent but the seat-dip effect is measurable. P54

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He proposed that the seat-dip effect, although present, is minimised by the sequence of early reflections containing substantial low frequency energy; he also discussed the architectural features that support this proposition.

Octavio Inacio described detailed acoustic measurements made in the Teatro Nacional de Sao Carlo in Portugal; an opera house that was built in 1793 but that has undergone modifications over the years. Acoustic shortcomings are still evident and the results of their measurements will form a strategy for acoustic improvements.

The design of the Stavros Niarchos Foundation Cultural Center

Chair: Anne Minors

This session was devoted entirely to the design of the Stavros Niarchos opera theatre. The lead acoustician for this project, Alban Bassuet, described the design in terms of a pure opera house but showed how this evolved design, which involves longer reverberation and more open orchestra pits, is compatible with acoustical performances in symphonic halls.

Alban's colleague, Ryan Bizorek, outlined the flexible acoustic systems which include an orchestra shell, variable acoustic curtains, moveable panels and extensive audiovisual infrastructure and distributed sound systems. These enable events both inside and outside the building. The range of events includes pure opera, symphonic music, spoken word, amplified music, and large-scale outdoor events.

The architects for the building were the Renzo Piano Building Workshop and they were represented at the conference by Vassily Laffineur, who described the architectural design and explained how the architects and acousticians worked in close collaboration to achieve a holistic outcome.

Following a visit to the opera auditorium to listen to operatic arias (as mentioned above), the session concluded with a description of the sound isolation systems and HVAC noise control by Rached Abu-Hanson. Abu discussed the box-in-box design of Performance Hall 2 and showed how a low background noise can be achieved even with high diffuser face velocity.

Auditorium acoustics

Chair: Philip Wright

Peter Exton of Marshall Day presented his work on whole stage imaging in theatres. Peter was concerned with the importance of early reflecting surfaces that effectively cover extended sources, showing an ingenious image source digital tool by which the extent of the source image can be seen from arbitrary audience positions.

Tapio Lokki was concerned with the responsiveness of concert halls to musical dynamics, an important dimension of musical experience not directly addressed within standard (e.g. ISO 3382) auditorium parameters nor easily formulated in terms of objective measures, but generally better exhibited in halls with higher reputations. A comparison of the objective formulation and subjective tests, across four halls, supported the essential validity of the approach.

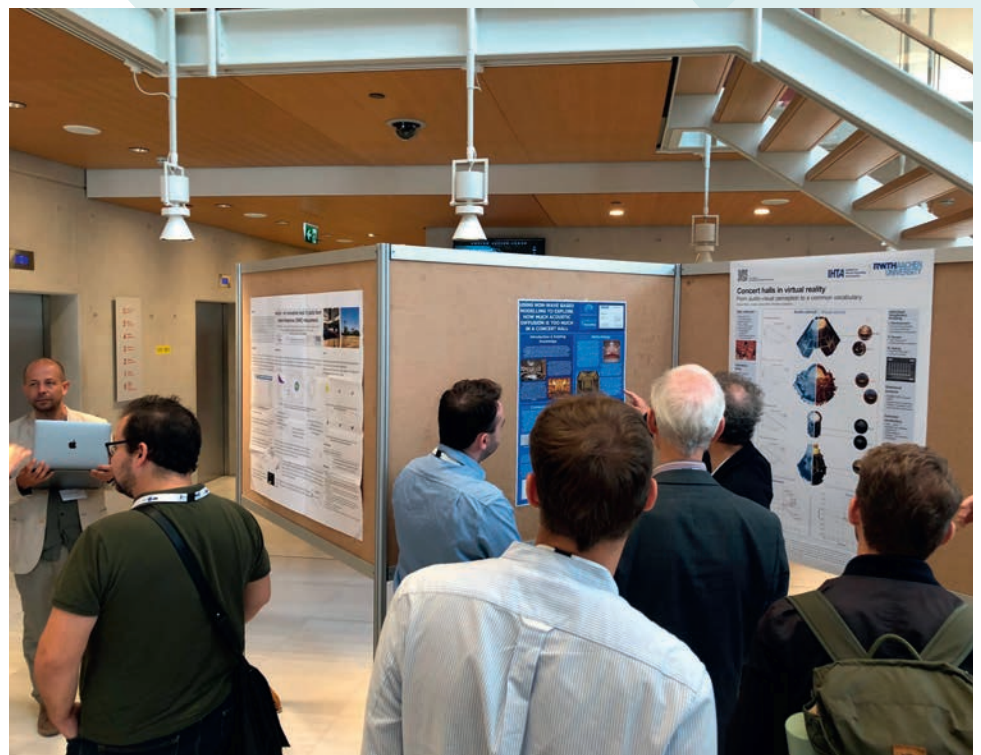
Paul Bavister provided a compelling account of his research which used psychophysiological responses of listeners in a virtual environment, and emotional response as a 'fitness criterion', to evolve organically the spatial form of an ideal auditorium through virtual manipulation and positioning of early reflecting surfaces and overall reverberation, using skin conductance as the measure of the unconscious physiological responses of listeners, monitored in real time.

Yuxiao Chen's presentation provided a zoomed-out contrast, being a meta study of 56 auditoria from around the world, for which she had compared stage view quality (as an overall metric determined on the basis of all audience seat locations in each case) with acoustical quality rating, and considering this as a function of typology (rectangular, horseshoe, fan, and geometric).

Magne Skalevik resumed the examination of actual real-time listening experience, through the perspective of salient features of the binaural signal reaching listeners. Magne considered various binaural metrics, in particular IACC, and showed fascinating traces of fluctuations in cross correlation during an unfolding orchestral musical performance, and dependencies on solo versus distributed instrumental source effects on this, as well as associated considerations of fluctuation of perceptual parameters such as source broadening, localisation, and envelopment.

Evan Green was concerned with the scale of early reflecting surfaces required to provide good bass quality and fast recovery from the seat dip effect. He focused on architectural features such as balcony overhangs, commonly used to promote mid and high frequency reflections, and the scale necessary to extend support to

Below:
Delegates study
Michael Fort's
poster at the
Poster Session



bass notes. Using two dimensional BEM simulations Evan showed the relative effects of different scales of projection, and equally, the likely occurrence of highly directional reflections from individual elements owing to interference effects, pointing to the need to blend contributions from an ensemble of elements to provide even support.

Concert hall acoustics

Chair: Mike Barron

A frequent task for a chairperson is to summon one's audience, to break up discussions in the foyer. With listeners in place, Toshiki Hanyu talked about the subjective issues linked to reflections from the rear wall in rectangular halls. He had conducted subjective experiments using a simulation system in an anechoic chamber. Employing a dissimilarity technique, he found a good correlation between his primary dimension and the late lateral level. Reflections from the rear are acceptable for audiences if above threshold but below the level responsible for echo disturbance. The latter can be influenced by prior reflections. Meanwhile many musicians appreciate late reflections returning to the stage.

Eckhard Kahle considered more 'global' issues for larger concert halls (more than 1,500 seats). Regarding early reflections, he demonstrated the need for more than one significant reflection. One technique is to have non-horizontal balcony soffits to increase the area

receiving a cornice reflection. In the case of the late sound, reflections arriving at listeners laterally or from behind are desirable. Placing an emphasis on early reflections may require a longer reverberation time to provide sufficient reverberance. The challenge of course is to apply these principles over the whole seating area.

From 'global' to 'specific', John O'Keefe looked at optimisation of geometric reflector profiles. Starting from a series of Non-uniform Rational B-Spline (Nurb) curves, he has now replaced a computationally expensive technique with a genetic algorithm which permits an efficient generation of an optimised reflector. John chose a balcony front reflector that was initially semi-cylindrical for optimisation and showed how this led to an improved coverage of vision of the source area from the selected receiver area.

Alexandros Galatas was concerned with optimisation to achieve a regular distribution of reflections from large, curved surfaces. Theory demonstrates that the optimum shape is often close to a parabola. The theory he provided can also be used for stepped profiles and extended to 3D analysis. Examples concentrated on an optimum profile for the ceiling, though could equally well be applied to side walls.

Such ceiling profiles have been tried in the past and include risks — focusing by concave surfaces and in reverse, focusing audience noise onto the stage (although short sections can be acceptable).

Bob Essert and Anne Minors presented a brief appreciation of the late consultant, Russell Johnson (1923 – 2007). They recounted how Russell began his working life with Bolt, Beranek and Newman, at the time when concern arose over the acoustic failure of Philharmonic Hall, New York (1962). He subsequently set up the Artec consultancy, based in New York. His consulting life can be summarised by two major contributions — insistence that acoustic advice be followed and not ignored by architects, and the return to the traditional rectangular hall. His well-known designs include the McDermott Concert Hall, Dallas of 1989, and Birmingham Symphony Hall (1991), England.

Concert hall acoustics

Chair: Anders Gade

Gunter Engel described the recent acoustic improvements to the concert hall in the Sydney Opera House. They involved the installation of new acoustic reflectors, stage risers and diffusing timber cladding. He also showed how the changeover times between classical and pop concerts have been considerably shortened by acoustic measures, which can reduce reverberation at the touch of a button.

JA Nepomuceno reported on the latest acoustical alterations made to what is now called the David Geffen Hall in New York but was originally named the New York Philharmonic Hall when it opened in 1962. The original hall was heavily criticised for its poor acoustics, which led to a major reconstruction in 1976, although, in time, this was also claimed to have inadequate acoustics. The latest renewal, completed in 2022 is already achieving acoustical acclaim.

Petri Lehto outlined the fine tuning of the Sibelius Hall stage acoustics. Variable elements comprised a mobile orchestral canopy, variable volume via opening doors and absorbent curtains. Experimentation involved detailed acoustic measurements and orchestral performances where the musicians had to fill in questionnaires. The results enabled the design of acoustical set-ups for different sizes of ensemble.

Svein Folkvord discussed challenges with a highly absorptive stage environment with regard to the listening experience and the dynamics of amplified music. He explained that the usual solution of a highly absorbent stage influences the overall ensemble dynamics and this is often not helped by having to rely on monitor sound. Svein then went on to demonstrate his concepts by bringing the Norwegian jazz band, Subtrio, onto the stage, comprising baritone saxophone, double bass, and drums. As well as playing some fantastic jazz pieces, Svein explained the complexities of playing in a jazz ensemble. The delegates were also able to hear for themselves the difference between an absorbent stage and a largely reflective stage. This was certainly one of the highlights of the conference. P56

Below:
Professor Tapio Lokki



Classical theatres

Chair: Raf Orlowski

Panagiotis Karampatzakis reviewed the connection between iconography and reverberation in Byzantine temples and observed that more complex geometries tended to reduce reverberance which was beneficial for worship.

Ian Rees addressed the intriguing question about the acoustic quality of the ancient theatre at Epidaurus when it was fully occupied. Using measurements and computer modelling, he presented his results which led to a lively discussion focused principally on the directionality of computer sources.

Konstantinos Dadiotis described the design of a new amphitheatre based on ancient Greek models in the windy city of Andros. The new venue hosts the International Festival of Andros and care was taken in the design to ensure minimum impact on the urban soundscape.

Theo Niaounakis described the design of a 600-seat underground amphitheatre housed in an iconic building which is the home of the Athens Conservatoire. The acoustic design was directed at providing appropriate conditions for the performance of chamber music and sinfoniettas.

Small auditoria/ rehearsal rooms

Chair: Henrik Moller

The session consisted of four papers, three of which were case studies essentially and the last a description of a new material or system for variable acoustics.

1. A 350-seat concert hall auditorium with 'budget' version concrete side walls: acoustics design and performance by Andrzej Klosak. (An example of tight budget concert hall design, with creative use of cheap materials such as concrete).
2. In-situ acoustic efficiency of variable broadband absorption in music rehearsal studios and music halls by Maarten Luykx. (A presentation of rather elaborate variable acoustic surface in three different rooms).
3. Optimising (too) small ensemble rehearsal rooms for acoustic loud music by Bård Støfringsdal. (Converting an industrial type building into a rehearsal



Above:
The Stavros
Niarchos
opera house

hall for a large brass band, discussing the trade-off between reverberation and listeners' levels (noise levels)).

4. The research behind the design of a new variable acoustics technology by Niels W. Adelman-Larsen. A new design for a variable surface which, first of all, shows a very large variability of bass absorption and more freedom of design regarding the visual surface than previous 'commercially available' products).

Measurements

Chair: Tapio Lokki (who renamed this session as 'Auralisation')

Brian Katz presented a paper on scale models. He covered new solutions for miniature transducers, both small omni sources as well as small microphones, even a 1/10 scale 3D printed dummy head. The most interesting part of his presentation was a real-time system to listen to scale models. The signal processing steps include shifting the microphone signals to 10x higher, reproduce and record that in the scale model and then shift the frequencies back to the audible frequencies. All that is done in real-time, allowing interactive studies of room acoustics with scale models. More information and some open source software are available here: <https://smallroomz.dalembert.upmc.fr/>

Takayuki Hidaka presented their ambitious work on scale model auralisations, including

laser-induced breakdown acoustic pulses as sound sources and a robot-controlled movable miniature microphone to act as a microphone array. In addition, they have done new anechoic symphony orchestra recordings (musicians one-by-one in an anechoic room) and with this new technology they can auralise a concert hall scale model with symphony music.

Sarabeth Mullins presented her PhD work on real-time auralisation of multiple singers. With the implemented system, four singers could sing together in an anechoic room so that they hear their singing auralised with the measured acoustics of the Cathédrale Notre-Dame de Paris. The singers use open headphones which enables the auralisation of spatial sound.

The last presentation was by Prof. Jens Ahrens on open source tools for auralisation of room acoustics modelling results. He has implemented functions with which wave-based room acoustics modeling results with hundreds of adjacent nodes can be auralised by transfer to a spherical harmonic representation or direct binaural format. Such a framework allows a pipeline of volumetric sampling for obtaining a spherical harmonic representation of the simulated sound pressure field that is rendered binaurally. The software toolbox as well as a variety of anechoic and reverberant binaural audio examples are available here: <https://github.com/AppliedAcousticsChalmers/auralization-toolbox>

Measurements and theory

Chair: **Evan Green**

The Measurements and theory session began with a fascinating and enlightening presentation on acoustic measurements by Ingo Witew, summarising his decades of research into the uncertainties present at every step of the measurement process. Two key results were that source directivity is the most significant contributor to measurement uncertainty, and microphones must be placed with 20-25cm accuracy for repeatable measurements!

Mike Barron illustrated a theoretical relationship between the two principal parameters related to early spatial impression, namely, early lateral energy fraction ELEF and inter-aural cross-correlation coefficient IACC. While the theoretical relationship would seem to be valid, some anomalies remain, such as the fact that zero spatial impression does not correspond to a zero value of measured $(1 - IACC)$.

As Ning Xiang was not able to make the conference, Jean-Dominique Polack completed the session by presenting two papers on sound energy decay processes. His own presentation showed that, contrary to the Sabine and Eyring formulae, it is possible to develop reverberation time formulae which do take the shape and relative variance of the free paths into account.

Intelligibility

Chair: **Alban Bassuet**

Bob Essert discussed combining natural acoustics and audio in a debating chamber. He outlined a multipath model which considers the sensitivity of speech to the various components involved. He concluded that achieving STI criteria in an empty room may not be sufficient to evaluate speech intelligibility.

Byron Harrison set out the challenges of maintaining speech intelligibility in in-the-round theatres referencing Chicago's newest in-the-round theatre, The Ensemble Theatre. He discussed the key design parameters and the traditional and non-traditional design metrics used to evaluate the design options.

Onur Gulen described the acoustic design of the Shakespeare North, a Jacobean theatre in Liverpool, UK. The design was based on an historic timber construction within which timber panelling was introduced to provide both absorption and diffusion. The acoustic detailing was based on ray tracing modelling which was shown to be in accord with the completed building.

Anne Minors' paper had the intriguing title of 'Covid, Separation and all the Jazz'. The first project she described was designed during the pandemic; it involved the repurposing of arsenal buildings into orchestral music and dance rehearsal spaces. The design had to cater for smaller numbers initially whilst allowing for full capacity at a later stage. The second project involved the creation of a 100 seat performance space, recording studio and practice rooms within a two storey commercial block.

Active acoustics

Chair: **Bob Essert**

Henrik Moller described room acoustic measurements in halls with electro-acoustic enhancement systems. The measurements involved examining three types of enhancement system in various halls namely, in-line, feedback, and combination types. The sound source was a scaled down version of the virtual orchestra as described by Patynen et al. The results presented an intriguing insight into the performance of these systems.

Volker Werner presented an evaluation of a geometric approach to active acoustics. Experiments were conducted in a 50m² test laboratory in which 36 speakers and 12 microphones were evenly distributed to create several settings with different spatial properties. The results were evaluated by musicians and acousticians as well as comparing them with ISO 3382 criteria.

Benedict Ross compared musical performances in different acoustic environments created with an active acoustic system. A hybrid active system was installed in a 180m² hall with a 0.5s RT; the system was set with different acoustic presets having acoustic properties comparable to typical concert halls. Objective and subjective results suggested that the dynamic range was the most prominent parameter.

Pauline Heister discussed the significance of excellent concert hall acoustics for audio recordings of classical music. She examined the effects of Covid on concert recordings and streaming where the orchestral players had to separate themselves from each other and also to perform with no audience. She concluded by saying that the audiences had no idea of the difficulties encountered by musicians and recording engineers.

Perttu Laukkanen described the acoustic design of a 15,000-capacity multipurpose arena in Tampere, Finland. Although the arena is multipurpose, the design focused on its use for amplified music performances using extensive room acoustic modelling to optimise the sound in all seating areas. The outcome has elicited positive feedback from audiences. 🎧



Left:
VR demonstration

Supporters of the conference included the International Commission for Acoustics, the Acoustical Society of America, the UK Acoustics Network, Knauf, Flex Acoustics, the KP Acoustics Group and Gerriets.

Sound insulation of suspended ceilings:

A finite element method-based comparison of suspension systems

Suspended ceilings are an often-applied solution to improve sound insulation between overlapping spaces, and they are also used in different room-within-a-room applications.

By Jesse Lietzén, Ville Kovalainen, Lauri Talus, and Mikko Kylliäinen, all of AINS Group, Department of Acoustical Engineering, Finland, with Aitor Lopetegui and Ander Aldalur, both of AMC Mekanocaucho, Spain

In general, the suspended ceiling systems consist of three essential parts:

- 1) one or several layers of building boards;
- 2) a frame behind the boards for the board installation; and
- 3) a suspension system, i.e. hangers attached to the frame to support the ceiling from the bearing floor slab.

Frequently, the building boards used in the system are plasterboards or wood-based board products, and the frame consist of metal or timber profiles. The hangers used to suspend the ceiling are either *elastic* or *rigid* (i.e. very stiff in comparison with the elastic hangers). Together, these parts form an airspace between the bearing structure and the ceiling, which is usually attenuated, e.g. with a mineral wool.

To simplify the acoustical behaviour of the solution, the suspended ceiling together with the bearing structure, either a concrete or a timber slab, constructs a mass-spring-mass system. Again, two different behaviour types can be identified from the system, namely the acoustical coupling between the bearing structure and the ceiling boards through the (attenuated) airspace, and

the mechanical coupling of the respective parts via the hangers and the frame¹. If the airspace is sufficiently attenuated and large, the sound insulation of the structure will mostly be limited by the mechanical coupling rather than the airspace¹.

An appealing solution to improve both airborne and impact sound insulation performance of a suspended ceiling is to use an elastic suspension system. This way, the mechanical coupling through the hangers can be reduced and the sound insulation of the entire floor structure improved. According to laboratory measurements on a concrete slab^{2, 3}, the improvement of sound insulation achieved with the ceiling increased, when elastic hangers were used instead of rigid ones. The improvement was apparent in the frequencies above 100 Hz. The purpose of this article is to further study the behaviour of differently suspended ceilings and to ease the comparison of hangers even in the low-frequency range below 100 Hz. This has been carried out with simulations where the abovementioned phenomena were investigated. We created simulations applying the finite element method (FEM) and parametric calculation models

to predict both the airborne and impact sound insulation of a laboratory concrete slab with two differently suspended ceilings. In addition to rigid hangers, the ceilings were suspended with elastomer hangers.

Materials and methods

Suspended ceilings

Studied floor structures

We studied the sound insulation of two floors (F1 and F2) equipped with suspended plasterboard ceilings installed below a concrete slab (Figure 1). Two 13mm thick plasterboards were hung from a 140mm thick concrete slab with different suspension systems; rigid hangers (F1), and AMC Mekanocaucho's elastic elastomer hangers (F2). In the studied cases, the air gap between the concrete slab and the plasterboard was 130mm including a 100mm layer of mineral wool. Additionally, we assessed the sound insulation of the bare reference concrete slab (F0) to study the improvement of the sound insulation (both ΔR and ΔI) achieved with the ceilings, and the floor (F3) equipped with the ceiling without any mechanical coupling between the layers.

The configuration of the structures F1–F2 was otherwise the same in all situations but

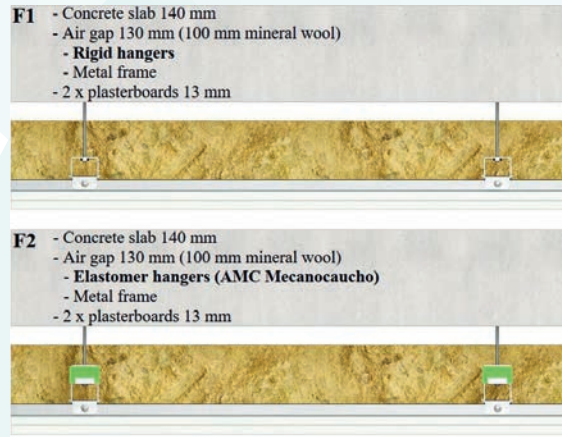
the type of the hanger changed. The hangers were attached to the concrete slab by threaded steel rods with diameters of 6mm. The spacing of the hangers was 1,200mm along the metal frames and 600mm in the perpendicular direction corresponding the frame spacing. The height of the metal frame was 18mm and width 45mm. The plasterboards ($m' = 9 \text{ kg/m}^2$) were attached to the metal frames with screws.

The rigid hangers were relatively stiff, but the elastomer hangers acted elastically. The natural frequency f_0 (of a mass-spring system) for the elastomer hanger was 11.5 Hz, when the mass per hanger was 8.5 kg. This mass corresponds the total mass from the plasterboards divided for each 32 hangers in the ceiling. Spring constant for the elastomer hanger 44 400 N/m.

Improvement of sound insulation with the ceilings

Previously, the airborne and impact sound insulation of structures similar to the floors F0–F2 were measured by a building acoustics laboratory^{2,3}. To distinguish the measured structures from the studied ones, the measured floors were denoted as F0 lab... F2 lab, respectively. The floor F1 lab, however, differed from the studied floors here in that the air gap between the concrete slab and the plasterboards was 100mm, and the hanger spacing was 600mm in both directions. In this case, the measurements were carried out in the frequency range 100–5000 Hz². For the structures F0 lab and F2 lab, the measured frequency range was 50–5000 Hz³.

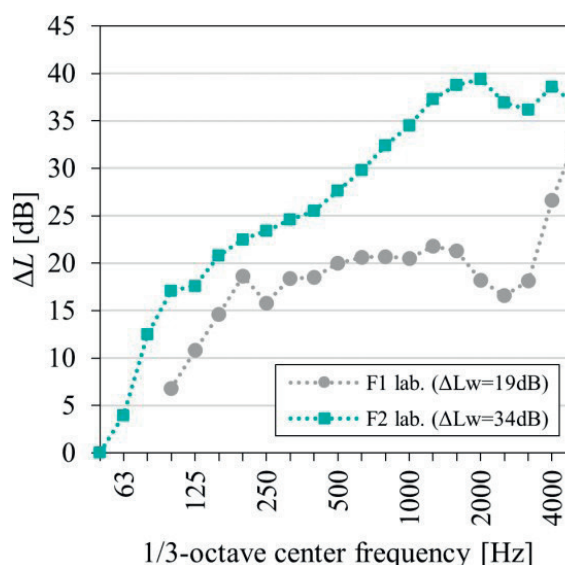
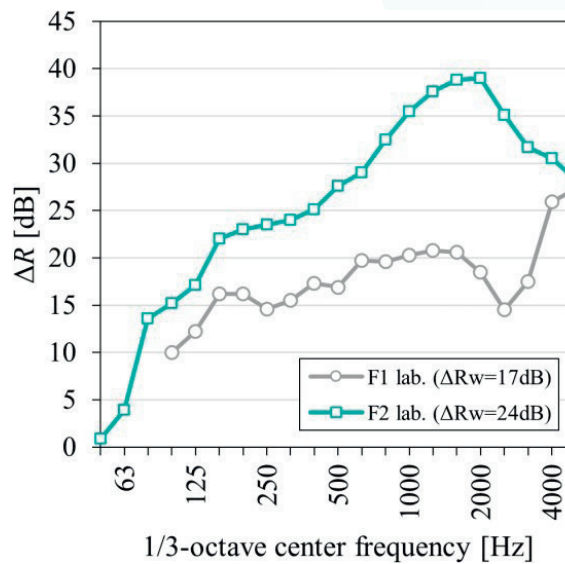
Based on the laboratory measurements^{2,3}, improvements of the sound insulation gained with the suspended ceilings were determined for F1–F2 lab. Measurement results for the improvement of sound reduction index (ΔR) are illustrated in Figure 2 and for the reduction in impact sound pressure level (ΔL) in Figure 3. Additionally, Figures 2 and 3 give the improvement in single-number quantities (SNQs) ΔR_w and ΔL_w according to standards ISO 717-1⁴ and 717-2⁵. The weighted sound reduction index R_w of the bare slab F0 lab was 56 dB and the weighted normalised impact sound pressure level $L_{n,w}$ 77 dB.



Above: Figure 1: Floor structures F1 and F2. Additionally, a mechanically fully uncoupled floor F3 was studied

Below: Figure 2: Measured improvement of sound reduction index ΔR and ΔR_w for the ceilings of the floor structures F1–F2 lab

According to Figures 2 and 3, the results for ΔR and ΔL are highly dependent of the suspension system. The improvements in SNQs ΔR_w and ΔL_w were 7 and 15 dB higher for the ceiling of the floor F2 where the elastic suspension system was used in comparison to the rigid one (F1). These differences cannot fully be justified with the differences of the ceiling configurations discussed above.



Simulation procedures and model descriptions

The airborne and impact sound insulation of the floor structures F0–F3 was evaluated through simulations. The simulation models were used to study the phenomena affecting the acoustical performance of the three different suspension systems. The simulations were carried out by applying FEM using COMSOL Multiphysics 6.1 in the 1/3- octave frequencies 50–200 Hz and supplemented with parametric calculation models for airborne and impact sound insulation developed by AINS Group in the 1/3- octave frequencies 250–5000 Hz.

FEM simulations

The FEM simulations were performed in frequency domain by applying a fully coupled multiphysics problem with a two-way interaction between the structural and acoustical domains. In the structural domains, i.e. concrete structures, plasterboards and metal parts, the governing partial differential equation of motion (without the volume force part) was:

$$(1) \nabla \cdot \mathbf{S} = -\rho \omega^2 \mathbf{u}$$

where \mathbf{S} is the second Piola-Kirchoff stress tensor, ρ is material density, $\omega = 2\pi f$ is the angular frequency, and \mathbf{u} is the displacement⁶ [6].

The governing equation in the acoustical domains (airspace) was the Helmholtz equation:

$$(2) \nabla \cdot \left(-\frac{1}{\rho_0} \nabla p \right) - \frac{\omega^2 p}{\rho_0 c_0^2} = 0$$

where p is the time-harmonic sound pressure, and ρ_0 and c_0 denote the air density (1.21 kg/m³) and the speed of sound in air 343 m/s, respectively⁷ [7].

Additionally, the poroacoustical domains, namely the mineral wool inside the airspace of the suspended ceilings, were modelled as an equivalent fluid by applying the modified Allard and Champoux model^{7,8}. Thus, the Helmholtz equation governed also in the

Left: Figure 3: Measured reduction in impact sound pressure level ΔL and ΔL_w for the ceilings of the floor structures F1–F2 lab

poroacoustical domains, but the Eqn. (2) was solved with modified complex values for the density and speed of sound in the material.

In addition to the model of the structures, the FEM models included a half-infinite receiving airspace below the structures to solve the sound power radiation directly with FEM. The fully absorptive boundary conditions for the airspace were achieved with perfectly matched layers.

First, the models were applied to solve the sound reduction index R . The upper surface of the concrete slab was excited with a diffuse sound field by generating a sum of N plane waves with random phases and an even distribution over a half sphere over the surface⁹ with sound power P_{dif} . The model was used to solve the sound power $P_{rad,air}$ radiating into the receiving airspace below structures. The sound reduction index was determined from the sound powers:

$$(3) R = 10 \log \left(\frac{P_{dif}}{P_{rad,air}} \right)$$

Secondly, the FEM models were used to evaluate the normalised impact sound pressure level L_n of the floor structures. The floors were excited by point forces representing the impact force excitation generated by the ISO tapping machine¹⁰. The sound power $P_{rad,imp}$ radiated by the structure was solved, and the normalised impact sound pressure level was determined as:

$$(4) L_n = 10 \log \left(\frac{P_{rad,imp}}{P_0} \right) + 10 \log \left(\frac{A_{ref}}{A_0} \right)$$

where $P_0 = 10^{-12}$ W is the reference sound power, and A_{ref} and A_0 denote the reference sound absorption areas of 4 and 10m², respectively. Thus, a perfectly diffuse sound field in the receiving room was assumed.

Parametric calculation models

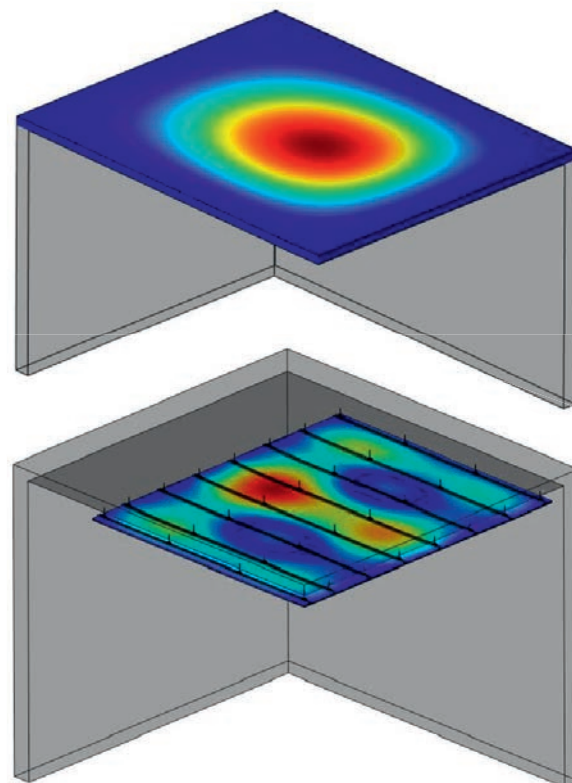
Parametric calculation models by AINS Group were applied to evaluate both the airborne and impact sound insulation of the structures in the high-frequency range. The parametric model applied in this case for the airborne sound insulation is based

on references^{1, 11, 15}. The model takes into account, e.g. the mass and stiffness of structural layers, absorption materials inside the structure, the stiffness of studs and frames. The parametric calculation model for the impact sound insulation is based on references¹⁶⁻²⁰. In addition to the abovementioned features of the parametric model for the airborne sound insulation, the impact sound insulation model considers the force interaction between the ISO tapping machine and the floor.

Simulations

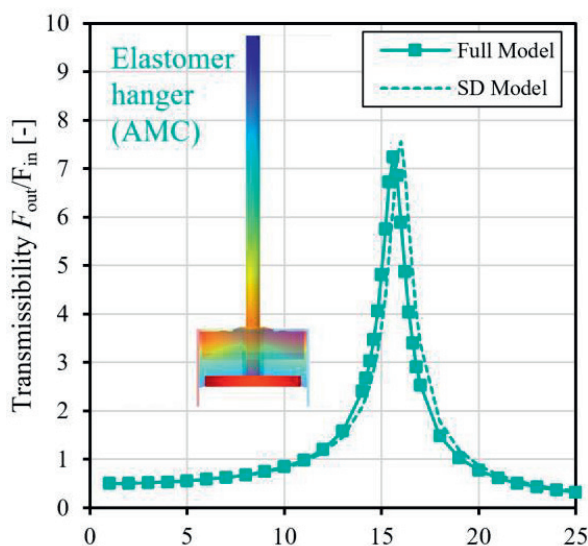
The computational models were validated by comparing the simulation and measurement results on the bare floor structure F0 and the floor F2 with elastically suspended ceiling (presented in reference 3). The validated models were further applied to simulate the sound insulation of the floors F1 and F3. Elastic material properties for all the parts in the floors were not available, but the parameter values (density ρ , elastic modulus E , Poisson's ratio ν , structural loss factor η_s) presented in Table 1 were applied in the simulations to model the structural parts as isotropic elastic materials. Additionally, it was presumed that the static airflow resistivity of the mineral wool was 15 000 Pa·s/m². Most of the materials in the FEM simulations were modelled as solid domains, however, the metal frames were modelled with shell elements. As an example, the computed displacements of the floor structures F0 and F2 have been illustrated in Figure 4.

To account for the hangers in the FEM models, spring-damper components were applied to connect the metal frames to the concrete slab, as previously done by Kohrmann et al.^{21,22}. The validity of the simple spring-dampers was assessed by comparing the transmissibilities of mass-spring-mass systems for the fully modelled elastomer hangers and by replacing the models with the spring-damper



Above: Figure 4: Simulated displacements of the bare floor structure F0 (above) and the floor F2 with the suspended ceiling (below) at 18 Hz, when the concrete slab was excited with diffuse sound field

components (Figure 5). According to the comparison, the equivalency between the full and simple models was reasonable. The peak in Figure 5 represents the f_{msm} of the modelled systems (rigid masses of 8.5kg at both ends) for the elastomer hanger. In case of the rigid hanger, the respective f_{msm} was 454 Hz. P62



Above: Figure 5: Transmissibility comparison of fully modelled and spring-damper (SD) elastomer hanger (AMC) together with the simulated displacements at the resonance frequency f_{msm}

Material	ρ [kg/m ³]	E [MPa]	ν [-]	η_s [-]
Concrete	2,320	30,000	0.2	0.006*
Plasterboard	720	2,600	0.3	0.01
Steel**	7,850	210,000	0.3	0.005

* Total loss factor was fit in validation to match airborne sound insulation measurement

** Metal frames and steel in hangers

Above: Table 1: Applied elastic material properties

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Results

Validation results

Comparison between the simulated and measured sound reduction indices R of the floor structures F0 and F2 is shown in Figure 6, and for the normalised impact sound pressure L_n in Figure 7. The comparisons show that the simulation models enabled accurate evaluation of the sound insulation of the bare floor. The measured and simulated R_w differed 1 dB and 4 dB in case of floors F0 and F2, respectively. The respective differences for $L_{n,w}$ were 0 dB and 2 dB. Slight discrepancies between the simulation and measurement results for the L_n were prominent in the low and mid-frequencies. In case of R , the differences were minor, but at their highest in the mid-frequencies. Due to the good correspondences, the simulation models for the R and L_n were regarded as valid.

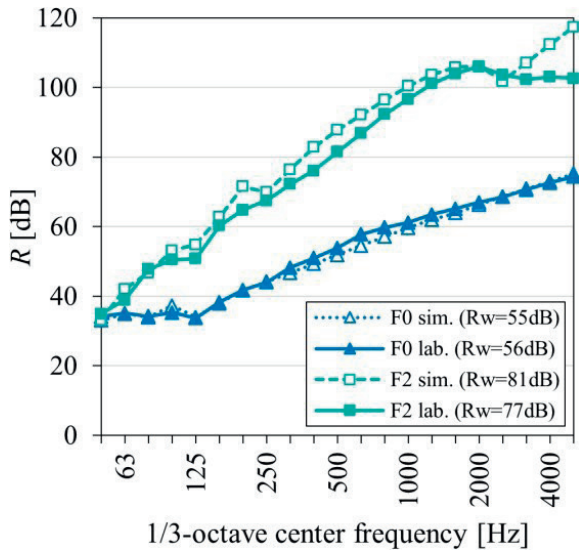
Improvement of sound insulation

The validated models for F0 were further applied to simulate the behaviour of the suspended ceilings. The derived improvement of sound reduction index ΔR and reduction in impact sound pressure level ΔL are shown in Figures 8 and 9, respectively, to illustrate the performance of the ceilings for the floors F1–F3. The weighted sound insulation improvement values presented in the figures were calculated according to the standard series ISO 717^{4,5}. The hangers were modelled as spring-damper components as discussed in Section 2.3.

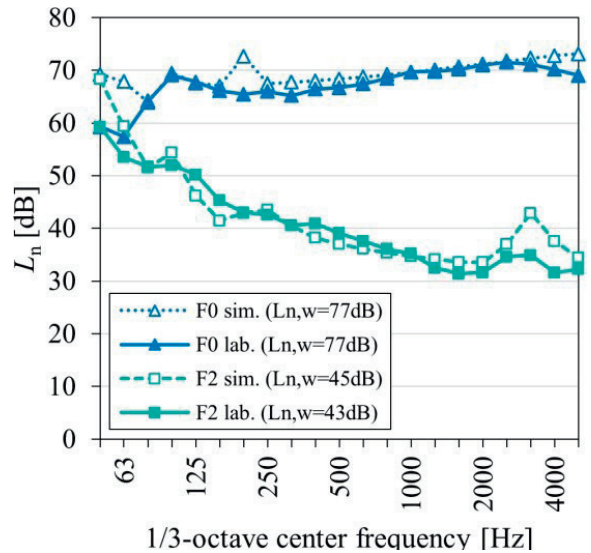
The results presented in the Figures 8 and 9 show distinctive differences between the performance of rigid and elastic suspensions systems. The elastic hangers enable over 10 dB improvement to the performance of the suspended ceilings in comparison with the

rigid hangers. The differences are prominent in the frequency range 50–5000 Hz. In case of elastic hangers, the differences in ΔR and ΔL were minor because of the close values for f_0 . However, it is notable that the simulated ΔR and ΔL values were greatest for the elastomer hanger and close to the performance of the mechanically fully uncoupled ceiling (F3).

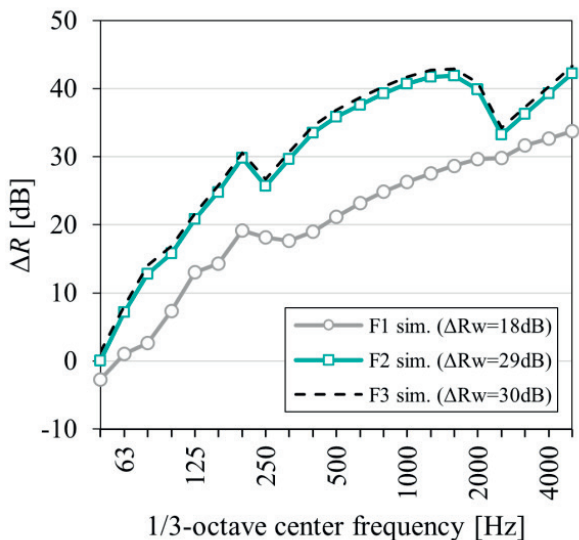
In case of the elastomer hanger, a full 3D model of the hanger was also applied in FEM simulations for sound reduction index R to study the low-frequency behaviour of the hanger in comparison with the spring-damper components. In the low frequencies between 50–200 Hz, the differences between the ΔR and ΔL of the elastically suspended and the fully uncoupled ceilings were approximately 1 dB (Figures 10 and 11). It is also evident that the rigid hangers decrease the ΔR values above 50 Hz. P64



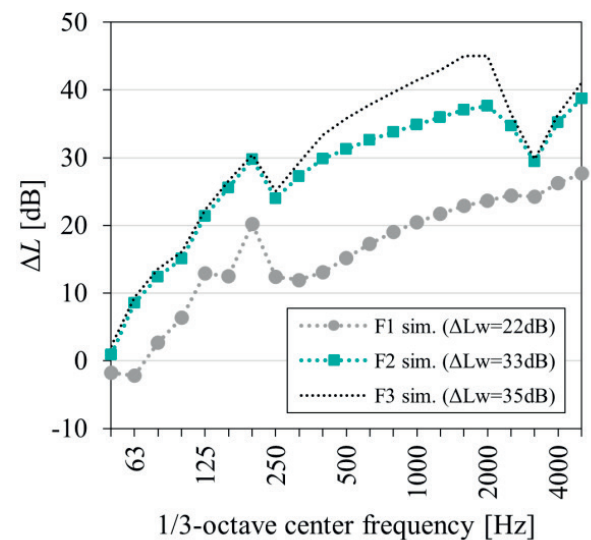
Left: Figure 6: Validation results of the floor structures F0 and F2 for sound reduction index R and R_w .



Right: Figure 7: Validation results of the floor structures F0 and F2 for normalised impact sound level L_n and $L_{n,w}$.



Left: Figure 8: Simulated improvement of sound reduction index ΔR and ΔR_w for the ceilings of the floor structures F1–F3.



Right: Figure 9: Simulated reduction in impact sound pressure level ΔL and ΔL_w for the ceilings of the floor structures F1–F3.

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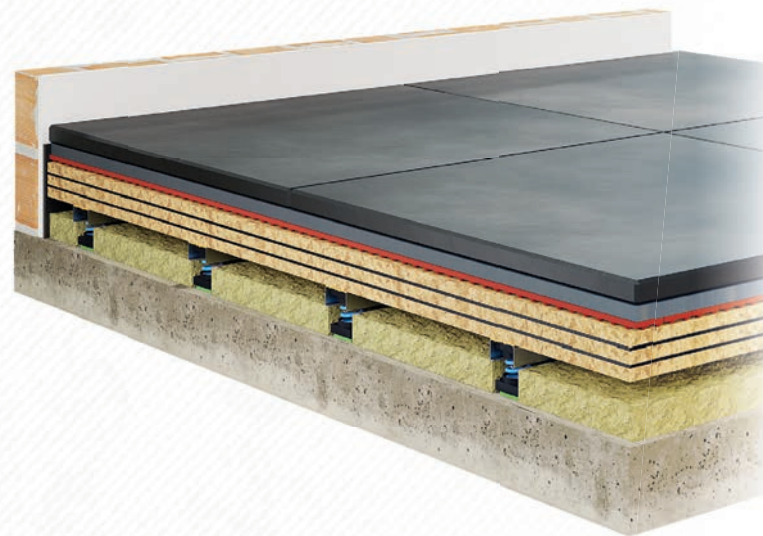
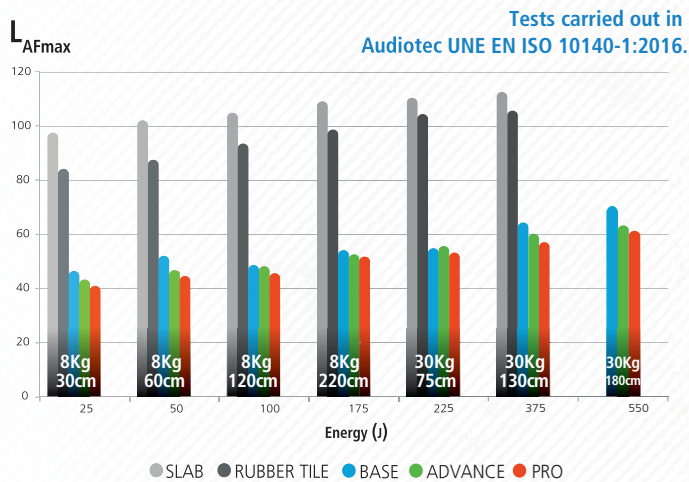


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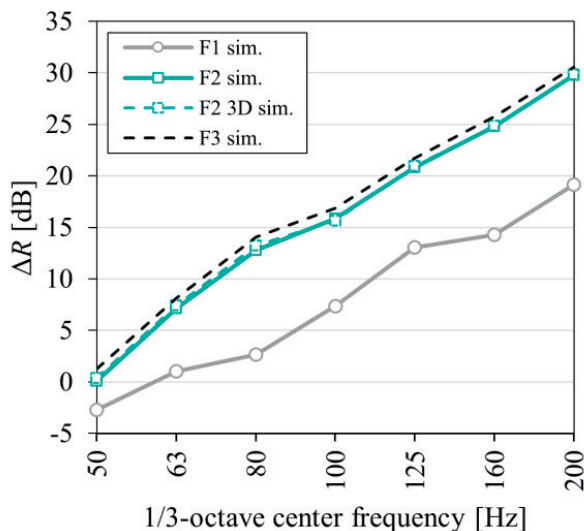
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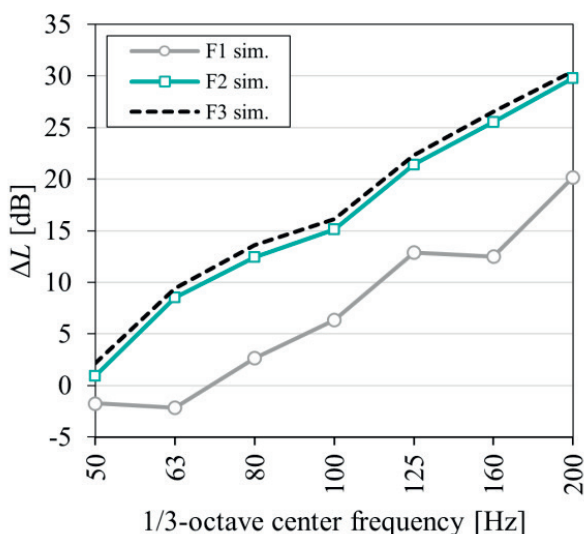
Discussion

The measured sound reduction indices R of the floor structure F2 were rather high and close to maximum measurable values obtainable at the facility above 400 Hz³. This could indicate that flanking sound transmission may alter the overall performance measured and hence lower the achieved sound insulation values in the laboratory. Moreover, measuring such high sound reduction indices demands great sound power levels in the sending room. The presented measurements for the floor structure F1² are not fully comparable with the newer measurement of structure F2 since the overall cavity thickness and the hanger spacing was different. However, based on the measurement results it is evident that ΔR and ΔL were close to each other.

The simulated sound insulation improvements ΔR and ΔL (Figures 8 and 9) were comparable with the measurement results (Figures 2 and 3) for the floor F2 even though it should be noted that exact material parameters and dimensions were not known in all respects. Only minor differences were observed between rubber and elastomer hanger suspension systems where the estimated difference between f_0 was only about 3 Hz. This is in line with a simple transmissibility model¹⁵ which estimated the difference to be around 1 dB generally in this case. However, the differences in the hanger performances seen from Figs. 2 and 3, cannot fully be explained by the discrepancies between the measurement situations in references [2 and 3].



Above: Figure 10: Simulated improvement of sound reduction ΔR in low frequencies for the ceilings of the floors F1–F3



Above: Figure 11: Simulated improvement of sound reduction ΔL in low frequencies for the ceilings of the floors F1–F3

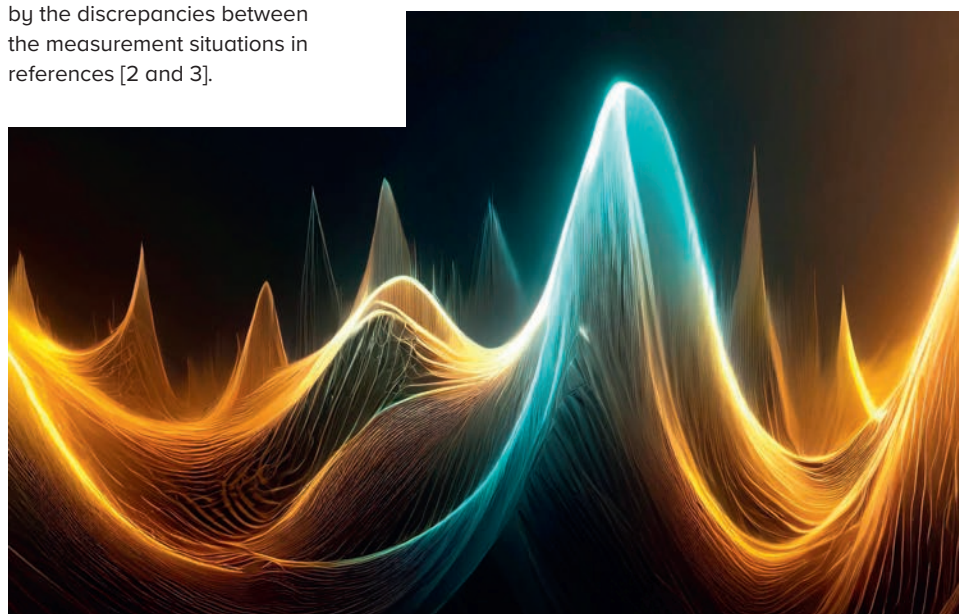
An idealised point-point connection involving spring-damper components proved to accurately describe the hanger behaviour in low frequencies (Figure 10). The inclusion of an accurate elastomer hanger geometry (in F2 3D) did not affect the improvement ΔR below 200 Hz. Thus, simplifying the hanger geometry (and probably the material parameters) into an ideal spring-damper seemed justified in the low-frequency range. Only minor differences are observed between elastic suspension systems. The stiff hanger system F1 will differ from other simulations starting at 50 Hz, but more prominently at 63 Hz.

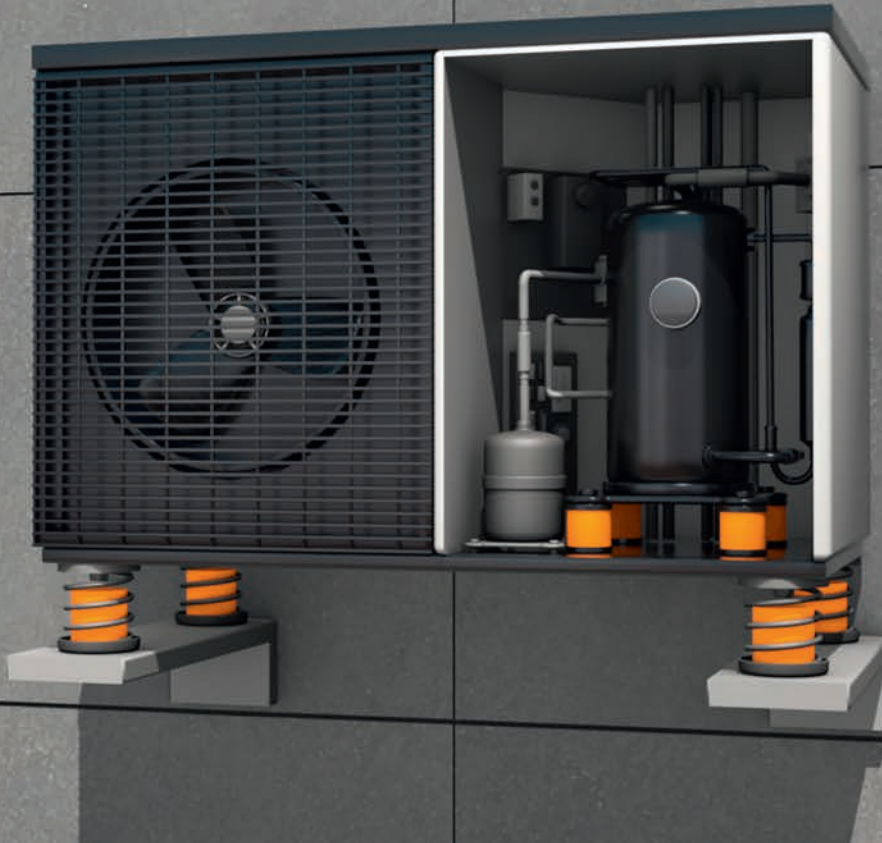
Using the parametric models requires simplifications to the real geometries of the floor structures F1 and F2. The parametric model cannot accurately describe a connection between plates (concrete slab-plasterboards) where the connecting force is not symmetric and the ceiling frames are not accounted for. Hence, a moderate estimation is most likely achieved. The uncertainties caused by the simplifications can be seen from ΔR and ΔL results (Figures 8 and 9) around the coincidence frequency of the plasterboards in the 1/3-octave bands 2500–3150 Hz. Additionally, uncertainty is assumed to involve the possible frequency-dependent material characteristics.

Conclusions

In this article, we assessed the sound insulation behaviour of two differently suspended ceilings and compared the results to the performance of the fully uncoupled ceiling. According to the results, it is beneficial to suspend the ceilings with elastic hangers. This improves the ceiling performance with more than 10 dB, and the improvement is prominent even at very low frequencies. Thus, the results confirm the efficiency of the elastic hangers in comparison with the rigid ones.

By using the different modelling techniques (spring-damper components and fully modelled hangers) it was observed that at least the lowest resonance frequency of the hangers should be known when designing suspended





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ceilings. However, differences in geometry and elastic material properties between hanger models may become a more prominent

and important factor when especially high sound insulation values are to be achieved. In case of the ceiling suspended with the

studied elastomer hangers (F2), the addition of accurate geometry had no effect on the ΔR and ΔL results. ©

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London Branch

IOA Diploma best final project course 2022-23 at London South Bank University, receives NTI-Audio award

By Dr Luis Gomez-Agustina (FIOA), course director of IOA courses at LSBU



Above: (L-R) Charles Greene, Dr Luis Gomez-Agustina, and Rebecca Page

As it is customary at the IOA January London Branch meetings, some of the best IOA Diploma student final projects undertaken at the London South Bank University (LSBU) are presented by their authors, and the NTI-Audio LSBU IOA Diploma Student Final Project award ceremony also takes place.

This competitive award was set up in 2019 by LSBU Diploma course director, Dr Luis Gomez-Agustina, in collaboration with the sponsor of the award, NTI-Audio, to recognise and celebrate excellence of final Diploma projects at LSBU.

This year's meeting took place on 17 January 2024 in-person and was streamed online to remote attendees. It has marked the sixth anniversary of this successful award event. The hybrid meeting was well attended by a mix of senior consultants, academics, acoustics students and alumni.

The two shortlisted finalists of the class 2022-23 for the award were: Rhiannon Hawkins on *Acoustic design of heritage school buildings* and Rebecca Page on *Impact noise and vibration induced by deadlifts*. (Rhiannon could not attend the award ceremony due to bad health on the day.)

Rebecca Page presented her investigation into the noise and vibration induced by impacting deadlifts in gymnasiums. She started by noting that as the UK health and fitness industry continues to grow, it is vital to understand how gym activities can induce noise and vibration. Of particular importance, is the contribution to noise-induced hearing loss (NIHL) caused by impacting deadlifts. In a literature review, she found that there was very limited research investigating this subject. Most of those related studies used smartphone applications to collect data, which is a contested resource for these types of investigations.

The study aimed to characterise the noise and vibration emissions caused by impacts during weightlifts in a typical gym. The research work also intended to assess the validity of a smartphone application to measure noise and vibration level cause by the impacts.

The acoustics and vibration experimental tests took place at a large residential gym, a professional calibrated acoustic analyser and vibration meter as well as a smartphone application were employed for the data collection. The deadlifts were performed by a professional

personal trainer and the weights employed ranged between 20kg and 70kg. For each weight, there were three drops on the gym floor and three drops on an extra 15mm rubber mat over the flooring. By adding an extra mat, considerations to damping vibrations and impact on sound levels were made.

Rebecca's study found there was no definitive correlation between noise levels and deadlift weight impacts. This was because plate numbers and composition added to the barbell were deemed influential factors over noise. Consequently, the extra 15mm mat had no influence on impact noise levels, as the mat was unable to prevent the plates colliding. In comparison, there was a proportional relationship between deadlift weight and vibration levels. Thus, it was found that the mat was successful in reducing vibration levels.

By measuring with both sound level equipment and smartphone applications, this study concluded smartphones were inaccurate and unreliable to measure sound and vibration. This was because the noise measurements performed by the smartphone application were underestimated, while the vibration measurements were unsuccessful.

After the presentation, Rebecca took questions from the interested audience.

Charles Greene, General manager of NTI-Audio UK and Luis hosting the event, presented the award trophy to Rebecca the winner of the competition.

LSBU and the IOA are grateful to Charles Greene and NTI-Audio for the continuous support to the IOA Diploma at LSBU and sponsorship of the award.

Congratulations to Rebecca and to the shortlisted student, Rhiannon Hawkins. We wish you all the best for the future.

<https://www.lsbu.ac.uk/courses/course-finder/acoustics-diploma>
<http://lsbu-acoustics.blogspot.co.uk/> **P68**

North West Branch *By David Terry*

Good news — the North West Branch has been revived after a period of inactivity. On 30 November 2023 a meeting was held at WSP’s Manchester office, where Matt Torjussen (ANV Measurement Systems) gave an intriguing and interactive talk titled *Estimating BS 4142 Character Corrections at the Planning Stage*. The idea of using a simplified auralisation to

estimate acoustic character corrections was discussed and tested on a live audience of acousticians. Not surprisingly, there was a range of opinion.

The AGM was held after the meeting where new committee members were recruited including Helen Sheldon (RBA), and Zackary Simcox and George Mackenzie were appointed as Young Persons Rep and Student Rep,

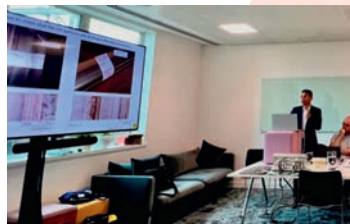
respectively. David Waddington, who along with Jo Webb, have recently helped renew the North West Branch, stood up and said some kind words at the end of the AGM about the sad passing of Geoff Kerry late last year, and about the IOA’s forthcoming 50th anniversary. A social was held after the AGM hosted by Farrat, providing a much needed chance to catch up with colleagues in person.

Southern Branch

Wilson Ho’s talk on railway noise reduction retrofits for curved tracks

By Teli Chinelis, Viable Acoustics Ltd

On Monday 11 September 2023, around 60 online (and 20 in-person) IOA Southern Branch members had the pleasure of welcoming Wilson Ho and his colleagues from Wilson Ho and Associates Limited, who gave us a talk about the product his company invented that provides noise reduction at railway curved tracks.



Above: Wilson Ho

Wilson reminded us that the noise impact of a new railway line is assessed during the planning phase and, if needed, mitigation measures are put forward during the construction phase to reduce transmitted vibration and noise levels. However, at times, unexpected noise problems have been highlighted during the operation or commissioning phase of the new railway line, many of which occur on curved tracks.

Wilson explained that rail corrugation is a wave like wear/deformation on the rail running surface and that slight corrugation (<5µm) causes loud noise, but has no impact on the operation of the train. Such corrugation can increase the noise level by around 15 dB (where the noise level at the undercar can exceed 110 dB). Curved tracks and rail tracks with resilient baseplates are prone to such corrugations.

During the planning and/or design stage, it is difficult to predict the location and depth of such corrugations and such assessment usually allows for a 3/5 dB corrugation correction factor.

Since the railway line is already constructed, any additional mitigation measures are retrofitted. Wilson said that in his experience such retrofitted measures include frequent rail milling and grinding, reducing train speed, incorporating rail noise barriers (these being absorptive panels sandwiching the rails), solid stick wheel flange lubricants and rigid contact tuned mass dampers (RCTMD).

Rail slippage is greater than 10 times of the wheel slippage, during stick-slip at curve track. This is the main cause of the corrugation generation at curve track. A rail damper (without rubber interface) reduces such corrugation by 90%.

Wilson informed us that rail grinding and the installation of rigid contact rail dampers results in no impact to the normal service, provides good noise reduction (more than 5 dB), suppresses rail corrugation, and is easily implemented. However, the main difference is that rail grinding is costly, in terms of machinery and track maintenance scheduling and manpower requirements. Rail grinding is currently TfL’s principal means of addressing Tube noise in London. However, rigid contact rail dampers at approximately one-tenth the cost offer a promising alternative.

Laboratory measurements of lightweight floating floor systems on cross-laminated timber (CLT) slabs

By David Yates, Syntegra Consulting

On Thursday 9 November 2023, the Southern Branch welcomed Sarah Huskie and Marina Rodrigues of CDM Stravitec to present on their recent laboratory measurements of lightweight floating floor systems on cross-laminated timber (CLT) slabs,

Southern Branch members attended at Reading Town Hall, with more joining online and were treated to a comparison of measurements of different floating floor systems on top of a common CLT slab.

Following an introduction by Sarah Huskie to introduce CDM Stravitec, Marina Rodrigues, who had flown in from Portugal especially for the talk, went through the testing methodology and analysis methods before presenting the results.

Airborne and Impact sound insulation measurements were carried out and the analysis included the difference in $D_{nT,w} + C_{tr}$ and $L'_{nT,w}$ over the 100 Hz – 3150 Hz frequency range which is most relevant for the audience in England and other parts of the UK, as well as analysis for both quantities down to 50 Hz, which has been introduced in other countries and continues to be discussed amongst acousticians in the UK for introduction in our own Building Regulations.

An interesting comparison was made between using standard particle board in the floating floor and using cement particle board with the low frequency weakness of lower mass materials being highlighted.



Above: Sarah Huskie and Marina Rodrigues of CDM Stravitec

Southern Branch December meeting

By Chris Barlow



Above: KEF's Sébastien Degraeve's presentation of the Watkins woofer

In December 2023, 12 members of IOA Southern Branch made the trip to KEF for a half-day technical visit at their headquarters in Maidstone.

The visit started with a tour of KEF's museum to see the development of their loudspeakers from KEF's inception in the 1960s to the present day. We then were given demonstrations of how KEF's in-house developed FEM and CAD software is used to simulate and optimise loudspeaker performance at the design stage.

We returned to the conference room for two technical presentations by the KEF acoustics team. The first presentation by Sébastien Degraeve looked at an analysis of the Watkins woofer. This technique uses a dual coil woofer to increase the efficiency of an infinite baffle or closed box loudspeaker. While this technique was first described in the 1970s, no detailed analysis has previously been undertaken and this study used a Theile-Small approach to examine the volume, bandwidth, and sensitivity trade-offs of this technique.

The second presentation by Prathmesh Thakkar focused on the acoustic design of the KEF listening room and how this had been adapted using an active room correction system to optimise the listening environment, particularly for low frequencies.

After the presentations we had a demonstration of two KEF loudspeaker systems in their listening room (including a demo of their room correction system). The demo started with the mid-price LS60 series speakers, before moving onto their flagship Blade speakers, which showed impressive dynamic range and clarity across a range of music styles, including finishing up spectacularly with the finale from Mahler's 8th Symphony. An interesting and enjoyable tour, and we'd like to express our thanks to the team at KEF for hosting us. 🍷



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Committee meetings 2024

DAY	DATE	TIME	MEETING
Wednesday	13 March	10.30	Council
Tuesday	19 March	11.00	CPD Committee
Tuesday	16 April	10.30	CCWNRA Examiners
Tuesday	16 April	13.30	CCWNRA Committee
Thursday	18 April	10.30	Membership
Thursday	25 April	10.30	Meetings
Thursday	2 May	11.00	Publications
Wednesday	15 May	10.30	Research Co-ordination (London)
Thursday	16 May	All day	Engineering Interviews
Thursday	23 May	10.30	Executive
Thursday	30 May	10.30	Engineering Meeting
Wednesday	5 June	10.30	Council
Wednesday	19 June	10.30	CCENM Examiners
Wednesday	19 June	13.30	CCENM Committee
Tuesday	9 July	10.30	Diploma Tutors and Examiners
Tuesday	9 July	13.30	Education
Thursday	18 July	10.30	Meetings
Thursday	25 July	10.30	Membership
Thursday	15 August	11:00	Publications
Thursday	22 August	10.30	Executive
Wednesday	5 September	10.30	Council

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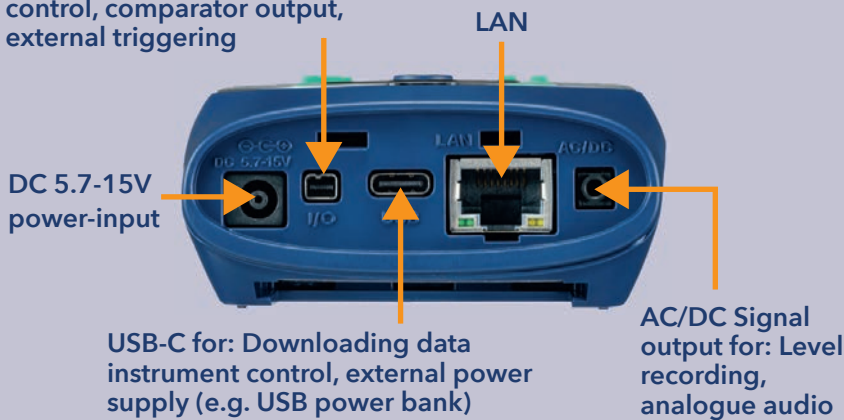


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