Volume 48 No 5 September/October 2022

ACOUSTICS BULLETIN

Institute of Acoustics
Sound • Noise • Vibration

ACOUSTICS BULLETIN

Acoustics Bulletin Volume 48 No 5 September/October 2022

Contacts

Publisher
Juliet Loiselle

Contributions, letters and information on new products to:
Nicky Rogers
Email:
nickyr@warnersgroup.co.uk
Tel: 01778 391128

Advertising:
Dennis Baylis MIOA
Email: dennis.baylis@ioa.org.uk
Tel: 00 33 (0)5 62 70 99 25

Published and produced by:
The Institute of Acoustics
Silbury Court,
406 Silbury Boulevard,
Milton Keynes,
Buckinghamshire MK9 2AF
Tel: 0300 999 9675

Edited, designed and printed by:
Warners Group Publications
The Maltings
West Street
Bourne
Lincs
PE10 9PH

This publication is printed by Warners 01778 395111

Annual Subscription (six issues) £140.00
Single copy £24.00

Institute affairs

Technical

Regular

Cover image by Professor Gary Heald

Submit your nominations

All nominations for the IOA 2023 Medals and Awards must be received by 1 October 2022
https://www.ioa.org.uk/about-us/awards

Technical articles review procedure

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

Institute of Acoustics
Sound • Noise • Vibration

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

Dear Member

At the time of writing, I have been your President for less than 24 hours. Stephen Turner has completed his tour of duty and I now have the privilege of becoming the 26th President of our Institute. I first joined our Council when Bernard Berry was President and since then have served in various capacities under 13 presidencies. There have been many challenges but those faced over the past two years perhaps have been the most significant.

COVID impacted everyone. In a matter of weeks, family, work and leisure times were going to look very different for some time to come. Little did we know then just how long that would last for. It impacted physical and mental health, and the financial circumstances of individuals and businesses. At a stroke, all IOA management and committee meetings had a new factor added to every agenda item: COVID-19 impact and mitigation measures. I would like to pay tribute to the extraordinary dedication, ingenuity and effort of our volunteers and HQ staff who succeeded in not only mitigating the COVID impact, but often found creative solutions to provide added value to our members and services.

As President, Stephen Turner provided the high-level strategic leadership, direction and commitment needed to look out for our Institute's interests and those of our members. Two areas which I feel should be particularly recognised were his emphases on engaging with our members and the importance of influence in government. Stephen will continue to contribute as Past President and David Waddington, Professor of Acoustics at the University of Salford, joins us as President Elect.

Changes

Graham Parry is stepping down after six years as VP Groups and Branches. As well as keeping his eye on the health of our very many Groups and Branch activities, under Graham's watch we have seen the notable additions of the Middle East Branch and the Sound, Noise and Health Group. Hilary Notley has now taken over the reins, having shadowed Graham's work over the past year. Thank you to Josie Nixon for taking over from Tom Galikowski as Chair of the Early Careers Group committee. In noting Tom's appointment at the Council meeting of 10 June 2020, little did we know just how much of a positive impact he would have in this role. Thank you, Tom, for all you have achieved.

Thank you to the Ordinary Members of Council stepping down; Dr Hardial Sagoo after two years and Vicky Wills after six. In addition to her significant contribution to the work of Council, Vicky's ongoing enthusiasm and commitment to STEM outreach is having an impact on an ever-increasing number of young lives. Welcome to Professor G J Heald (Chair of our UAG) and Peter Rogers (Chair of PLG) who replace them. In recognition of the importance to this Institute of promoting and supporting STEM activities, I will be inviting Matthew Muirhead in his capacity as Chair of our STEM Committee, to be in attendance at our Council meetings.

Inter-Noise

It is now the morning after Inter-Noise22 and just short of 1,300 delegates from all over the world participated in presentation sessions and panel discussions covering a huge range of topics. The 1,000 of us who made it to Glasgow in person also benefited from chatting to the specialist exhibitors, taking part in tours and visits and enjoyed the social events. It was particularly gratifying to see the high number (430) of 'early career' delegates attending. Thanks are due to the enthusiastic programming partnership between ECG, EDI Working Group and Scottish Branch which encouraged this.

We have to recognise the dedicated and selfless leadership of the Congress President, Barry Gibbs, for steering the massive tanker that is Inter-Noise, safely to harbour. It was a triumph in the face of so many potential adversities and for that success we also have to thank Chris Barlow for technical programming; Bob Craik as Proceedings Editor; Martin Lester as I-INCE liaison; Jo Brown and her team at In-Conference; and all the volunteer Programme Chairs.

On a final note, Barry Marshall Gibbs has completed his term as Past President of the IOA and become a Past President of Inter-Noise22. It has been an absolute pleasure and a privilege to serve with him in both capacities and therefore it was doubly an honour at our AGM to present him with the award of Honorary Fellow of the Institute of Acoustics, recognising his Presidency from 2018 to 2020 and ongoing, outstanding service.

The next challenge

As my presidency approached, many Past Presidents have advised me they were confronted with at least one significant challenge which could not have been foreseen. Looking back on Stephen's presidency it is very clear what his major challenge was. I wonder what mine will be! Whatever it is, there is one reassuring constant – the incredible member, volunteer and staffing resource that is the IOA.

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

During the pandemic we had a number of candidates who completed their paperwork and submitted for interview. Things have slowed a little since we have come out of lockdown and at the last set of interviews, we only had one candidate, Richard Grove. I am pleased to say he was successful and his comments on his experience can be found on page 7.

For those of you who regularly read this article, you will remember that I have been saying for a while that Malcom Carr-West, our Engineering Council liaison officer, would be sitting in on an interview. Richard was the lucky person who had the privilege to be chosen and I am pleased to say that Malcom was very complementary about our process. He identified some good practice that he intends to take back to his own institution, the Institution of Agricultural Engineers (IAgrE).

Candidates are provided with guidance material when they first apply, and we are always happy to comment on the content of their professional review report prior to them submitting the final draft. Just recently, applicants have submitted reports which do not initially address the competencies in UK-SPEC. 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.

Housekeeping

We still get a number of candidates who, once they have paid their invoice, then ask what the next steps are. These are all clearly laid out in the guidance. 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.

Emma Lilliman has been doing some housekeeping and some of you will have been asked if you still intend to go through the registration process. There are a couple of reasons for this. Firstly, we are now interviewing using the Engineering Council UK-SPEC version 4 which is available from their website here: **https://www.engc.org.uk/ukspec**, and secondly, we have been asked to avoid keeping old data which we do not intend to use.

We are still asking Neil Ferguson to help us with academic equivalence support for those candidates who do not have recognised qualifications. You can check for yourself if your qualifications meet the required specification by visiting the 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 this article).

We hold several interview events through the year, depending on the number of candidates we have coming forward for registration. Our next set are scheduled for 25 and 26 October 2022. If you are interested in taking the next step to becoming a professionally registered engineer, email us at **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 on page 7).

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.

The **individual assessment** route, for applicants who do not have the recognised qualifications and who will have an individual assessment of their qualifications and any other relevant learning such as: formal academic programmes, in-employment training and experiential learning 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. They provide the essential peer review process that affirms that you are at the appropriate level for recognition as an Engineering Council Registered Professional Engineer.

Engineering Council successful candidates

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

It also sets and maintains the internationally recognised standards of professional competence and ethics that govern the award and retention of these titles.

This ensures that employers, government and wider society can have confidence in the knowledge, experience and commitment of professionally registered engineers and technicians.

The IOA is pleased to announce that Richard Grove has attained the standard required for admission to the register.

Richard Grove CEng

Richard is Director, Europe, for Inhabit Building Performance and Engineering Consultants, overseeing specialist design consulting for acoustics, lighting, façade and building sustainability design. He has worked in the built environment sector since graduating in mechanical engineering in 2005, subsequently going on to specialise in acoustics and vibration, providing technical consultancy and leadership on high-profile building schemes. His passion for high quality design, sustainability and inclusivity has been applied throughout his career, developing acoustics designs which aim to balance the spirit of the architecture with the need for acoustic performance, which enables the use and enjoyment of spaces for everyone, targeting interventions for the most sustainable outcomes.

More recently, he has diversified his work to encompass broader aspects of building design including façade design, lighting design and sustainability (particularly building performance for reduced energy use). Richard has been active within the industry through pro-bono participation on panels and steering groups and is a regular public speaker in academic and industrial circles. He is Chair of the Acoustics Technician Apprenticeship Trailblazer Group, and is a regular guest lecturer at London South Bank University on the subject of acoustics for sustainability and inclusivity.

Right: Richard Grove

Never too late

Developing the evidence for the Chartership application enabled Richard to reflect on the projects he has been involved with and allowed him to consider the many problems he solved over the years. He said: "The process was seamless from start to finish with great support from the team at the IOA, who helped to refine and distil many professional experiences into a concise set of evidence.

"Achieving the recognition of the Engineering Council is fantastic, and I would highly recommend the Chartership route to anyone who has considered it. After some 20 years in the industry, I'd like to say...it's never too late!"

IOA Events for 2022/3

IOA events 2022

Organised by the Musical Acoustics Group
New Developments in Musical Acoustics
19 October 2022
Birmingham City University
https://www.ioa.org.uk/civicrm/event/info?id=734&reset=1

Organised by the Electroacoustics Group
Reproduced Sound 2022 (Auralisation and Personalisation – Beyond Reality)
15-17 November 2022
The Bristol Hotel, Bristol
https://reproducedsound.co.uk/

IOA events 2023

Organised by the Underwater AcousticsGroup
5th International Conference on Synthetic Aperture in Sonar and Radar
6-8 September 2023
Villa Marigola, Italy
https://www.ioa.org.uk/civicrm/event/info?reset=1&id=718

11th International Conference on Auditorium Acoustics
28-30 September 2023
SNFCC, Athens Greece
https://www.ioa.org.uk/civicrm/event/info?reset=1&id=717

Acoustics 2023
Institute of Acoustics Annual Conference, Exhibition and Dinner
16-17 October 2023
The Guildhall, Winchester

Other events 2023

NOVEM 2021 (Noise and Vibration: Emerging Methods)
Now 10-12 January 2023
Auckland, New Zealand
www.novem2021.ac.nz

Acoustics 2023
International Convention Centre Sydney (ICC Sydney)
4-8 December 2023
https://acoustics23sydney.org/

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

CAMPBELL ASSOCIATES
SOUND, VIBRATION & AIR SOLUTIONS

SONITUS
SYSTEMS

DM30 NOISE & DUST MONITOR

IEC 61672 -CLASS 1 | MCERTS PM_{10} & $PM_{2.5}$

IOA Medal citations

The IOA's A B Wood Medal and attendant prize is awarded in alternate years to acousticians based in the UK/Europe (even years) and in the USA/Canada (odd years). It is aimed at researchers who are aged under 40, whose work is associated with the sea.

The 2021 and 2022 A B Wood Medals were presented at the IOA's International Conference on Underwater Acoustics 2022, that was held last June in Southampton.

The 2021 A B Wood Medal

Dr Megan Ballard is the recipient of the 2021 A B Wood Medal, her citation reads:

As humans continue to explore and work in the ocean environment, both in person and remotely, and strive to utilise and manage its resources, we have a seemingly endless need for an improved understanding of how sound behaves within that environment. This is because sound is one of the most important ways we interact with the environment, for sensing that environment, and communicating within it.

This award recognises Megan Ballard's numerous and significant scientific advances in a broad range of application areas within underwater acoustics, spanning forward modelling, inference procedures, in situ measurements, laboratory measurements and acoustic remote sensing.

Dr Ballard was introduced to underwater acoustics as an undergraduate at Florida Atlantic University. Her interest in acoustics led her to Penn State University, where her graduate work focused on geoacoustic inversion. The objective of geoacoustic inversion research is to develop methods from which acoustic properties of the propagation environment can be inferred from measurements of the acoustic field. Dr Ballard made a number of advances which allowed for estimates of the geoacoustic properties of a three-dimensional stratified seabed, which is most similar to the real-world environment, and was a significant improvement over previous one- and two-dimensional inversions which required smoothly varying geoacoustic models. Today, this work has evolved and expanded and is currently being used in a long-term acoustic monitoring system that assesses the health of seagrass meadows on the Texas Gulf Coast.

Upon moving to the Applied Research Laboratories at The University of Texas at Austin, Dr Ballard began to investigate the acoustic properties of marine sediments and, in particular, the acoustic properties of mud. Mud can be composed of the three grain types (sand, silt and clay) found in other sediments, but mixed together in varying proportions along with organic material and infauna. Because of this diversity and the unique electrostatic properties of clay platelets, mud is a material for which there is still no agreed upon forward model for predicting its acoustics properties. Dr Ballard has made numerous advancements toward a better understanding of the acoustic properties of mud, using both idealised laboratory measurements, and in situ measurements, both of which required the development of new and innovative instrumentation.

Megan Ballard has made significant advances in the use of acoustics in areas that span national security to climate science. Her star continues to rise in the fields of ocean acoustics and acoustical oceanography. The research community has benefitted from these advances and, importantly, she continues to produce innovative research and improve upon the advances that she has already made.

The Institute of Acoustics is delighted to award Dr Megan Ballard with the A B Wood Medal, in recognition of the importance of her work in this field. P12

Left:
Dr Megan Ballard, recipient of the 2021 A B Wood Medal

Acoustic Panels

Soundsorba manufacture and supply a wide range of acoustic panels for reducing sound in buildings.

www.soundsorba.com

Wallsorba™

- Wide range of modern vibrant colours
- Custom sizes can be manufactured
- Soft fabric facings
- Class A performance

Woodsorba™

- Beauty of real wood facings
- High impact resistance
- Modern face patterns
- Maintenance free

Wavesorba™

- Futuristic shape
- Soothing wave pattern
- Lightweight
- High acoustic performance

Cloudsorba™

- Wider range of different shapes available
- Suitable for a wide range of building interiors
- High acoustic rating

Soundsorba's highly skilled and experienced acoustic engineers will be pleased to help with any application of our acoustic products for your project.

Please contact us by calling **01494 536888** or emailing **info@soundsorba.com** for any questions you may have.

SOUNDSORBA®
ACOUSTIC PRODUCTS

TEL: +44 (0)1494 536888
FAX: +44 (0)1494 536818
EMAIL: info@soundsorba.com

SOUNDSORBA LIMITED, 27-29 DESBOROUGH STREET, HIGH WYCOMBE, BUCKS HP11 2LZ, UK

The A B Wood Medal 2022

Above: Dr Sophie Nedelec, recipient of the 2022 A B Wood Medal

Dr Sophie Nedelec is the recipient of the 2022 A B Wood Medal, her citation reads:

Dr Sophie Nedelec is currently a Natural Environment Research Council-funded Postdoctoral Research Fellow at the University of Exeter. Sophie's work to date has focused on using an understanding of sound in the natural and anthropogenic environment to understand and protect wildlife better. She has taken a strong interest in the ecological relevance of the particle motion inherent in sound waves, as it is greatly understudied compared to pressure, but is the element that is detected by most of the ears in the ocean (fish and invertebrates). She has a wide, independently developed, collaborative international network across academia, industry and policy. She also has a varied research history and has delivered on outputs in the spheres of both academia and policy.

Sophie has a rare combination of passion, creativity and boundless energy combined with intelligence, meticulousness and critical awareness. Ever since embarking on her Masters, she has tackled some of the most critical outstanding questions in bioacoustics, from developing statistical approaches to predict ecosystem health from coral reef soundscape recordings, through developing inverse filters to control feedback in tank playback experiments, to creating open-source software to calibrate and analyse particle motion recordings made with accelerometers. Sophie has had significant scientific impact given her career stage, as attested by her very strong publication record.

During her time in research, Sophie has developed a wide range of industry and policy partnerships. Her skills as a communicator and networker, empathetic drive to find best outcomes for all, creativity to find innovative solutions, hard-working mentality and uncompromising attention to detail all make Sophie a valuable asset to everyone with whom she engages. She maintains strong working relationships with government scientists, technologists, consultants, industry representatives and academics throughout the world.

Sophie is a keen spokesperson for exploring and understanding the world of underwater acoustics, engaging with primary and secondary school groups, the general public through the Bristol Festival of Nature, the print and broadcast media, and, with the many undergraduate and postgraduate university students, she has inspired to pursue bioacoustics research projects.

Beyond her science, Sophie often collaborates with artists, musicians and creative technologies to connect audiences with the world of acoustics. She gives acoustic walks in cities and coastlines, bringing sound to life with hydrophones, accelerometers and geophones mounted on bridges, in kayaks and on participants themselves. Sophie is a wonderful mentor to many early career researchers, a tireless advocate for sustainable practices in university teaching and research, a strong voice for better working conditions for women in STEM, and a mother of two wonderful amateur bioacousticians.

The Institute of Acoustics is delighted to award Dr Sophie Nedelec the A B Wood Medal, in recognition of her work in this field.

Following his graduation from Manchester University in 1912, Albert Beaumont Wood became one of the first two research scientists at the Admiralty to work on antisubmarine defence. He designed the first directional hydrophone and was well known for the many contributions he made to the science of underwater acoustics and for the help he gave to younger colleagues. The A B Wood Medal was instituted after Albert's death by his many friends on both sides of the Atlantic and was administered by the Institute of Physics until the formation of the Institute of Acoustics.


IMMI

ICUA 2022 conference report

The International Conference on Underwater Acoustics (ICUA) 2022 was held on 20-23 June 2022 at the Leonardo Royal Hotel Southampton Grand Harbour, Southampton, UK. There were 188 delegates from 17 countries and 152 submitted abstracts.

Right:
Andrew Holden, Dstl UK, Chair of ICUA2022

By Andrew Holden

The idea for an international conference on underwater acoustics had been discussed by the IOA Underwater Acoustics Group committee for several years. We traditionally hold two-day conferences, but there are several underwater topics which are too small for a separate conference, and it's also highly beneficial to get underwater acousticians together to network, hear the latest research and share ideas.

We always wanted to organise a follow on to the European Conference on Underwater Acoustics (ECUA) 2012 that we held in Edinburgh where we had 300 presentations and 450 delegates. We had originally picked 2020 because, amongst other reasons, that year marked the 50th anniversary of the AB Wood medal. Ultimately, we had to turn that conference into a virtual one. So we were delighted to hold ICUA2022 as an in-person conference and the feedback during the event showed that delegates shared the same view.

Below:
Drinks reception aboard HMS Warrior

The conference had two invited speakers. On Monday morning, Dr Philippe Blondel, University of Bath UK, gave a talk on 'Mapping marine habitats – exploring and monitoring, from human impacts to climate change'. Then on Tuesday morning, Dr Ying-Tsong Lin, Woods Hole Oceanographic Institution US, gave a talk on '3D shelf break acoustics'.

The conference was organised into three parallel streams grouped into themed sessions over the four days and a selection of the sessions are described in this article. As well as the talks, there were several social events planned for some informal and relaxed times.

The early careers event, organised by Adam Woolley of Thales, was held on the Monday evening. Around 60 delegates gathered to listen to presentations from six companies and to network, all while enjoying plenty of pizzas and beverages. The companies were: Frazer Nash Consultancy, JASCO Applied Science, Thales, NPL, Ultra and QinetiQ. While operating in a diverse range of industries from marine ecology to metrology to maritime defence, what they had in common was that their work all revolves around underwater acoustics. Each promoted their areas of expertise, their international presence (where applicable) and gave examples of the sort of work done by early careers employees with the aim of showcasing what is on offer for new acousticians in the industrial world of underwater acoustics.

Tours of National Oceanography Centre Southampton (NOCS) and Institute of Sound and Vibration (ISVR) took place on the Tuesday afternoon, which gave delegates a chance to see some of their facilities and learn about some of their world-leading research.

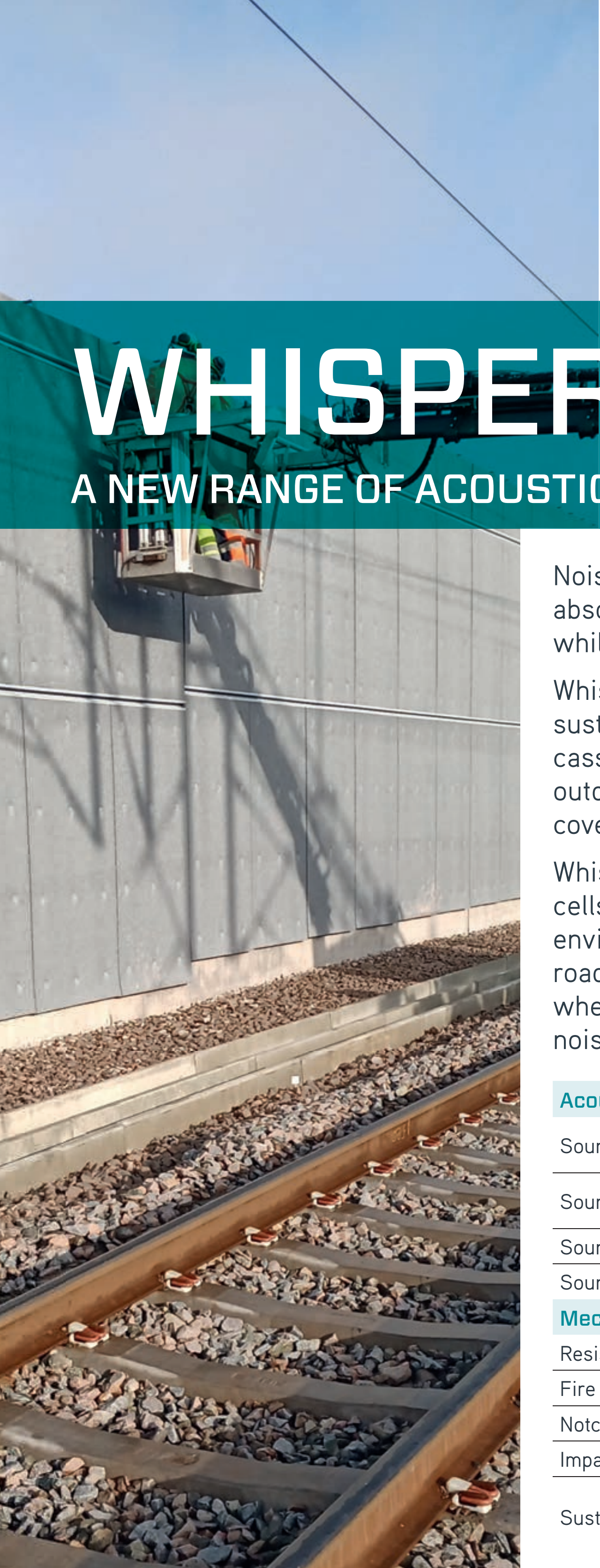
The conference dinner was held on the Wednesday evening on HMS Warrior, Britain's first iron-hulled armoured battleship, moored in the Portsmouth Historic Dockyard. A drinks reception was held for conference delegates on the upper deck in the warm evening sunshine with views around the harbour, before going down to the gun deck for a buffet dinner sitting amongst the cannons.

To make the event run smoothly required the work of a number of groups so we would like to thank In Conference, our conference organisers, the presenters, session chairs, the IOA and the ICUA2022 organising committee.

We would like to thank our co-sponsors; the Acoustical Society of America, The International Commission for Acoustics, The Office of Naval Research Global (ONRG) and the UK Acoustics Network.

The conference papers are being submitted to POMA and the IOA. P16

Sealed Air®



WHISPER® NB

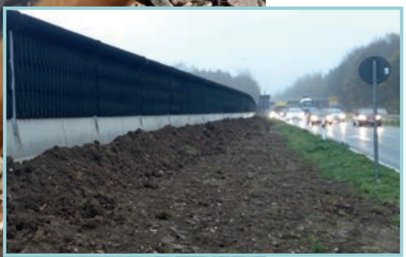
A NEW RANGE OF ACOUSTIC PANELS FOR NOISE BARRIER WALL USE

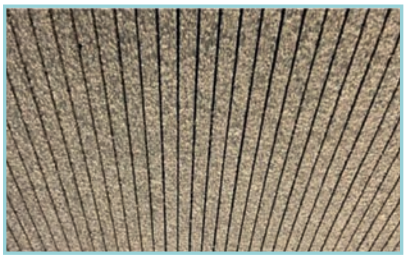
Noise barrier wall designers face multiple challenges when sourcing absorption fill and cladding materials. Panels need to be sustainable while delivering effective absorption over decades of use.

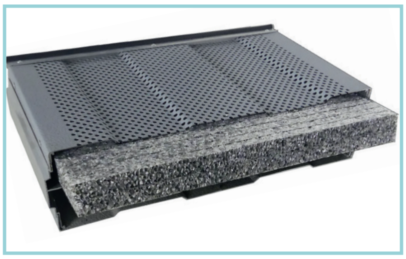
Whisper® NB Acoustic Panels have been designed to offer a sustainable and durable alternative to traditional mineral wool cassette fill materials. Whisper® NBO was formulated to be a durable outdoor wall cladding, eliminating the need for perforated aluminium covers.

Whisper® NB is a honeycomb-like matrix of networked closed cells which efficiently absorb noise, even in challenging external environments. Flat parallel slots boost absorption at critical rail/road frequencies, providing the material with category A3 absorption whether inside a cassette, or installed as a cladding to reflective noise barrier walls.

Acoustic Properties Whisper® NBO			
Sound absorption street DL_{α}	EN 1793-1	dB	9 dB without steel post cladding; 9 dB with steel post cladding
Sound absorption rail DL_{α}	EN 16272-1	dB	11 dB without steel post cladding; 12 dB with steel post cladding
Sound reflection DL_{RI} in-situ street	EN 1793-5	dB	5
Sound reflection DL_{RI} in-situ rail	EN 16272-3-2	dB	6
Mechanical Properties			
Resistance to frost and de-icing salt	EN 14474	-	Fulfilled
Fire resistance	EN 1794-2	-	Class 1
Notch test	EN 1794-2	-	Class 2
Impact of stones	EN 1794-1	-	Fulfilled
Sustainability	EN 14389-1-2		Acoustic and non-acoustic properties 50 years EPD on request







NOISE CAN BE ANNOYING...JUST MAKE IT WHISPER®

Find out more about Whisper® Acoustic Panels

pages.sealedair.com/uk-whisper

FIND OUT MORE

Sealed Air | T: +44 1536 315700 | E: info-pack@sealedair.com

Selection of conference sessions

Seabed and sediment acoustics, chaired by Professor Gary Heald, IOA UAG Chair and Dr Tony Lyons, University of New Hampshire

Left: Professor Gary Heald

Left: Dr Tony Lyons

This session included 18 papers ranging from topics such as grain level analysis, sediment classification, temporal and spatial variability, backscatter, detection of pipelines on the seabed and the impact of bottom reflections on propagation. As is often the case, the papers included a wide range of frequencies where lower frequencies needed to take account of the sub-bottom sediment and volume scattering through to high frequency, high resolution imaging sonars (including synthetic aperture sonar) where the surface roughness dominates. The sessions chairs were delighted with the discussion and questions that followed each paper. The session included a number of student papers and they were all of the highest quality and very well presented.

Radiated noise, chaired by Professor Stephen Turnock, University of Southampton and Dr Thomas Lloyd, with assistance in the paper selection process of Dr Artur Lidtke, MARIN

In two sessions, 11 papers gave an excellent overview of the state-of-the-art in ship radiated noise. Several papers concentrated on the challenges of measuring and interpreting data from hydrophone arrays including the influence of unknown seabed acoustic properties and shallow water. Theoretical approaches examined methods of images and how they could be applied including a paper on the reverberation in towing tanks. Overviews were given of the large European Maritime Safety Agency-funded project, SOUNDS, examining continuous underwater noise. Interesting experimental studies included the measurement for validation of vibration of a ship like structure in an anechoic chamber, the use of digital image correlation to assess propeller blade vibration and the application of drones for measuring noise. Overall, the session emphasised the growing importance of tackling ship radiated noise and the active engagement of the audience indicates the expertise being brought to bear.

Synthetic aperture sonar (SAS), chaired by Dr Alan Hunter, University of Bath

There were 11 presentations by delegates from academic, industry and government organisations in the UK, US, Germany, and Norway. A broad range of topics were covered including:

- technical advances (e.g. mitigating layover, enhancing micro-navigation and bathymetric mapping, and increasing mapping rates); and
- practical issues (e.g. laboratory testing and field calibration), and applications (e.g. imaging internal waves and recognising/characterising objects on the seafloor).

There were also some interesting cross-disciplinary talks on new methods borrowed from the field of medical ultrasound. The talks inspired plenty of questions and discussions and we are all looking forward to continuing these at the SAS/SAR conference in Italy next year.

General underwater acoustics, chaired by Kevin Hamson, Frazer-Nash Consultancy

The two sessions included 10 papers, by speakers from across the UK, France, Switzerland, USA and Israel. The first session started with a look at the use of artificial intelligence applied to acoustic sensors. The second session finished with an interesting method for processing the scattered returns from a sea surface, recovering coherence and thereby extracting parameters describing the roughness of the sea surface. Other papers looked at:

- new finite element formulations for faster vibro-acoustic modelling;
- the dramatic impact of internal Kelvin waves on sound propagation;
- exploration of soundscapes for automatically distinguishing ships from other marine noise sources;
- an experimental method for characterising macro-voided materials;
- discussions on how we consider clutter in active sonar;
- a method to artificially recreate a scattering object experimentally and computationally;
- a practical demonstration of a method for estimating the bearing of a manoeuvring contact on a small, non-straight towed array deployed by an unmanned surface vehicle; and
- the use of a wideband active system to detect hydrates in insulated pipes.

Target Echo Strength (TES) – measurements and modelling, chaired by David Nunn, Dstl and Duncan Williams, Dstl

This session included five papers submitted by the UK, US and Israel, covering government, industry and academic organisations. It was a very well attended session, with lively questions and answers. All papers worked well together, combining measurements and modelling in equal measure. P18

New President takes charge

Following the Institute of Acoustics AGM which was held at the SEC, Glasgow, on Wednesday 24 August 2022, Stephen Turner handed over the Presidency to Alistair Somerville. Stephen Turner is now the Immediate Past President, and David Waddington becomes President Elect.

Above:
Stephen Turner presenting Alistair Somerville with the President's chain

Above:
Alistair Somerville congratulating David Waddington on his role as President Elect

Usually the TES sessions I have organised and chaired in the past have attracted many more papers, but perhaps this session suffered from the immediate after-effects of Covid-19, with speakers not prepared to travel – I am hopeful that future sessions will be better populated. However, irrespective of the short session we held, it was extremely successful and provided a welcome return to face-to-face meetings, allowing the international TES community to join together again and share ideas. In that regard, ICUA 2022 was a resounding success. Papers covered the following areas:

- elastic phenomena – measurements and modelling;
- photogrammetry – uses in acoustics and TES;
- wideband TES measurements in the UK;
- application of Pogo to underwater acoustics; and
- use of parametric arrays to excite targets.

Polar acoustics, chaired by Dr Philippe Blondel, University of Bath, and Hanne Sagen Nansen Environmental and Remote Sensing Center, Norway

With 14 accepted presentations, this was a very popular topic at the conference, reflecting the importance of polar regions to climate change studies (and the importance of underwater acoustics, of course). Presentations included a nice spread of early career researchers and very experienced scientists, covering a variety of topics and approaches. Health and travel restrictions prevented a couple of speakers from attending in person, but their pre-recorded presentations were very well received too. This session sparked many conversations throughout the conference, bringing together research groups from across several continents.

Bioacoustics and biosonar, chaired by Dr Philippe Blondel, University of Bath

This short session (with just three presentations), concentrated on focused research about the interaction of ships and marine mammals, with a clear emphasis on convolutional neural networks and continuous observations.

Signal processing, chaired by Professor Gary Heald, IOA UAG Chair

This session comprised four papers that were drawn from international researchers in Germany, Norway, USA and Canada. The topics covered were:

- time series predictive modelling;
- beam pattern analysis and control;
- single snapshot SNR improvement; and
- inversion for the sound speed profile using received acoustic.

These were four quite different topics but each one created significant interest and prompted excellent questions and discussion from the audience.

Sonar performance measurement and modelling, chaired by Mark Prior, TNO, and Jan Ehrlich, WTD-71

The papers in this session were presented by delegates from The Netherlands, Germany, Canada and Norway, covering topics concerning the prediction of passive-sonar detection performance, inclusion of directivity in parabolic-equation models split-beam-sonar performance modelling and including tactical considerations in sonar-performance modelling. The session was well attended by an attentive audience whose questions generated interesting discussions.

Bubble acoustics, chaired by Professor T. G. Leighton, University of Southampton

Although a range of interesting papers were submitted for the session on bubble acoustics, Covid-19 travel restrictions made attendance of overseas presenters for this session impossible (there was no option for online presentation), such that only two papers were presented, both from Southampton teams.

The first paper was entitled ‘Determining the sound of gas percolating through marine sediments’ and was presented by ISVR and the National Oceanography Centre. It outlined the progress that oceanographers and climate scientists have made in deploying at sea the apparatus and methodology to quantify gas leaks from the seabed using passive acoustics. Primarily, the Leighton-White Method was deployed to check the integrity of carbon capture and storage facilities, which are usually made from depleted seabed oil reservoirs, into which atmospheric gas is pumped. The presentation by Roche et al. explored the extent to which precursor acoustic signals, emitted before the bubble is released from the seabed, should be taken into account when quantifying the amount of gas released.

The second paper was by T. G. Leighton and co-workers/students, describing the testing of his invention for ultrasonically removing marine biofouling from ship hulls, and also showing how it successfully removes MRSA biohazard from hospital floors. The talk ended by showing how an adaptation of the approach produced another invention, that grew skin over wounds using just sound, air and water, without any drugs or chemicals (and so not driving up antibiotic resistance).

Marine renewables, chaired by Michael Bellmann, The Institute of Technical and Applied Physics, Germany and Dr Paul Lepper, Loughborough University

Papers presented by delegates from the UK, Germany and Belgium covered topics including:

- disposal of unexploded ordnance during offshore wind farm construction;
- detection of subsea cables;
- offshore wind farm noise assessment methodology;
- underwater noise mitigation for offshore pile driving; and
- a summary of 10 years of offshore wind farm construction experience in Belgian waters.

The session was well attended and generated interesting questions from the audience and stimulating discussion afterwards.

Ambient noise and ambient sound measurement and modelling, chaired by Stephen Robinson, National Physical Laboratory and Michael Ainslie, JASCO Applied Sciences

This long session was divided into three parts, with a wide range of papers presented. A gratifying feature were the large number of questions generated by the P20

presentations, which was indicative of the strong interest in the topic. The papers presented covered:

- the measurement of ocean noise, including reports of the reduction observed in 2020 and its attribution to the ship traffic reduction during the pandemic;
- detection of tropical storms using their acoustic signatures;
- novel sensing of ocean noise and seismic signals using fibre-optic communication cables; and
- low-cost recording systems making measurements available to more users.

Modelling ocean noise was also a featured topic, including the generation of a global atlas of ocean noise, and fast computation of propagation applied to the mapping of noise in the North Sea. The effect of noise on ecosystems was also reported, including the masking potential for fish and marine mammals of ship traffic noise in the North Sea, and the detection of baleen whale signals in deep-ocean measurements. Finally, a presentation of the need for and progress toward standardisation for measurement and modelling of ambient ocean sound generated an extended discussion with the audience.

Sonars, transducers and calibration, chaired by Victor Humphrey and Stephen Robinson, National Physical Laboratory

This was a short but highly interactive session containing several papers on calibration and measurement of transducers and hydrophones. The papers included a report of the development of a new primary method of calibration of hydrophones for very low frequencies using a laser pistonphone, and a report on the challenges of undertaking free-field self-reciprocity calibrations at marginal distances between plane-wave and spherical-wave conditions. This was followed by a paper on performance modelling of acoustic wedges used as absorbent boundaries for underwater test facilities, and the session was rounded off with a paper describing the experimental investigation of a virtual planar array for MIMO sonar systems.

Underwater acoustic detection, classification and clearance of unexploded ordinance, chaired by Chris Capus, Hydrason Solutions Limited and Professor Gary Heald, IOA UAG Chair

This well attended session covered diverse aspects of the development of new techniques to tackle problems associated with abandoned subsea munitions. Application of recent developments in deep learning were covered in several papers. Approaches covered techniques to reduce false alarm rates for sidescan sonar and application of Mask R-CNN to detect and classify sea-mines. Methods for utilizing multiple sonar views were featured alongside techniques for improved rendering of artificial sonar images for test data and the use of image geometry meta-data in classification of synthetic aperture sonar. Two papers reported on test facilities and recent work from the SERDP/ESTCP programme on remediation of unexploded ordnance and highlighted differences in requirements and approaches between Europe and the US.

Student prizes

The student prize was sponsored by the UKAN+ Special Interest Group on Underwater Acoustics (SIGUA). To be eligible for this award, the author must have been enrolled as a student in a connected degree, listed as the first author on the submitted abstract and have presented their work at the meeting.

The prize winners were selected by a panel of ICUA2022 committee members and the SIGUA committee P22

Below: Philippe Blondel presenting a keynote talk on mapping marine habitats

Sound Masking

from aet.gb ltd

Open plan offices benefit from Sound Masking

Cellular offices achieve better speech privacy with Sound Masking

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

In today's office speech privacy becomes a key aim and open plan offices can suffer from two speech problems:

- Other people's conversations can be an irritating distraction
- Confidential conversations can be almost impossible to conduct

Similar problems also exist in cellular offices. Apart from noise breakthrough via partitions, flanking over, under and around them, other problem areas include light fixtures, air conditioning systems and services trunking. Sound masking compensates for these problems.

An investment in increasing privacy of speech is certainly cost effective, with Sound Masking one of the easiest ways of achieving this aim. Sound Masking systems along with acoustic panels and acoustic door seals are increasingly used to achieve the desired level of privacy by a number of our major clients including:

- Vodafone World HQ
- Procter & Gamble
- Swiss Re
- Mobil Exxon HQ
- Elizabeth Arden
- Barclays Bank
- Freshfields
- KPMG
- PWC
- BP

Sound Masking is now available with a host of extras including:

- PA, either all call or zone by zone call
- Dual level options for audio visual room etc
- Automatic ramping to conserve energy and produce profiled masking
- Fault reporting
- Automated amplifier changeover

AET GB LTD

www.aet.co.uk

AET.GB Ltd., 82, Basepoint, Andersons Road, Southampton, Hampshire SO14 5FE
Tel: 0044 (0)8453 700 400 sales@aet.co.uk

ACS Registrars ISO 9001 Certificate Number 130222

Sound Masking is also known as sound conditioning or white noise systems of UKAN+, based upon the originality, clarity and quality of research, and its presentation. The first prize was £250, the second prize £150 and the third prize was £100.

We extend our congratulations to the student prize winners:

First:
Ellen White, University of Southampton

Second:
Oscar Bryan, University of Bath

Third:
Håvard Arnestad, University of Oslo

A B Wood Medal

The A B Wood medal is aimed acousticians who are aged under 40, whose work is associated with the sea. On the Wednesday afternoon there was a plenary session where Stephen Turner, President of the IOA, awarded the 2021 Medal to Dr Megan Ballard, University of Texas, US, and the 2022 Medal to Dr Sophie Nedelec, University of Exeter, UK. Megan gave a talk which included the many aspects of seabed acoustics that she has worked on during her career. Sophie gave a talk about the aspects of bioacoustics that she has worked on. (See pages 10 and 12 for the 2021 and 2022 A B Wood Medal citations).

The IOA always welcomes suggestions for recipients for this prestigious award. If you have anyone in mind, please use the nomination form on the IOA website (**https://www.ioa.org.uk/about-us/awards**).

Above: Conference speakers, Dr Philippe Blondel, University of Bath, with Dr Ying-Tsong Lin, Woods Hole Oceanographic Institution, US

Left: Dr Megan Ballard, winner of the 2021 A B Wood Medal with Stephen Turner

Left: Dr Sophie Nedelec, winner of the 2022 A B Wood Medal with Stephen Turner

Future events

The Underwater Acoustics Conference & Exhibition (UACE) 2023 will be held in Greece (**uaconferences.org**) so hopefully delegates from this 2022 conference will attend UACE, which is always well organised and offers high quality presentations.

We already have some thoughts about ICUA2024, but we would welcome any ideas you might have. In the meantime we are looking forward to welcoming our friends and colleagues from all over the world to future conferences.

isomass

Isocheck Isoblock & Isobar system

- raising the performance bar -

Copies of this laboratory test data and additional test data are available via email to technical@isomass.co.uk

- in floors -

- Base floor - impact test 1 -

22mm chipboard, 225 x 47mm timber joists @ 400mm centres, 15mm plasterboard

Impact $L'_{n}T'_{w}$ = 80db

- Impact test 2 -

22mm chipboard, 100mm insulation,
225 x 47mm timber joists @ 400mm centres,
Isoblock & Isobar, 20kg/m^2 plasterboard

Impact $L'_{n}T'_{w}$ = 56db

- Impact test 3 -

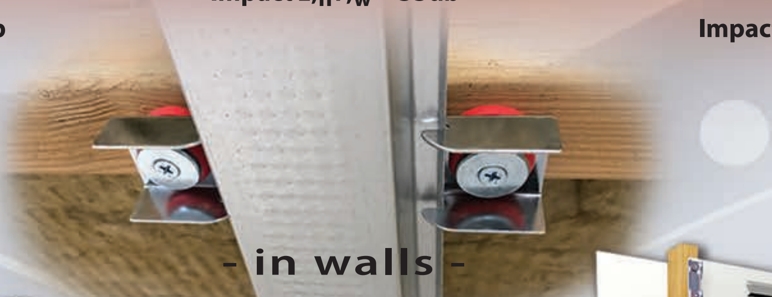
Isocheck 24T, floorboards, 100mm insulation,
225 x 47mm timber joists @ 400mm centres,
Isoblock & Isobar, 20kg/m^2 plasterboard

Impact $L'_{n}T'_{w}$ = 53db

- Impact test 4 -

Isocheck 32T direct to joists, 100mm insulation,
225 x 47mm timber joists @ 400mm centres,
Isoblock & Isobar, 20kg/m^2 plasterboard

Impact $L'_{n}T'_{w}$ = 49db



- in walls -

- New metal stud wall -

2 layers of 15mm sound grade plasterboard,
70mm metal stud frame, 50mm insulation,
Isoblock & Isobar,
2 layers of 15mm sound grade plasterboard

Airborne $D_{n}T'_{w}$ +C_{tr} = 57db

- New timber stud wall -

2 layers of 15mm sound grade plasterboard,
50 x 100mm timber stud frame,
100mm insulation, *Isoblock & Isobar*,
2 layers of 15mm sound grade plasterboard

Airborne $D_{n}T'_{w}$ +C_{tr} = 60db

- Upgraded timber stud wall -

15mm plasterboard, timber stud frame,
no insulation, 15mm plasterboard,
Isoblock & Isobar, insulation,
2 layers of 15mm sound grade plasterboard

Airborne $D_{n}T'_{w}$ +C_{tr} = 60db

ISO 9001:2015 Registered Company

Institute of Acoustics sponsoring organisation

NHBC TESTED BY NHBC ACOUSTIC SERVICES

Why not benefit from our decades of experience and visit our web site on www.isomass.co.uk

Isomass Ltd, 14 Cambridge Westpoint, Stirling Way, Papworth Everard, Cambridgeshire CB23 3GY

Tel: 0330 175 8228

Government policies

The IOA continues to actively monitor interest about noise across the UK Government administrations, although with recess of parliaments, the summer months are a quieter time for activity in developing policy. Meanwhile, the IOA Parliamentary Liaison Group (PLG) has been working on a number of briefings to inform decision makers on topical acoustic issues – and the first one of these, on drones, is now available.

Healthy Homes Bill debate

The second reading of the Healthy Homes Bill in the House of Lords in July prompted comments on the importance of good quality homes in promoting health and equality. A number of members of the House emphasised the importance of protection from excessive noise as an essential element of a healthy home. Baroness Prashar said: “The most vulnerable are more likely to live in unhealthy homes that are damp, energy inefficient, noisy and poorly ventilated.” The Lord Bishop of Ely welcomed the proposed Bill as including healthy homes principles including accessibility, inclusivity, resilience to climate change, noise and light pollution. Baroness Walmsley emphasised the link between climate resilient homes and quieter homes saying: “On noise pollution, I can confirm from my own experience in a passive house that a well-insulated house is a quiet house.” We will be monitoring the Bill as it progresses.

New briefing on drones

The IOA Parliamentary Liaison Group (PLG) is working on a series of topical briefings for policy makers and politicians, introducing them to acoustic issues associated with developing technologies, and technologies that can help address noise issues. The first of these briefings, Noise from Drones – was published in July and is available for download. The briefing outlines the potential applications for drones, acoustic issues and how these should be managed to avoid impacts on people and wildlife. (**https://tinyurl.com/dronebriefing**)

Draft Transport Plan for Wales outlines noise policy revisions

In their consultation on a National Transport Delivery Plan 2022-2027, the Welsh Government set out a number of noise policy revisions pending in the coming year. In their section on clean air and noise policies they pledge to publish a new Technical Advice Note (TAN) 11 on Air Quality, Noise and Soundscape for planning authorities and developers by 2023. In the section on air quality and noise reduction, they state their intention to strengthen the powers available to local authorities to tackle unnecessary idling of vehicles to improve air quality and reduce noise and carbon emissions. New strategic noise maps under the Environmental Noise (Wales) Regulations will be published this year. These noise mapping outputs will inform a new Noise and Soundscape Action Plan which will be published in 2023. It is also acknowledged that the strategic road network soft estate contributes to reducing noise impact of traffic. As part of sustainable management they plan to seek to reduce the effect of the road network on the surroundings in terms of noise pollution through the use of low noise surfacing and natural screening.

Above: The IOA PLG published their Noise from Drones briefing in July and it is available to download

The consultation is open until 11 October 2022 and can be found at: **https://gov.wales/national-transport-delivery-plan-2022-2027**

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

Support us in raising acoustics issues with MPs

The IOA is working to establish an All Party Parliamentary Group (APPG) on Noise, Sound and Health – to provide a forum for discussion on these topics and measures to manage them.

By Mary Stevens, IOA policy support

We will need MPs to join our new APPG and one of the IOA Parliamentary Liaison Group (PLG) members, Teli Chinelis, has already built a good relationship with his MP.

Teli said: "I still remember the day I stood inside the top of the Elizabeth Tower while a hammer hit the 13.7 tonne bell of Big Ben, 12 times. I remember how terrified I was with all the tremors (while wearing my hearing protection of course). How did I get in there? Simple. I wrote to my MP and asked for a free guided tour.

"Throughout the years my MP has also secured free Prime Minister's Question Time tickets for me (great fun) and a tour of both Houses of Parliament. I have met my MP a few times at local council events and visited a surgery when I needed assistance with a personal matter. I email my MP at least a couple of times a year with my thoughts on subjects of the day, mostly asking him to support my view on a matter (and sometimes he does). Through regular contact I have built some rapport with my MP."

Your support

The IOA PLG encourages members to build a relationship with their own MP. Instead of sending out a generic email/newsletter asking for their support, we believe there is a greater chance of success if members who have previously made contact with their MPs to communicate with them directly (the IOA PLG can provide template wording on any matters we wish to raise).

We therefore ask for members' support in raising the profile of the work of acousticians with their elected representative. We invite everyone interested to email us at **parliament@ioa.org.uk** with the name and constituency of their MP (with their email address) so that we can build a database as the next step in this work.

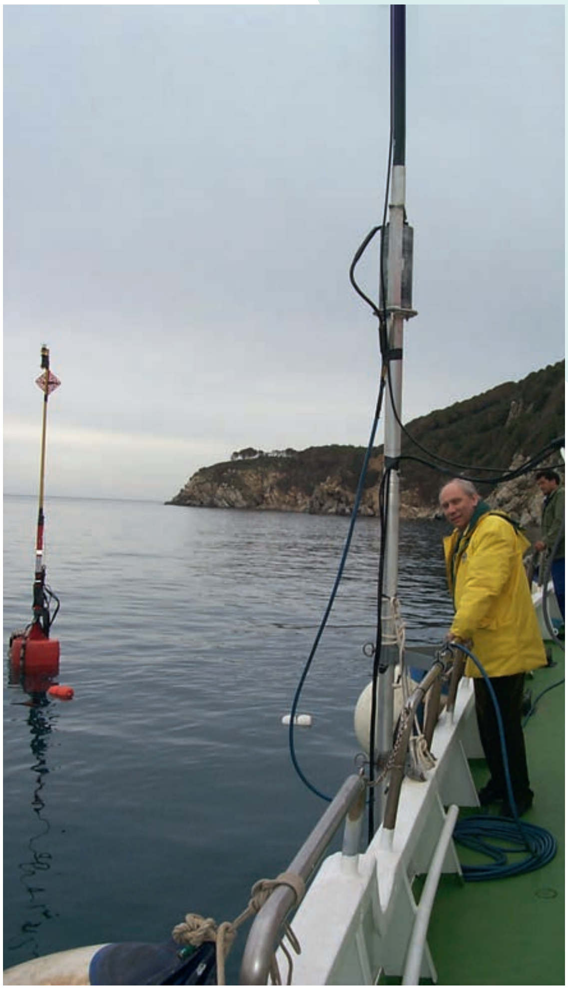
We look forward to hearing from you.

A tribute to Professor Emeritus Nick G Pace:

Underwater acoustics, from theory to experiments

The international underwater acoustics community mourns the passing of Professor Emeritus Nick G Pace. Nick had retired from the University of Bath but he was still very active in advising young and old colleagues throughout the world.

By Dr Philippe Blondel (University of Bath) and Professor Gary Heald (Defence Science and Technology Laboratory and Chair of the IOA Underwater Acoustics Group).



Above:
Nick as we all remember him; happiest doing experiments. Here, he is testing his new bistatic sonar offshore Elba Island, Italy, while detached at the NATO Undersea Research Centre

Born in 1945, Nick studied at St Peter's School in York, where his teachers described him as 'a keen chap'. He kept in touch with his school friends over the decades, and they fondly remember his early passion for science and his leadership, as Head Boy and Head of House. Shared adventures included 'liberating' bread loaves in the kitchens to feed always hungry teenagers or smoking the odd (and illicit) cigarette at 'Cup Cake Corner'. Like all who worked with Nick in the following decades, they remember his willingness to share knowledge, ask questions and work hard, showing great humanity throughout.

Nick's career

Nick received a BSc in physics from the University of Durham in 1967, and he finished his PhD in 1970, also at Durham, on 'Ultrasound propagation and binding in solids' (**https://tinyurl.com/Nickphd**) under the supervision of George A Saunders. His first published article was in *Nature* in 1967, and it was still being cited in 1996. In 1970, Nick joined the Geophysics Group recently formed by Professor W Deryck Chesterman at the University of Bath. He set up new research into acoustic scattering from seabeds, natural and artificial, and this soon branched out into many domains of underwater acoustics, from the deep oceans to pipelines and even sewers. Nick's main research encompassed a wide range of topics including propagation of sound in shallow water and fluctuations in the ocean. He worked on many types of sonar, including echo sounders, sidescan sonar, multibeam echo sounders and parametric sonars. In more recent years his research had included developments in synthetic aperture sonar, which offers high-resolution sidescan images from the seabed, provided the variability can be compensated, multi-aspect sonars, providing 'surround sound' details of seabeds and targets, and multi-frequency acoustic imaging of discontinuities below complex seabeds (for which he co-signed a patent in 2021, with his former student, Jacques Guigné). Many of Nick's articles[1] are still cited now, for example Pace and Dyer (1979) about seabed classification. He also wrote patents, technical reports for government agencies and leading industries, and books. Nick was frequently called upon to conduct research for the Admiralty Scientific branches of the MoD (AUWE, ARE, DRA, DERA) where he was well known and highly respected.

Left: The first IOA conference organised by Nick (in 1983) was an international success, fondly remembered by all participants for its science and also for its networking. Nick organised other international conferences at Bath each decade

In 1995, Nick was detached from Bath to the NATO Undersea Research Centre for three years. He was so good that his contract was extended by two years. And then he was offered the position of Head of the Mine Counter Measure Department, where he supervised a large team of world-class researchers and expert engineers and technicians, working on the acoustics of the marine environment, using ships and underwater robots. He came back to Bath for good in 2005, where he became a professor. His research was recognised with the IOA's Tyndall Medal in 1990. Nick was also awarded the prestigious titles of Fellow of the Institute of Acoustics and Fellow of the Acoustical Society of America.

Nick's scientific legacy

Nick's scientific legacy also included encouraging people to share their science and to work together, in particular through IOA conferences in Bath (in 1983, 1993 and 2005, on his return from Italy). We carried this over in 2015, with a special session in his honour, where former students and collaborators came to show how much he did, and how much they enjoyed working with him. His care towards people was also found in many other ways, finding exotic ways of funding students to enable them to finish their degrees, directing them towards positions where they would thrive and excel. It is impossible to cite all the testimonies readily sent by his former colleagues and students, but here is a selection:

- **Professor Jacques Guigné** (PhD, 1986; DSc, 2014) is now CEO of Acoustic Zoom, in Canada. He remembers long walks along the Kennet and Avon canal with Nick, who worked with him on "stubborn physics problems", or enjoying a swimming pool in stifling heat at a conference in Crete, while creating industry game-changers for seismic imaging. The work Jacques started during his PhD with Nick also led to an experiment flown on the International Space Station.

- **Professor Sir Duncan Wingham** (PhD, 1984) is Executive Chair of the Natural Environment Research Council in the UK. His fondest and most immediate memory was being invited to his PhD supervisor's home for dinner. Very impressed, and afraid of any social faux-pas, Duncan was greeted at the door by Nick holding the hand of a small child, windmilling her around in circles and telling his new student: "After you've had several, you realise they're quite robust" (needless to say, Duncan felt immediately at ease).

- **Dr William (Bill) Grimley OBE** was a director of AUWE. Throughout his career and life, he maintained a strong interest in the physics and engineering of sonar and underwater acoustics. He enrolled for an MSc at Bath with Nick as his supervisor. Following his retirement, Bill registered for a PhD on bistatic sonar, through the Open University, which was awarded in 1996 when he was already in his 80s. He frequently visited Nick to discuss his research.

- **Professor Gary Heald** (PhD, 2000) remembers Nick as an enthusiastic supervisor, equally at home with the development of underwater acoustics theory, controlled tank experiments and gathering data at sea. Nick was delighted when Gary suggested doing tank experiments over different sediment types to validate the theoretical aspects of his research. The four large trays containing silt, sand, gravel and cobble are still in place in the Nick Pace Lab at Bath and have seen frequent use ever since. When Nick moved to Italy, they set up collaboration between Gary's research team in DERA and Nick's team. There were frequent visits to Italy where, alongside some ground-breaking research, Nick and Françoise's hospitality was a regular feature.

- **Professor Zyad al-Hamdani** (PhD, 1984) at the Geological Survey, Denmark, remembers that Nick was: "one of a kind for me and we built up a very nice relationship which continued after my graduation", concluding: "Nick's science and knowledge will stay for many generations to come."

- **Dr Philippe Blondel** (who started at Bath in 1999 as a postdoctoral researcher with Nick) remembers asking Nick for a quick equation on bistatic scattering patches on rough seabeds, and getting in return 20 pages of handwritten equations, showing how complex the theory was, and which parts were the most important in experiments. He also remembers Nick guiding him with gusto through Italian menus and wine lists, concluding successful experiments at sea with the ideal type of debriefing.

- His NATO colleagues in Italy remember the wonderful dinners organised by Nick and Françoise, "la chef du chef", "the boss of the boss", as they called her. They also remember being taught how to make "proper English sausages". **Dr Eric Pouliquen**, Head of Innovation at the Headquarters Supreme Allied Commander Transformation (NATO) remembers that "Nick loved every second of his tour in Italy, certainly in part for the great food and wine but above all for the fun he had at work. He instilled a great spirit in his team and loved to share his knowledge with younger scientists and make an impact in this new field of science."

Nick transformed many lives in his professional journey, helping people realise their potential and helping science progress at the same time. Nick is a role model of what a true scientist is. And he is also a role model of what a true friend is. ◎

References

1 https://scholar.google.co.uk/citations?hl=en&user=Nv04cZUAAAAJ&view_op=list_works&sortby=pubdate

International Year(s) of Sound (IYS2020+) report

The International Year of Sound is a global initiative to highlight the importance of sound and related sciences and technologies for all in society. Dr Paul Lepper was on the IYS 2020 coordinating committee and, in this article, he reports on some of the events that helped it become such a success.

By Dr Paul Lepper

The extended International Year of Sound (IYS2020+) coordinated by the International Congress on Acoustics (ICA) and La Semaine du Son, started with its opening ceremony on 31 January 2020 in Paris and ran all the way through to late 2021. During that period there were nearly 200 globally hosted IYS linked events organised in more than 30 countries related to the celebration of the importance of sound in our society

The aim of these events was to foster international understanding and collaboration by organising *'coordinated activities on regional, national and international levels. These activities will aim to stimulate the understanding throughout the world of the important role that sound plays in all aspects of our society. As well, these activities will also encourage an understanding of the need for the control of noise in nature, in the built environment, and in the workplace.'* (**https://www.sound2020.org/**).

World-wide competitions

One of the major achievements of the IYS was the 'My World of Sounds' competition, which was sponsored by HEAD-Genuit Foundation. The competition was divided into two categories:

- the first for primary schools to generate drawings of their 'world of sounds'; and
- the second category for middle and higher (secondary) schools to produce lyrics in their mother tongue (or English) inspired by a stanza composed by the competition organiser.

There were 650 entries in the primary category and over 50 entries in the middle higher category, that came from 16 nations from around the world.

The winners were announced in 2021 and the primary school category competition was won by Neslÿ Ergün from Çekmeköy Final Middle School in Istanbul, Turkey.

Joint winners of the middle and higher school category competition were class 3°E – School: IC "Puccini" from Florence, Italy, and Roger Cortés, Laia Cuesta, and Coral Coll from the Institut Escola Salvador Vilarrasa in Besalù, Spain.

All of the winners and their entries can be seen and heard on the IYS website at (**https://www.sound2020.org/society/winners/**). In April 2022 a YouTube video comprising a wide range of entries to celebrate the competition was made and you can watch it at **https://youtu.be/tsytfjWAffc**

The organisers also plan to release further videos in 2022 including more information and interviews with some of the winners.

IOA schools competitions

The IOA's own 2021 student competition was also held as a IYS special event with contributions from across the UK. It was won by the team at St Oscar Romero School (see more on page 39) who received their prize at the John Connell Awards organised by the Noise Abatement Society, at the Houses of Parliament.

The 2022 competition has now closed with information for primary schools here **https://www.ioa.org.uk/video/ioa-primary-schools-competition** and for secondary schools here: **https://www.ioa.org.uk/video/ioa-secondary-schools-competition-2022**

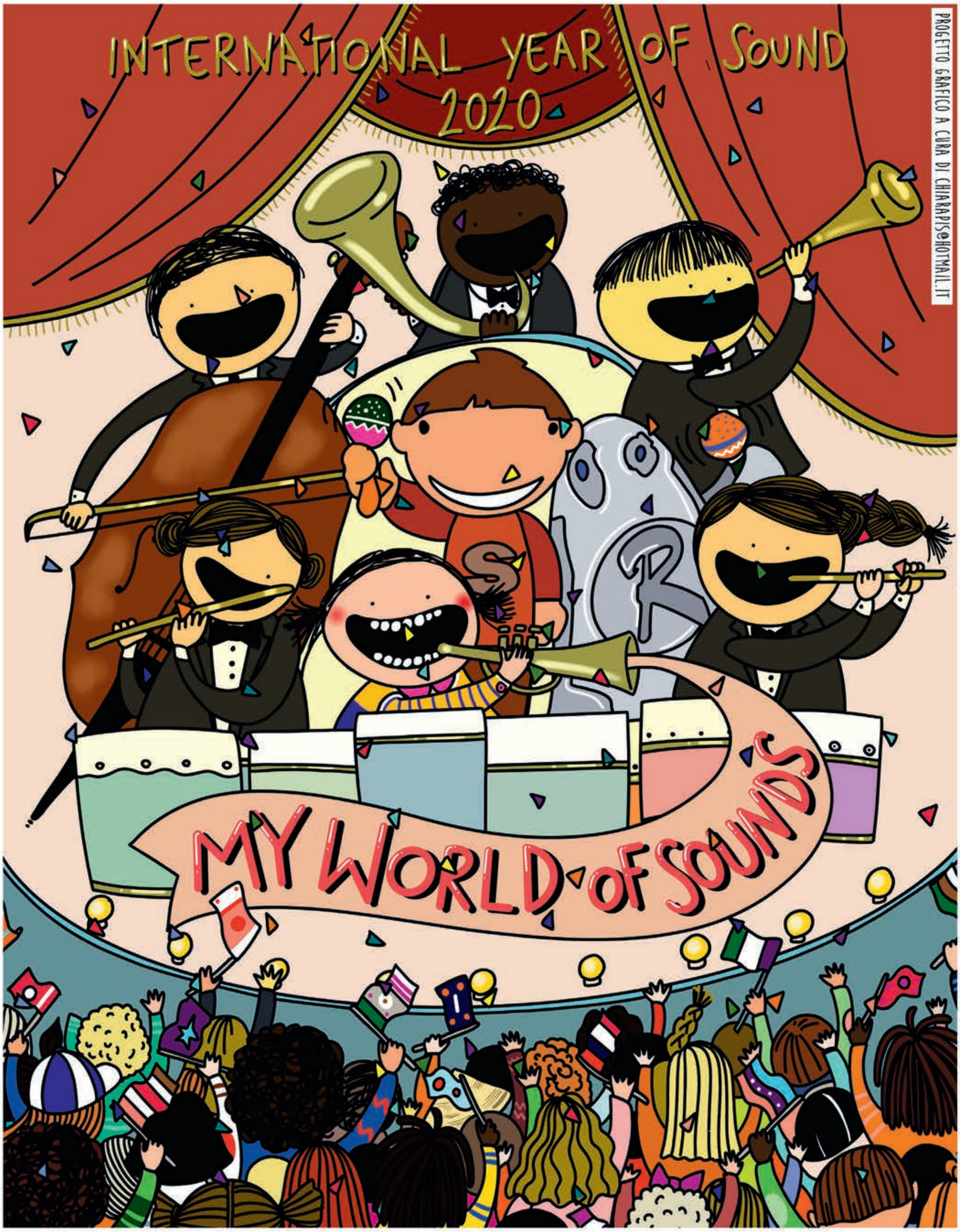
Other UK-based registered events that took place as part of IYS2020+ to demonstrate the huge diversity of acoustics included:

- 'See the Sound!' exhibit at the Big Bang Fair;
- birdsong identification training;
- mini lectures on noise from the Parliamentary and Scientific Committee;
- public lectures on acoustics, music and hearing;
- international conference on underwater acoustics in Southampton; (see report on page 14);
- events at Sensoria, the UK's festival of music, film and digital in Sheffield;
- topics such as Metadiffusers - An Acoustic Solution to Improve the Environment for Musicians, presented by the IOA; and
- other internationally collaborative events covering topics such as light and sound for heritage sites.

The IYS is now officially over, however, events and legacy projects are still ongoing and a summary of the outputs of the programme will be presented at a special session at the International Congress on Acoustics to be held October 24-28, 2022 (**ica2022korea.org**) in South Korea.

IOA support

The IOA is proud to have supported many of the IYS events and looks forwards to building on the international collaborations and understanding of the importance of sound in our societies that these have helped to foster.



About the author:
Professor Paul Lepper is IOA Vice President – International, and Professor of Underwater and Bioacoustics at Loughborough University.

Paragon Acoustic Consultants

It is with great sadness that we announce the death of long-standing IOA member, Patrick Shortt, who was a partner in Paragon Acoustic Consultants.

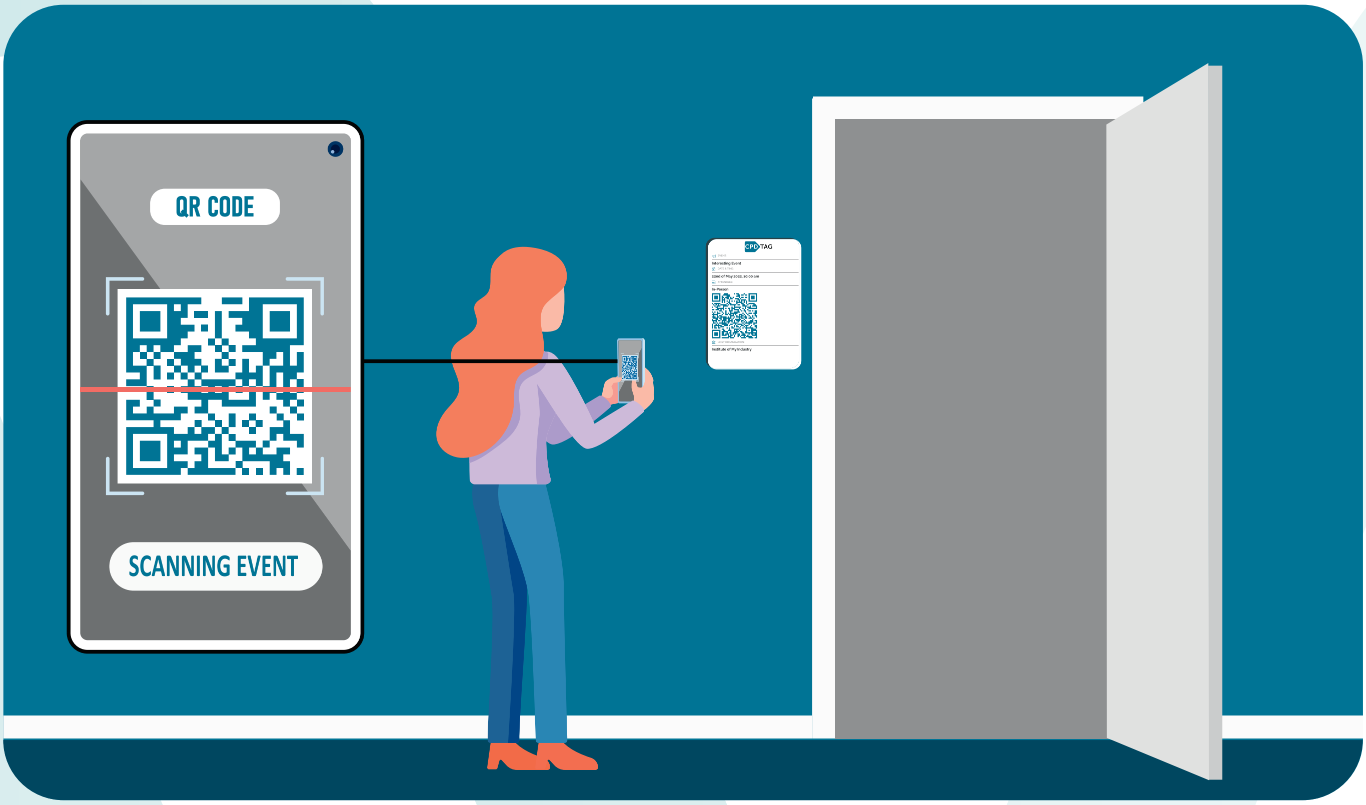
Patrick died recently in a car accident in which his business partner, John Gillott, was seriously injured.

In addition to his work in consultancy, Patrick was known to many in the industry for his work in numerous voluntary roles for the IOA, the ANC and BSI committees.

He was also known for his generosity in giving time and help to colleagues whenever asked, and his unfailing humour.

A full obituary will follow in a future issue of Acoustics Bulletin.

John remains in hospital and we send him our very best wishes for his recovery.



Introducing CPD Tag!

By simply scanning a QR code at CPD events, the newly developed CPD Tag system will update your Continuing Professional Development (CPD) record automatically. IOA CPD Committee member, Derek Nash, explains.

By Derek Nash

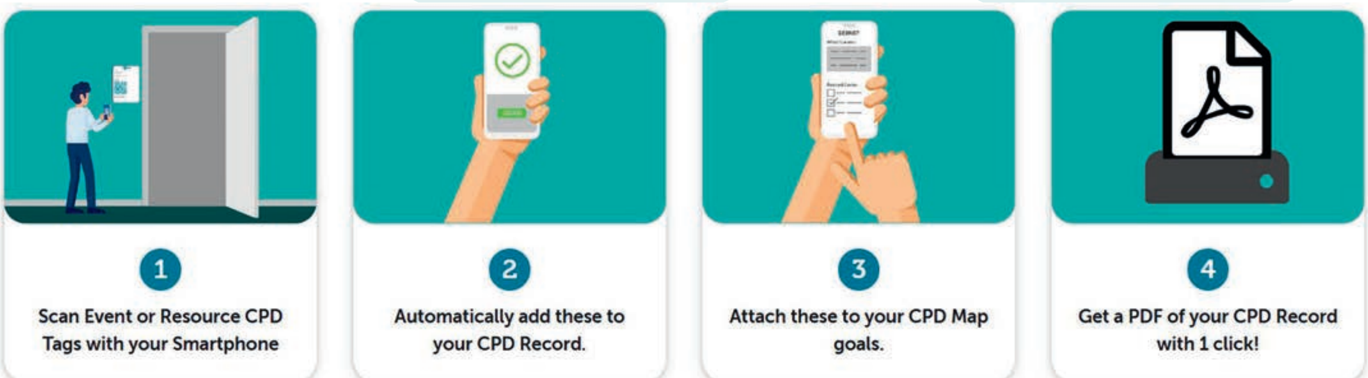
In late 2020, scanning myself into a pub for the 20th time, it occurred to me just how commonplace the idea of checking into and out of somewhere had become. QR codes and their usefulness seemed to gain an entirely new lease of life off the back of the unlikeliest of circumstances, and society as a whole was ready and willing to take advantage.

Like most people, I enjoy doing CPD a lot more than I do keeping track of it. Wouldn't it be great, I thought to myself, if we could use the same approach to automate our CPD records? When you arrive at an event, scan the QR code, the event then goes into your record with all the details – job done!

That was my thinking anyway, so in late 2021 I set myself the task of building a web-based platform that did just that. Six months and a few hundred cups of coffee later, I would like to introduce you to CPD Tag – you can see it here at **www.cpdtag.com**

How CPD Tag works

I thought if I were building a platform to track CPD, I might as well make it as useful as possible. As well as being able to scan events, the CPD Tag tools can be used to build a



CPD TAG

professional profile and a portfolio of projects that users have worked on.

Users can build their own CPD Map, which includes setting goals they want to achieve as part of their professional development, these can then be attached to the CPD activities they carry out, such as attendance at events or self-directed learning.

Being web-based, even if there's no CPD Tag, users can add any activity they want to their CPD record, anywhere, anytime. Best of all, if users need to share their CPD record with anyone else, they can generate a PDF with their curated content at the click of a button.

For organisations

For organisations – whether small companies or large industry bodies – CPD Tag has additional functionality to help streamline CPD activities. They can keep members up-to-date with upcoming CPD activities and the latest resources, and members can pledge attendance to events so that organisations can monitor numbers.

CPD Tag will automatically create CPD certificates for attendees, so there is no extra work for organisers after the event. Even attendees that aren't using CPD Tag can directly download CPD certificates at the event by scanning the QR code with any scanning app.

Attendees can be split into categories such as 'in-person' and 'online' for example, to get a breakdown of the different types – both pledged and confirmed attendees, and they can leave feedback to help guide future events.

It's completely free for individuals and organisations that want to use it and there's a live demo on **www.cpdtag.com** that you can play around with to your heart's content. Feel free to get in touch at **derek.nash@acousticscentral.com** if you have any questions or suggestions.

Student Representatives: Get involved and make some noise!

The Early Careers Group (ECG) is looking to recruit IOA Student Representatives from universities and IOA Diploma Centres.

By Josie Nixon, ECG Chair and Tom Galikowski

The ECG wants to encourage students to get involved with the IOA, so we have formed the Student Representative Working Group. This group will give students the opportunity to get involved in the world of acoustics at an early stage in their career, while allowing the ECG to put forward the valuable views and interests of student members to relevant IOA committees. Student Representatives will also help promote IOA events and resources to their colleagues.

The Student Representative Group (SRG) aims to bring students together from:

- Universities offering acoustics, audio technology or related courses (one per university);
- IOA Diploma Centres (one per Diploma Centre);
- UKAN+ Early Careers Special Interest Group representative (one);
- Research Coordination Committee ECG representative (one); and
- ECG Chair/Secretary (oversight and observers).

The SRG will be chaired by the Research Coordination Committee (RCC) ECG rep. The RCC ECG rep is a member of the ECG Committee who will represent the SRG Committee at the ECG quarterly meetings.

The group will meet several times a year to discuss the interests and explore opportunities for networking and cooperation, as well as developments in the IOA as a whole.

An ideal Student Representative candidate will be within the first two years of their programme, be an IOA Student Member (or be in the process of applying for membership), and be able to contribute a couple of hours a month to the role. The position would run for a full year initially.

In return, the role will allow the Student Representatives to bring their unique voice and connect with students from other institutions across the UK and access the wider IOA network. The Student Representatives will enjoy reduced fees for IOA events, opportunities to enhance their CV by gaining organisational, management and leadership skills.

If the Student Representative role sounds like something you would like to get involved with, please email: **earlycareers@ioa.org**

We need your help!

Everybody can help make the initiative a success by:

- getting in touch with the local IOA Student Group at **earlycareers@ioa.org**
- inviting students from local universities to your local branch activities;
- helping to set up then manage a local university IOA group;
- helping to organise talks for students by local companies (e.g. consultancies, manufacturers), visits to factories, construction projects or other places of interest; and
- inviting students to present at local branch meetings.

We will begin our recruitment and marketing campaign at campuses in October and hold first meetings with Student Representatives in early November and we will host a series of webinars for the IOA, the universities and the Diploma Centres. Watch our promotional video here: **https://vimeo.com/737893934/59adfb9c85**

Above: Josie Nixon, Chair of the IOA Early Careers Group

Many hands make light work

Any new initiative like the Student Representative Working Group is the sum of work done by several people with support from many more. Over its time, the working group consisted of the following ECG members: Laura Broadley, Chris Duffill, Tom Galikowski, Amelia Gully, Alec Korchev and Josie Nixon.

The group was advised by Stephen Dance (representing the Research Coordination Committee) and Nikhil Banda (representing UKAN+) and Alex Shaida coordinated the marketing. We are supported by the IOA Executive Board and the Council, the Membership Committee, Meetings Committee and Publications Committee. We have sought and received valuable feedback from all major universities, the IOA Diploma Centres and Professor Kirill Horoshenkov. We still need more help and support. But in the meantime, thank you all!

Summer socials

The Early Careers Group (ECG) held simultaneous summer socials on 29 June 2022 in Manchester (at the Hatch) and London (at the Charlotte), both sponsored by Masons UK. Their support allowed many members to get together and for some it was their first networking experience.

Having just taken over as the ECG Chair that day, it was a great way for me to meet more of our group and hear what they would like us to provide. I enjoyed listening to people talk about their different experiences of starting a career in acoustics and how they'd overcome various challenges.

Upcoming events

After our summer break, we will be back with news from Inter-Noise 2022 and more planned webinars in the autumn. If you have an idea for a webinar topic or would like to present one, then do get in touch: **earlycareers@ioa.org.uk**

FEATURE

Statutory Nuisance from the Environmental Protection Act 1990

This article considers two legal cases regarding noise. One from England and another in Scotland. While the legal systems in both countries are separate, they share the concept of Statutory Nuisance from the Environmental Protection Act 1990, which includes noise emitted from premises sufficient to be a nuisance or prejudicial to health.

The first case was taken under section 82 of the Environmental Protection Act 1999 by residents who lived near to and were aggrieved by noise from a multi-use games area (MUGA). At the first hearing in the magistrates' court, the district judge (DJ) (a district judge is a professional magistrate) dismissed the appellants' application for an abatement order in respect of an alleged statutory noise nuisance, caused by the following:

- ball strikes, kicks and bounces from the MUGA;
- impact noise of skateboards and other equipment on the metal ramps and installations in the skate park;
- noise from shouting from users of the MUGA, and;
- noise from music played in the MUGA.

In finding against the residents, the DJ held that there was a legal distinction between noise which was generated because of the 'intended use' of the MUGA and, on the other hand, 'anti-social use' (such as the playing of loud music and the continued use of the facilities after they were intended to be closed).

The DJ also found that the appellants had been rendered hypersensitive by the anti-social behaviour elements of what had been going on at the MUGA to the extent that they would not have been so adversely affected by noise arising from the intended use of the MUGA on its own.

The residents appealed to the High Court. Here the judge agreed with the residents and decided to overturn the DJ's decision, and confirmed the following:

- Consideration should have been given to the impact of all noise emanating from the MUGA regardless as to whether it was a result of intended use or from anti-social behaviour.
- It was incorrect to distinguish between noise generated by the intended use of the premises and noise emanating from anti-social behaviour associated with the premises.
- In the circumstances of this case, it was impermissible to distinguish between intended and anti-social noise, it was also impermissible to treat anti-social noise, in part, as a cause of hypersensitivity such as to negate a finding of nuisance.
- Hypersensitivity has long been a defence in cases of nuisance. This means the person affected is more than normally sensitive to something such P38

MASON UK LTD

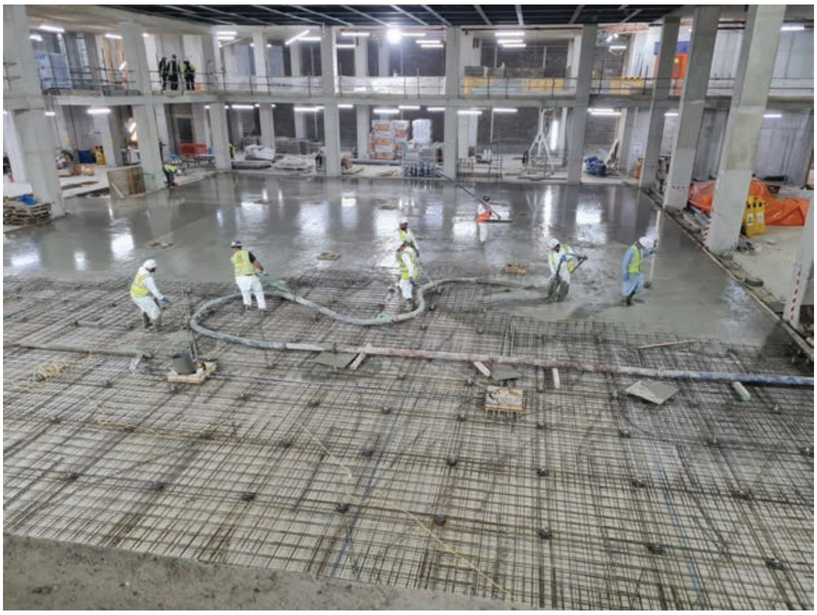
Vibration Control Products
& Acoustic Floor Systems

Engineering the best in vibration isolation

Mason U.K apply over 60 years of experience to fully support your project.

Mason U.K. have decades of experience in detailing box-in-box systems. We are the trusted partners for acoustic floating floors, walls and ceilings for customers as diverse as Abbey Road Studios, the BBC, Cinemas, PureGym, Peloton, Maybourne Hotel Group, Oxford and Cambridge Universities and many more. Detail is everything, we do not simply provide products, we provide engineering experience and site support to ensure designs and installations meet acoustic and vibration control requirements.

▶ ***Main Ballroom, Peninsula Hotel, London. Mason FSN Jack-Up system.***



◀ ***Mason BBNR core isolation bearings, 55 Knightsbridge, London.***

We have isolated many structures, big, small, old and new. We own the entire process, sourcing the raw materials to ensuring correct installation. We provide full support to the design from helping to determine the isolation line to aiding with fire protection details. Via essential low stress, low strain methodology we can provide bearings that last the lifetime of the structure without need for inspection or replacement which we back up with a 100 year warranty.

▶ ***Inertia bases, flexible connectors and pipe isolation system for Intel Corporation, Dublin.***

We have unrivalled engineering expertise in the isolation of residential HVAC and industrial pipe and duct systems. We perform the pipe stress and thermal movement analysis for risers and high temperature systems, check wind loadings on rooftop installations and account for caustic media to ensure failure is not a concern. We are trusted partners of Intel, Google and multiple other organisations who cannot tolerate downtime.

• Music Rooms • Night Clubs • Plant Rooms • Recording Studios • Bowling Alleys • Building Isolation
• Cinema • Gymansia • Laboratories • M+E Isolation • Suspended Ceilings • Industrial • Piping Systems

www.masonuk.co.uk

+44 (0)1252 716610 info@masonuk.co.uk Unit 6 Abbey Business Park, Monks Walk, Farnham, Surrey GU9 8HT

as noise. However, this case confirms that where the issue of hypersensitivity arises, the question to be addressed was what, objectively, a normal person would find it reasonable to put up with.

- The hypersensitivity of any given claimant is not a defence available to the noise source where the noise would also be unreasonable to expect a person of normal resilience to tolerate it.
- Furthermore, it would normally be wrong to hold that where an actionable nuisance is the cause of hypersensitivity in previously robust individuals, that the person responsible for the nuisance is thereafter absolved from its consequences.

The case is *Jones & Ors v Chapel-En-Le-Frith Parish Council* [2022] EWHC 1909 (QB) (25 July 2022) and the full decision can be seen at **https://tinyurl.com/3u6hmhkh**

Second case: wind turbines

The first case in this article references an earlier case involving noise statutory nuisance from wind turbines - *Frank A Smart & Son Ltd v Aberdeenshire Council [2022] SAC (Civ) 005* (see **https://tinyurl.com/4t4we42w**). In this case, a farming business was ordered to reduce the noise from two wind turbines on its land when it lost an appeal challenging an abatement notice issued by Aberdeenshire Council under the Environmental Protection Act 1990.

It was argued that the notice was invalid as it failed to specify what the statutory nuisance complained of amounted to, and that the Sheriff in the lower court had erred in finding the notice to be valid.

The turbines were erected in 2016 and commenced operation that September. An abatement notice under section 79 of the 1990 Act was issued on 23 July 2020 ordering the appellant to reduce the noise levels of the turbines by 14 August 2020. The notice was appealed to the Sheriff Appeal Court, with the appellant averring that the notice was invalid and had not sufficiently identified the circumstances giving rise to the alleged notice.

It was argued that in the absence of knowledge of what the appellant had to achieve by way of abatement, the only certain way of complying with the notice was to cease operation of the turbines. Also, that where a wind turbine was operating without any breach of planning permission the abatement notice was invalid if it is in terms which require complete cessation of operations as the only means for compliance. The thrust of the appellant's complaint was that the notice did not inform them as to the decibel-based boundary or boundaries between noise which is not a legal nuisance and noise which is said to be a legal nuisance.

The Local authority countered that the appellant had been disingenuous as the notion of 'nuisance' was a flexible concept which could be understood by the reasonable person in the context it was said to arise in. There was no doubt that the effect of the turbine notice was that the noise from the turbines had to be reduced.

The court dismissed the appeal and upheld the abatement notice stating the following:

- To be valid an abatement notice must set out with sufficient clarity what is complained about. However, in this case this requirement was satisfied as the notice identified that there was noise coming from the turbines and required the appellant to take steps to reduce the noise.
- On that basis there was no difficulty in identifying, on a plain reading, that the nuisance was due to the volume and character of the noise generated by the wind turbines.
- Established case law means local authorities have considerable discretion on leaving the method of achieving abatement to the perpetrator to identify and execute. There can be compelling reasons to leave the choice of the means of abatement to the perpetrator, not least that some methods may be considerably cheaper and less inconvenient than others.

The court also confirmed that there is inherent flexibility in the words 'abate' and 'nuisance'.

Consequently, the notice did not, as the appellant feared, force shutting down of the turbines on the basis that it this was the only guaranteed method of stopping the noise. Because not all noise amounts to a nuisance and abatement does not necessarily require elimination of all noise.

Author:
Dani Fiumicelli

Our STEM outreach work with a winning school

As we often say when talking about STEM to school students, acoustics is a brilliant industry to get into, but many young people don't know that the jobs in acoustics, sound and vibration even exist.

By Vicky Wills

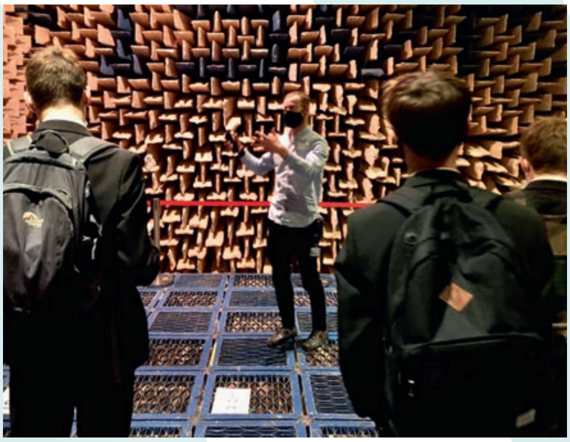
To tackle this issue, the IOA has been really proactive in improving the awareness of these careers by creating videos, handouts, workshop materials, an industry-wide virtual work experience programme and school competitions.

In 2021, the IOA ran the first Secondary School Competition on soundwalks, and we received lots of very impressive entries. The winning school was St Oscar Romero Catholic School whose team created a wonderful and interactive soundwalk of their local area. You can read more about the competition, the winning entry and the school's visit to the Palace of Westminster to collect their award in the November/December 2021 issue of Acoustic Bulletin.

It has now been a year since the school entered the competition and it has been brilliant to see the positive effect that this win has had on the school. Pete Clarke, their Head of Physics, been particularly enthused and proactive about giving students the opportunity to find out more about our industry, he said: "Thank you so much for visiting us and working with the students.

"It is really great for them to do some hands-on problem solving, and something completely different to what they would ordinarily be studying.

"It is so important for students to see 'real life' scientists, and for many it would be the first time they will have even heard of the career 'acoustician'... It's been a great 'year of sound' for us."



Above:
Y10 students with Michal Kalkowski in the anechoic chamber at ISVR

Below:
First visit by Gianluca Memoli, talking to the Y10s

Ongoing STEM work at St Oscar Romero Catholic School

The first visitor to the school, in late 2021, was Gianluca Memoli (University of Sussex). He worked with students on noise mapping and data representation and became 'an acoustic mentor' (my term) for the winning students; talking to them about work experience as well as encouraging them to review papers on acoustics from the Frontiers for Young Minds website (**https://kids.frontiersin.org/**)

In April 2022, the majority of the School's Year 10 students visited the Institute for Sound and Vibration Research at University of Southampton, where they spent time looking around the facilities and finding out more about acoustics.

Finally, in early June 2022, it was our turn. Matt Muirhead (Aecom), Andy Wardle (Bowers and Wilkins/ Sound United) and I (Atkins) visited the school for a day to run the IOA 'Your Banned' activity with students from Year 7, Year 9 as well as the Year 10 students that didn't visit ISVR in April.

We spent a fantastic day working with the students to create their band rehearsal space, and it was particularly lovely to see that one of the notice boards outside the science classrooms was dedicated to the competition and careers in acoustics.

On the whole, this competition was a real game changer for the school, and gave them the opportunity to open their eyes and doors to the fascinating world of acoustics.

You can get involved

The school competition 2022 deadline has now passed and it is hoped that we can continue to work with the winning schools, and beyond, to inspire more young people into careers in acoustics. If you are interested in getting more involved in STEM, please drop us an email at **STEM@ioa.org.uk**

INSTRUMENTATION CORNER

How instrumentation specification standards can contribute to the United Nations Sustainable Development Goals

This article discusses the alignment of the work of the international standardisation committee, IEC/TC29 'Electroacoustics', with the United Nations Sustainable Development Goals (SDGs), which are part of the UN Agenda for Sustainable Development.

By Susan Dowson, Convenor and UK member of several groups within IEC/TC29

Sustainability is very much a topic of interest at present, and indeed 'Noise control in a more sustainable future' was the subject of Inter-Noise 2022, but how does sustainability relate to international standards written to specify the performance of commonly used acoustical instruments?

While some authors apparently estimate there are over 300 definitions of 'sustainability' and 'sustainable development', the Oxford English Dictionary defines sustainability as *'The property of being environmentally sustainable; the degree to which a process or enterprise is able to be maintained or continued while avoiding the long-term depletion of natural resources'*, but how does, or can this definition, relate to specification standards?

Fortunately, the UN has provided more detail on their SDGs (see below) and recently IEC/TC29 has been exploring how the work of the committee fits with these.

IEC/TC29's technical work is related to sound-in-air and the standardisation of associated instrumentation for acoustic and audiometric measurements. The committee has Working Groups (WGs, who usually write new standards) and Maintenance Teams (MTs, who revise and maintain existing standards) looking at performance requirements, calibration and test methods for items such as microphones, sound calibrators, sound level meters, filters, equipment used for measurement of aircraft noise, audiometric measurement systems and related instruments and equipment, including transducers (earphones and bone vibrators), ear simulators, hearing aids and induction loop systems. Standards concerned with methods of measurement are covered by ISO/TC43 'Acoustics'.

United Nations Sustainable Development Goals

The UN 2030 Agenda for Sustainable Development adopted by all United Nations member states in 2015, provides *'a shared blueprint for peace and prosperity for people and the planet, now and into the future'*. To assist with this it details 17 SDGs as shown in Table 1.

Looking at the titles of these SDGs it is apparent acoustics and acoustical instrument specification does not fit with all of these goals but the number of areas where acoustics and standardisation can contribute, either directly or indirectly, is actually quite surprising. While this article does not cover work on ultrasonics or underwater acoustics (which are performed under IEC/TC87 'Ultrasonics' and ISO/TC43 'Acoustics') it is clear that those areas also make key contributions to the SDGs. Taking a wider view and considering all the work across the many topic areas both within IEC and ISO it can be appreciated that standards bodies can play an important role in the vast majority, if not all, of the SDGs.

UN SDG no.	Title
1	No poverty
2	Zero hunger
3	Good health and wellbeing
4	Quality education
5	Gender equality
6	Clean water and sanitation
7	Affordable and clean energy
8	Decent work and economic growth
9	Industry, innovation and infrastructure
10	Reduced inequalities
11	Sustainable cities and communities
12	Responsible consumption and production
13	Climate action
14	Life below water
15	Life on land
16	Peace, justice and strong institutions
17	Partnerships for the goals

Right: Table 1: United Nations Sustainable Development Goals

The Convenors of the IEC/TC29 WGs and MTs have been considering links to the key SDGs where TC29 can make a strong contribution now and over future years, and these are shown in Table 2. It is also likely that smaller contributions are made to some of the other SDGs.

Below: **Table 2:** United Nations Sustainable Development Goals with key contributions from IEC/TC29

UN SDG no.	Title
3	Good health and wellbeing
8	Decent work and economic growth
9	Industry, innovation and infrastructure
10	Reduced inequalities
11	Sustainable cities and communities
13	Climate action

Contributions of IEC/TC29 to DGs

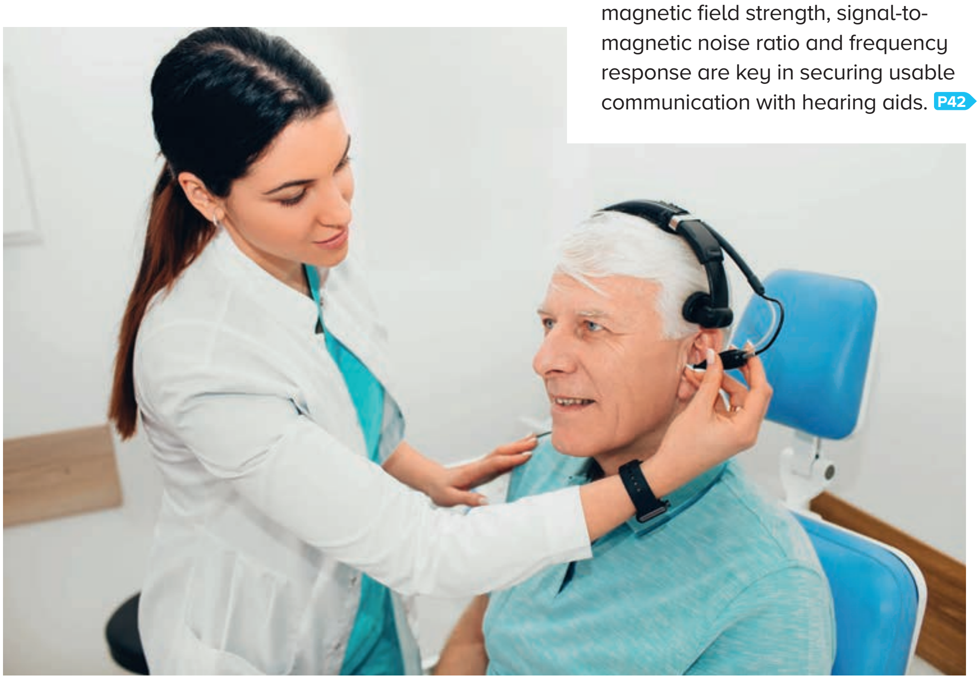
Each IEC/TC29 WG/MT has provided more detail on current and likely future contributions to the SDGs which can be summarised as follows:

SDG 3: Good health and wellbeing

It is quickly apparent this is an SDG where TC29 can make a major contribution.

It is well known that noise provides a risk to human health and the World Health Organization states that *'excessive noise seriously harms human health and interferes with people's daily activities at school, at work, at home and during leisure time. It can disturb sleep, cause cardiovascular and psychophysiological effects, reduce performance and provoke annoyance responses and changes in social behaviour'*. Noise is a major pollutant and vies with air pollution in having the greatest impact on health and wellbeing. It is therefore vital that the instruments used to measure environmental noise – whether it be industrial noise, transportation noise, windfarm noise etc – are specified internationally in IEC standards and there are testing protocols available to show that the *model* of an instrument such as a sound level meter, sound calibrator or filter set, for example, meets the full specifications of the standard (known as pattern evaluation testing), and that *individual specimens* of instrument still meet the requirements on an ongoing basis (known as periodic tests), and that these tests are included in the relevant IEC/TC29 standards. Applying for pattern evaluation tests to nominated institutes is usually the responsibility of the device manufacturer or supplier, whereas applying for periodic testing of a specific device is the responsibility of the user. These periodic tests will often be performed by an accredited laboratory – in the UK, the accreditation body is the United Kingdom Accreditation Service (UKAS). As an example, more details on the variety of testing available for sound level meters can be found in Ian Campbell's Instrumentation Corner articles in the March/April 2022 and May/June 2022 issues of Acoustics Bulletin.

Noise impact of aircraft take-offs, arrivals and overflights also constitutes a significant environmental impact and TC29 produces specific standards for the instruments used in aircraft noise type certification, with the aim of ensuring comparability around the world.



In an increasing number of applications acoustic measurements are no longer made with stand-alone sound level meters, but with modular (often computer-based and multichannel) systems that are user configurable. TC29 is therefore now working on a new standard for modular instrumentation systems, recognising the need for standardisation in this area.

Specifications for instruments to measure hearing and instruments to characterise the hearing aids required to help with hearing loss are a major topic for TC29. Hearing is one of our key senses and it is well known that hearing loss can be detrimental to human quality of life in various ways.

TC29 ensures hearing loss can be reliably and consistently diagnosed at all stages of life by providing standards for ear simulators and audiometers. With modern day electronics and software, hearing aids can now be adapted very specifically for individuals to ensure they obtain maximum benefit from their device, but of course their performance needs to be well-defined and verified and TC29 also provides specification standards for hearing aids.

Once a user has a suitable hearing aid it is important that they can use it as effectively as possible and in as many different situations as possible. TC29 again plays a part here by providing standards for hearing loop systems and system components for assisted hearing. Standardisation is required because magnetic field strength, signal-to-magnetic noise ratio and frequency response are key in securing usable communication with hearing aids. P42

SDG 8: Decent work and economic growth

Although this initially seems a rather more tenuous link to TC29 the standards written clearly have an impact on the instrumentation that is used in everyday work in acoustics, to help ensure reliable and reproducible results, particularly in safety critical environments with consequential impact on economic growth. For many years the IOA has been very much at the forefront of training and education in acoustics and for acousticians, via the IOA Diploma, training courses and Certificates of Competency, although numerous other examples could have been mentioned. The IOA is now looking to take this offering further by seeking a Royal Charter and the associated grant of Chartered Status, as well as developing other new training materials.

A further key example is the primary and secondary schools' competitions following on from the success of the secondary schools' competition last year. As part of this wide IOA remit, training in the use of acoustical instruments is a prerequisite to acousticians learning the trade in many sectors including consultancy, government, health, and academia. Use of international standards also means skills can more easily be transferred between countries, and this is also true for manufacturers selling their acoustical products around the world – so there are definite links to this SDG.

SDG 9: Industry, innovation and infrastructure

Over recent years the approach to building new infrastructure has changed with new innovations, for example in buildings or related to transportation. Industry places much more accent on remote management, monitoring and operation – the term 'Smart cities' is often used – and this, in turn, requires a new approach to measurement, including of noise. This will necessitate development of appropriate standards to ensure reliable measurements at the required level of accuracy. Innovation in terms of modular instrumentation is already being addressed by TC29. Wider use of cheap integrated sensors such as MEMS microphones are another example, with TC29 already having those on their radar of future topics to be addressed by the committee.

SDG 10: Reduced inequalities

This SDG looks at worldwide impacts and benefits and much has been written on health and wellbeing inequalities in different continents. An example of this is testing of hearing and dealing with any resultant hearing loss as mentioned in SDG 3 'Good health and wellbeing', where the ability to test and treat hearing disorders varies widely around the world.

TC29 aims to ensure that its specification standards are as simple as possible to implement, so they can be used readily in less developed areas, and has also been active in specifying equipment for neonatal screening programmes especially for use in developing areas around the world.

This SDG also overlaps with SDG 8 'Decent work and economic growth' above, particularly in terms of training and provision of transferable skills around the world.

SDG 11: Sustainable cities and communities

Populations are growing in many areas of the world, and often this means more people are living in cities with the consequent pressure on city infrastructure. Indeed, the UN estimates that more than half of us live in cities and, by 2050, two-thirds of all humanity – 6.5 billion people – will be urban.

Considerations of sustainability e.g. for infrastructure, buildings, transport, health and safety often have unwanted side effects and a key example of this is noise. As well as transport noise, changes in energy delivery including more accent on windfarms at the expense of fossil fuels and the more recent suggestion of heavier use of heat pumps, particularly in domestic situations, will lead to other noise challenges. Here again standardisation of the instrumentation used to measure the noise plays a vital role, and can be useful in improving future environmental quality, for example within buildings.

Infrasound, such as from windfarms, is becoming of increasing importance and TC29 has just started developing standards for calibration methods at infrasound frequencies, to improve the quality of data obtained from microphones and other acoustic sensors. Distributed, embedded sensors used as part of environmental management solutions will also require TC29 to continue to consider what new specification standards are required. Creating career and business opportunities through these routes and SDG 8 will also benefit communities.

SDG 13: Climate action

Climate change and actions required is a major factor in many key decisions for countries going forward and not many days pass without this topic being mentioned in the news. For TC29 this SDG links very closely to the actions outlined in SDG 8 and SDG 11 above, so they are not repeated here. Nevertheless; it is again clear that provision of good, relevant specifications standards is vital to work on climate change.

Conclusions

Examination by IEC/TC29 'Electroacoustics' of the UN Sustainable Development Goals has shown many clear links to the international standardisation of acoustical instruments, although at first glance these may not be obvious. Looking more widely across IEC and ISO as a whole it can be appreciated that standards bodies can play an important role in the vast majority, if not all, of the SDGs.

Further information on the SDGs can be found at **https://www.un.org/sustainabledevelopment/sustainable-development-goals/** and further information on IEC/T29 at **https://tc29.iec.ch/**

Another look at the relationships between frequency response and the speech transmission index, with respect to word scores and road tunnels – part 2

This is the second of two articles which take another look at the relationships between frequency response and the speech transmission index (STI).

By Glenn Leembruggen FIOA, Acoustic Directions and ICE Design, Sydney, Australia

Experience gained by the author and colleagues over many years of designing and commissioning sound systems has shown that a degraded frequency response can greatly reduce perceived speech intelligibility.

In reverberant, low noise environments, major degradation in responses can make speech essentially not understandable, and this loss of intelligibility is often barely reflected in the STI performance. Additionally, relatively small changes over an octave bandwidth, sometimes as small as 1 dB, can noticeably improve the perceived intelligibility of conversational speech under low noise conditions and this change in perceived intelligibility is not reflected in the STI.

Both of these situations suggest that the psychoacoustic masking mechanism that occurs with relatively low levels is not fully accounted for by the STI process.

The author's interest in intelligibility concerns situations where word recognition by listeners should not rely on the context of the sentence, which could contain unfamiliar words such as place names, proper nouns or single words, which are vital to the correct interpretation of the speech.

Situations involving sound systems should allow listeners to understand speech without concentrating on the listening process itself. There are many situations (for example rail and bus stations) which have sound systems meeting a specified STI performance, but in which listeners must concentrate to understand the speech, especially when that speech is delivered rapidly or with poor articulation. Other situations such as parliaments and courts are more demanding, requiring participants to listen for long periods and concentrate on the subject matter. These systems should not only deliver satisfactory speech intelligibility, but should provide 'acoustic comfort' for listeners, so that they can actively engage with the speech without straining to understand the content. To achieve this robust intelligibility, the system must accurately reproduce the full range of voice types and speaking styles.

Part 1 of this series (published in the May/June 2022 issue of Acoustics Bulletin on page 46) explored the relationship between the STI and word scores with different frequency responses, while this Part 2 looks at the effect of frequency response on the measured STIs in two road tunnels in the presence of noise produced by the ventilation jet-fans.

Sound system optimisation

Process

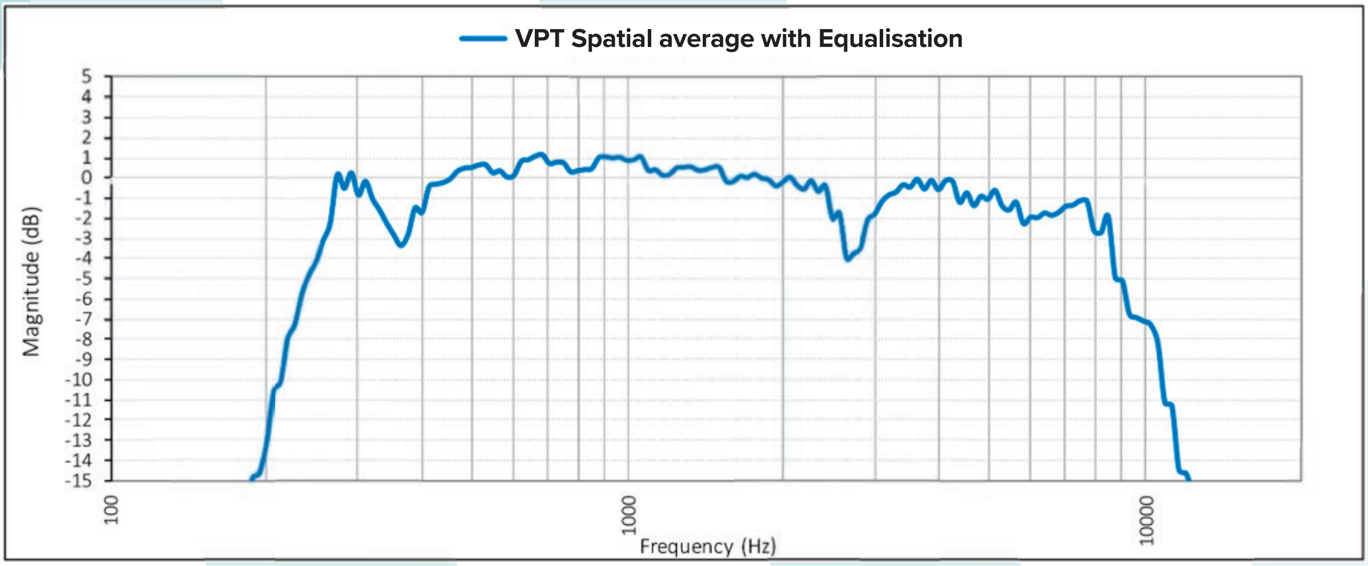
To provide a baseline for exploration of the effects of frequency response on STI, it is pertinent to describe the process that we use to optimise the perceived speech intelligibility and listening comfort for the emergency sound systems in hostile road tunnel environments. Road tunnels mostly use large horns driven by high-powered compression drivers, with responses down to 300 Hz.

The optimisation process consists of equalisation, setting signal delays and setting up the gain structure of the system. Equalisation is the process of applying a set of filters to the signal chain to correct deficiencies in the frequency responses of the loudspeaker as far as possible over the listening area. In most tunnel situations, there is considerable variation in the frequency response over the listening area.

a) The equalisation for the loudspeaker is initially formulated using acoustic measurements made over the entire listening area, with the goal of producing a flat spatially-averaged frequency response. As the frequency-varying directionality of tunnel horns can lead to excessive high-frequency energy for listeners on axis of the horn, caution is required with this process. In addition, narrow dips in the spatial average should be treated with care as equalising them can lead to strong colourations in the speech.

b) Extensive listening then follows with adjustments made to optimise the subjective speech intelligibility, naturalness of tone, and listening comfort at high sound levels above 90 dBA.

c) Human hearing was not designed to listen to speech levels exceeding 90 dBA, and words with strong high-frequency content due to sibilance that sound quite normal at 70 dBA rapidly become very uncomfortable to listen to at higher levels. To make sibilant words substantially more comfortable for listeners, reductions of up to 10 dB are required in specific high frequency bands. However, as good high-frequency response up to 10 kHz is essential for both good subjective intelligibility P46



Above: Figure 1: Example of the spatially-averaged frequency response after equalisation and optimisation of the perceived intelligibility and listening comfort

and measured STI performance, the system equalisation cannot be used to provide these large reductions and another method must be used.

The approach we use combines a slight reduction in the equalised response above 5 kHz, and careful de-essing of specific words in the announcement recordings, (which are mostly those words ending in the letter 's').

Figure 1 shows an example of the spatially-averaged response after completion of the listening process.

d) From the perspective of maximising the signal to noise to achieve a higher STI performance, a higher long-term L_{Aeq} level of speech and the STI test signal would appear to be optimum. However, given that listeners in tunnels must act on instructions broadcast by the sound system, those instructions must be easily understood, and this requires that the sound is not strongly distorted during the peaks in speech. Accordingly, the gain structure of the system must accommodate the crest factor of the speech at each frequency.

e) At face value, it would appear that compressing the dynamic range of speech would allow a higher L_{eq} level in each octave band for a given peak output level. In turn this would increase the speech-to-noise ratio potentially increasing the STI. However, after extensive listening in the tunnel to speech at these high levels, we concluded that the subjective intelligibility is higher without compression. We conclude that compression degrades the modulations that are critical for intelligibility.

f) Based on the crest factor of 18 dB for typical speech, a crest factor of at least 21 dB must be available to accommodate the high frequency equalisation.

System performance

With the systems optimised for perceived intelligibility and listening comfort, the STI performances were measured using the direct STI method known as STIPA[1]. In Tunnel 1 (VPT) measurements were made at 58 locations along its 410m length, while in Tunnel 2 (JH), measurements were made at 47 locations along its 320m length. In both cases, the jet-fans were not operating during the measurement, as their noise would be incorporated later into the STI calculations. The STIPA measurements at each position provided:

i) the level in octave bands of the test signal shaped to the standard IEC speech spectrum; and

ii) the MTF matrix.

The level of the STIPA signal was carefully set so that its spatially-averaged L_{Aeq} level was equivalent to the spatially-averaged L_{Aeq}level of the recorded speech. To achieve this, the level of the STIPA test signal was set 2 dB higher than the speech level to account for the reduction in long-term speech level that gaps between words produce. That reduction was computed from the speech audio file as the difference in total RMS levels between the announcement with gaps and without gaps.

Measurements were also made in octave bands of the noise produced by the jet-fans in the tunnels. Figure 2 shows an example of jet-fans in the VP tunnel.

Right: Figure 2: Fans in the VP tunnel

References

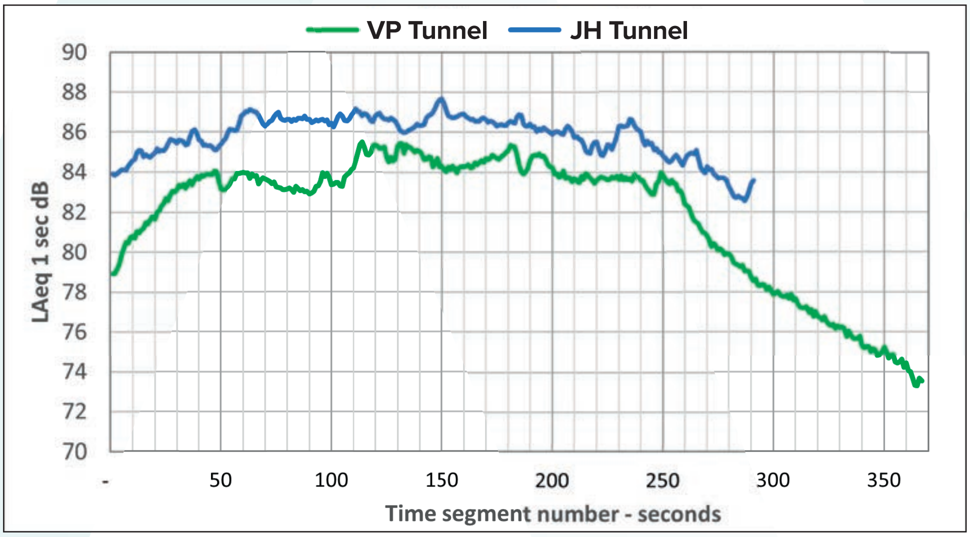
1 IEC. Sound System Equipment Part 16: Objective rating of speech intelligibility by Speech Transmission Index. 3rd Edition, 2011. International Standard No. 60268-16.

Figure 3 shows the $L_{Aeq\text{-}1second}$ sound pressure levels of the fan noise along VP (northerly direction) and JH (southerly direction). Each one-second interval corresponds to a spatial average of the sound levels over a traversed distance of approximately 1m.

Using a bulk calculation process following the method described in Annex M of the STI Standard IEC 60268-16, the jet-fan noise at each STIPA measurement point was introduced into the associated STIPA measurement. The averages and standard deviations of the resulting STI values were then computed with and without jet-fan noise. Table 1 shows the STI performances along with the equivalent L_{Aeq} levels of speech in the tunnel.

Neither of the two systems can be regarded as optimally designed, as the project brief was to make improvements to the existing systems by changing only the loudspeakers and cabling. No additional amplifiers were to be installed and this limited the number of loudspeakers that could be used. This constraint resulted in distances between loudspeakers that would normally be regarded as somewhat too high in VPT and greatly excessive in JHT.

P48



Above: Figure 3: Broadband noise levels along the two tunnels

VP tunnel			
	STI with noise	**STI without noise**	**Speech L_{Aeq}**
Average	0.48	0.51	93.5
Std Dev	0.07	0.05	1.2

JH tunnel			
	STI with noise	**STI without noise**	**Speech L_{Aeq}**
Average	0.38	0.45	92.0
Std Dev	0.05	0.05	1.5

Left: Table 1: STI results in the two tunnels

Filter No	Octave Band Frequency Hz							Adjustment dB	Tonal description
	125	250	500	1000	2000	4000	8000		
1*	0	0	0	0	0	0	0	0	as optimised
2	0	0	0	-3	-3	-3	-5	1.2	dull
3	0	4	2	-4	-4	0	0	-0.6	muddy
4	0	0	0	2	-5	-2	0	-0.2	squawky
5	0	0	-4	2	-4	-4	0	1.0	strongly squawky
6	0	0	0	-9	-9	0	0	1.9	muddy and shrill
7	0	0	0	-6	0	6	0	0.2	objectionably shrill

Above:
Table 2:
Octave band levels applied to shape the frequency responses in the tunnels. All values are in dB. *Existing frequency response without filter

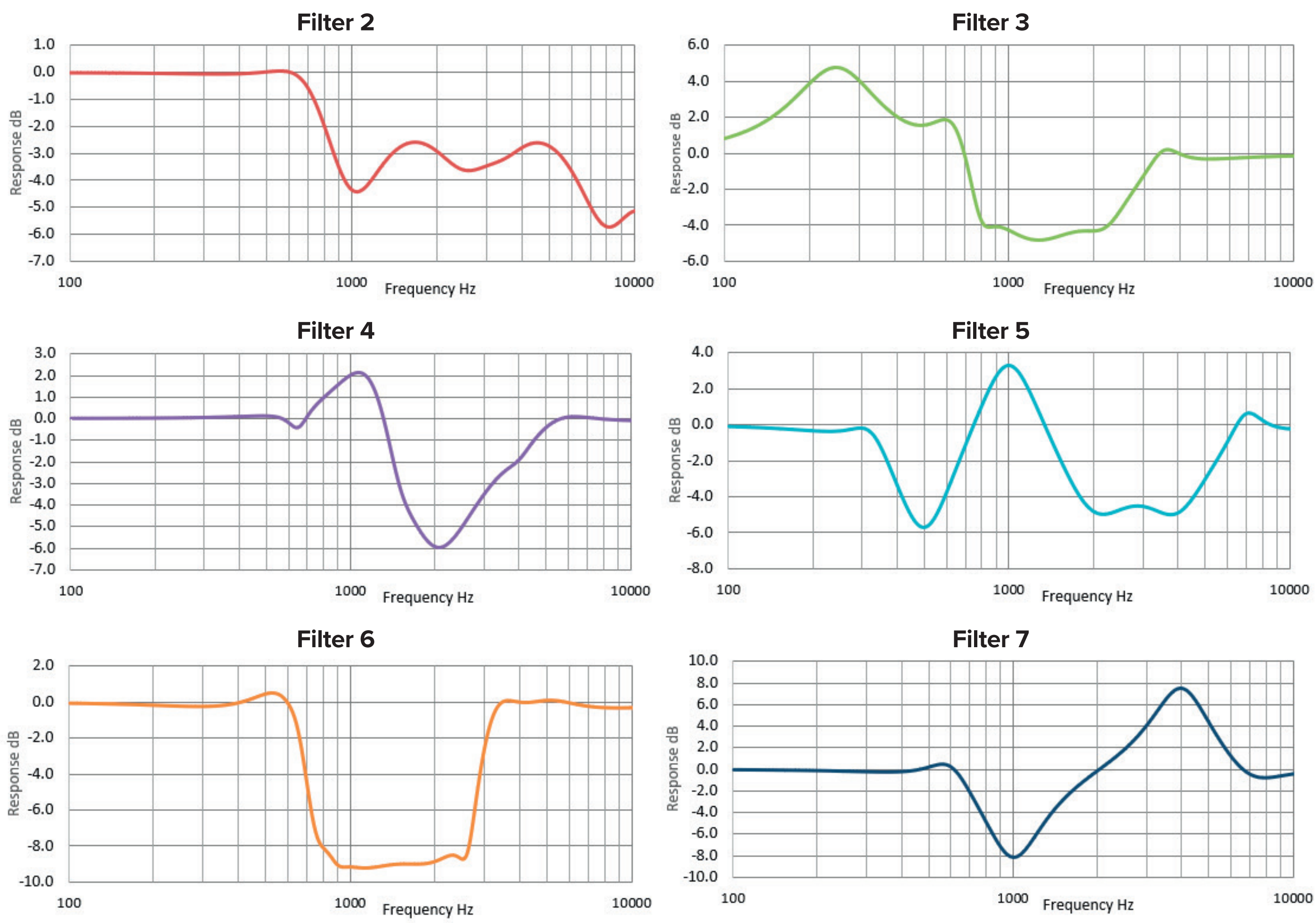
Effect of changes to frequency response on the STI

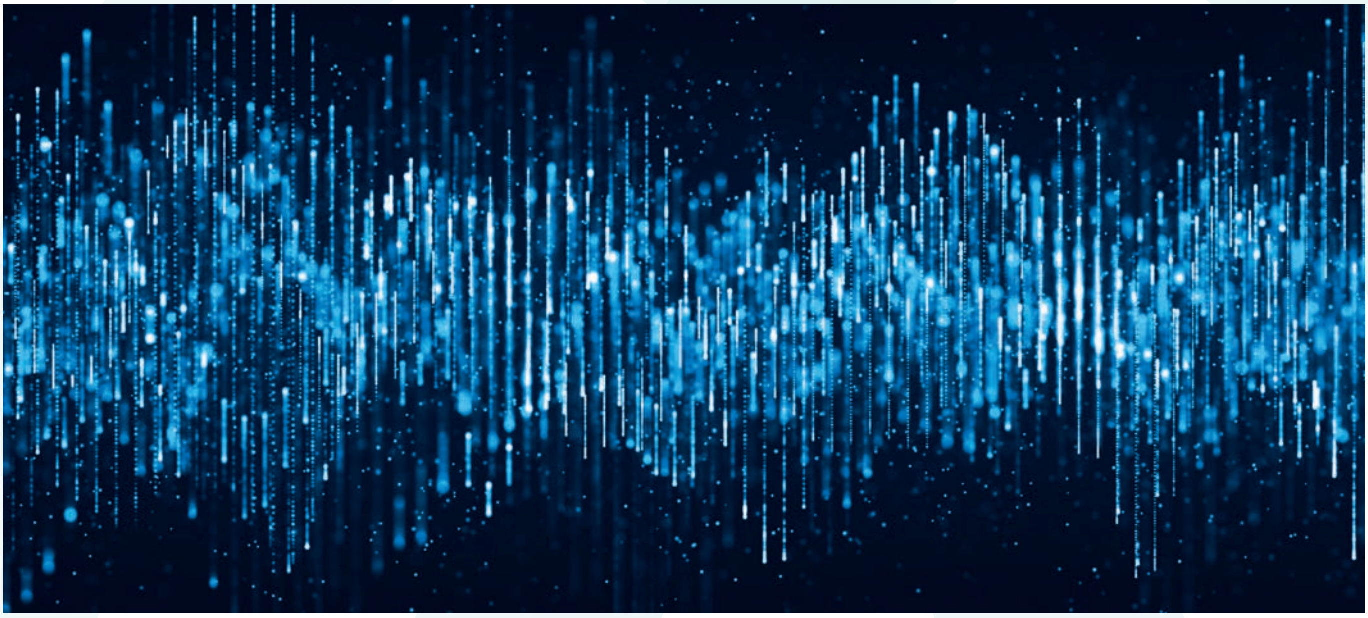
Frequency responses used

To assess the change in STI performance resulting from a change in the frequency response of the system, six different filters were applied in bulk to the STI calculations for each tunnel, again according to the method in Annex M. These filters were selected to demonstrate the insensitivity of the STI results to changes in frequency response that would produce extremely poor sound quality and highly degraded intelligibility. The filters took the form of boosts or cuts to a number of octave bands. Table 2 shows the levels in each octave band for the applied filters. Subjective descriptions of the sound produced by the filters are also stated.

As the boost or cuts affect the overall level of the speech signal in the calculations, an overall level adjustment was applied so that the L_{Aeq} of the speech signal would remain constant. Figure 3 provides graphical examples of frequency responses that would produce the tabulated octave band levels in Table 2 with pink noise fed to the system. P50

Below:
Figure 4: Example frequency responses that produce the octave band levels in Table 2 with pink noise. Subjective descriptions are also given





STI results

Table 3 compares the average STI results along the two tunnels with no filter and filters 2 to 7. Inspection of the results shows that with significant reductions in the sound energy in the octave bands deemed more critical for intelligibility (1 kHz to 8 kHz) have only minor effects on the STI, even during situations with high noise levels.

Given that the majority of STI specifications for STI in Australian road tunnels require a minimum STI of 0.45, there is a real risk that the system could comply with the STI requirement and yet fail to deliver adequate intelligibility to listeners.

The author concludes that when specifying or commissioning an emergency sound system in a road tunnel, blind adherence to achieving a STI performance without paying significant attention to the frequency response of the system over the entire listening area, can yield a system which produces poor perceived intelligibility although its performance meets the project specification.

Inclusion of a specification for frequency response performance in addition to STI performance would provide a much better basis for a tunnel system to provide good perceived intelligibility. An example of a suitable frequency-response specification for a tunnel sound system would be:

1. The spatially-averaged frequency response with pink noise to be 350 Hz to 8500 Hz +/- 2 dB (excluding troughs in the response narrower than 1/3 octave)
2. The frequency response at any listening position to be 350 Hz to 8500 Hz +/- 4 dB (excluding troughs in the response narrower than 1/2 octave)

Specification 1 is achieved by equalisation during commissioning of the sound system, while Specification 2 is achieved through the selection of the loudspeaker make/model, and the number and placement of the loudspeakers.

Below:
Table 3:
Average STIs and standard deviations for the two tunnels with the actual response (No 1*) and six shaping filters with jet-fan noise

	VP tunnel			JH tunnel		
Filter No	**Average STI**	**Std Dev**	**Change in STI**	**Average STI**	**Std Dev**	**Change in STI**
1*	0.48	0.07	NA	0.38	0.05	NA
2	0.46	0.07	0.02	0.36	0.05	0.02
3	0.45	0.07	0.03	0.35	0.05	0.03
4	0.44	0.07	0.04	0.36	0.05	0.02
5	0.45	0.07	0.03	0.36	0.05	0.02
6	0.43	0.07	0.05	0.34	0.05	0.04
7	0.47	0.06	0.01	0.37	0.04	0.01

Penguin Recruitment is a multi-disciplined Engineering and Environmental Recruitment Consultancy established in 2004. We offer nationwide and international job opportunities for anyone looking to kick start or develop their profession.

With extensive knowledge in the Acoustics and Air Quality Industry, we are proud to offer an energetic can-do approach whilst providing a friendly, professional and knowledgeable service at all times.

If you're a growing business looking to access a wider pool of candidates to help with your expansion plans, then please get in touch!

Penguin Recruitment advertise on more job boards than any other specialist recruitment agency within the acoustics industry, and have a well-established and expansive network of candidates accumulated over 16 years of service, allowing us to provide leading advice on the current candidate market.

For more information please contact Amir Gharaati or Charlotte Lavender on **01792 365000**, or email **amir.gharaati@penguinrecruitment.co.uk** and **charlotte.lavender@penguinrecruitment.co.uk**

PENGUIN RECRUITMENT

www.penguinrecruitment.co.uk

Professional speakers using smart transducers

By Professor Wolfgang Klippel

Loudspeakers use an electro-acoustical transducer (drive unit) which converts an electrical input signal via mechanical vibrations into sound pressure output. Most applications prefer an electro-dynamical transducer that uses a moving coil in a static magnetic field, a cone, and a mechanical suspension system.

Those hardware components determine the loudspeaker's maximum output, audio quality, size, weight, and cost. The progress in electroacoustical modelling, amplification, and digital signal processing provides new opportunities for pushing the transducer to the physical limits. New software algorithms actively compensate for undesired loudspeaker properties, increase system reliability and endurance, and provide other intelligent features that simplify product design, manufacturing, and maintenance. This article gives an overview of recent developments beneficial for professional applications.

Loudspeaker modelling

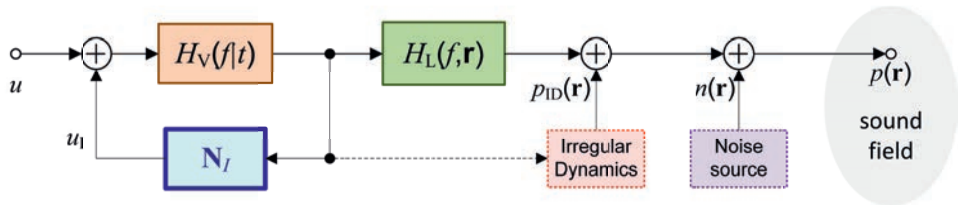
Physical modelling is the basis for numerical simulation of the predicted loudspeaker behaviour in an early design stage and also provides valuable a priori information for loudspeaker control.

A loudspeaker model providing sufficient accuracy with a minimum number of free parameters is essential for self-learning capabilities, adaptive parameter identification, robust control and low implementation effort and processing load.

Black box modelling of signal distortion

The reproduced audio signal $p(t,\mathbf{r})$ at a point r in the sound field is not identical with the original stimulus $u(t)$ at the loudspeaker input. Figure 1 shows a signal flow chart comprising five subsystems that describe the generation of particular signal distortions.

Below: Figure 1: Signal flow chart describing the generation of signal distortion in loudspeakers



This signal flow chart is the basis for acoustic output-based testing defined in IEC standard 60268- 21 [4], which assesses the parameters of the subsystems and meaningful characteristics of the signal distortion summarised in Table 1.

The spatial transfer function $H_L(f,\mathbf{r})$ describes the SPL and phase information of the direct sound at point **r** generated by the loudspeaker under free-field conditions. This function $H_L(f,\mathbf{r})$ represents not only the loudspeaker directivity, which is P54

Below: Table 1: Classification of signal distortion

Signal distortion	Black box modelling	Test methods (IEC 60268-21 [4])
Linear (time- invariant)	Linear system with spatial transfer function $H_L(f,\mathbf{r})$ at any point **r** in 3D space	Wave expansion based on near-field scanning or directivity far-field measurements
(Linear) time- variant	Time-variant, linear transfer function $H_V(f|t)$ describes heating, aging, fatigue, climate	Amplitude compression reveals the variation of the SPL frequency response
Nonlinear (regular)	Dominant loudspeaker nonlinearities N_i generate equivalent input distortion u_i	Harmonic and intermodulation distortion measurement (e.g., multi-tone stimulus)
Abnormal sound	Irregular, nonlinear dynamics with random properties (rub&buzz)	Time-domain analysis (peak value and crest factor of impulsive distortion), higher- order harmonics
Noise	Modelling not possible	Noise floor measurement without stimulus or using a second microphone for detecting ambient noise

the angular dependency of the SPL at a constant far-field distance r but considers the complex near field properties.

All linear properties that change over time by heating, aging, climate and other influences can be merged into a time-variant, linear transfer function $H_V(f|t)$ of a prefilter at the loudspeaker input in Figure 1, generating the same changes at all points in the sound field. It is assumed that all changes occur with a slow integration time constant (> 50 ms), generating new spectral components at low frequencies far below the audio band.

The loudspeaker nonlinearities limit the maximum output, reduce the audio quality and require a compromise with the loudspeaker's size, weight and cost. They generate instantaneous variations of the loudspeaker parameters, which causes harmonic and intermodulations in the audio band. A nonlinear feedback system N_l modelling the dominant nonlinearities generate equivalent input distortion u_l added to linear input u shown in Figure 1. The linear transfer functions $H_V(f|t)$ and $H_L(f,\mathbf{r})$ distribute the equivalent input distortion u_l with the linear signal part to any point in the sound field.

The abnormal sound p_{ID} is generated by irregular dynamics caused by material properties (e.g. paper), complex manufacturing process and diversity of possible loudspeaker defects. Voice coil bottoming is almost a deterministic mechanism. Still, most causes have semi-random properties, such as coil rubbing and modulated noise generated by air turbulence in a port or box leak. A loose particle (dirt) in the gap can cause a random incidence. Time-domain analysis of the isolated signal components reveals the particularities of each cause but shows a common property: abnormal sound has an impulsive fine structure generating a high crest factor and a spectrum covering a wide range of the audio band. The irregular dynamics can neither be modelled, predicted or actively compensated, but the impulsive distortions are not acceptable if audible.

While the audio signal or the test stimulus activates the irregular vibration, including the modulated air noise in the loudspeaker port, the electronics noise primarily generated in the microphone or other sensors is typically independent of the stimulus. Stationary noise can be assessed by performing an additional noise floor measurement with a muted input signal. Ambient noise generated by external sources is non-stationary. It requires a second microphone placed in the far-field to identify the corruptions in the sound pressure signal of the test microphone placed in the near-field of the loudspeaker by correlating the captured signals.

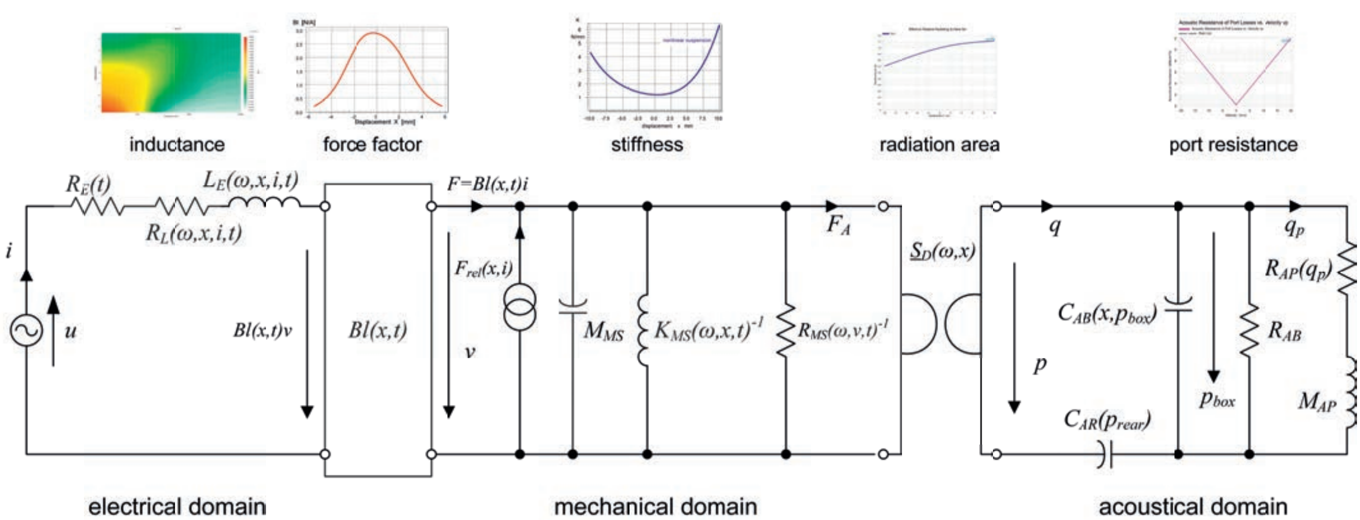
Lumped parameter modelling

Lumped parameter modelling is helpful at lower frequencies where the wavelength is much larger than the size of the mechanic or acoustic structures.

Figure 2 shows, for example, the lumped parameter model of a vented-box system using an electro-dynamical transducer. A transformer with force factor $B_l(x,t)$ couples the electrical with the mechanical domain. The gyrator with the effective radiation area $S_D(\omega,x)$ connects the mechanical with the acoustical network. The moving masses M_{MS} and M_{AP} of the mechanics and air plug in the port, respectively and the acoustical resistance R_{AB} representing the box filling and air leakage are constant parameters. In contrast, the other lumped parameters depend on time, frequency, displacement x, and other internal state variables. The frequency dependency in $R_L(\omega,x,i,t)$ and $L_E(\omega,x,i,t)$ show that the lossy inductance generated by eddy currents cannot be lumped together into two parameters. Visco-elastic behaviour of the suspension related to the mechanical creep causes a frequency dependency in the mechanical stiffness $K_{MS}(\omega,x,t)$ and resistance $R_{MS}(\omega,x,t)$. The effective radiation area $S_D(\omega,x)$ also depends on frequency after cone break-up.

Power dissipation and ambient temperature change the coil temperature of the electrical resistance $R_E(t)$ which is the dominant cause for time-variant speaker behaviour followed by the mechanical stiffness $K_{MS}(\omega,x,t)$ due to aging, fatigue and reversible material processes. Gravity, static air pressure and other forces change the voice coil rest position causing variation in the force factor $B_l(x,t)$ and lossy inductance $L_E(\omega,x,i,t)$. P56

Below:
Figure 2:
Equivalent circuit of a vented-box loudspeaker based on lumped parameter modelling considering nonlinear, time-variant behaviour and frequency-dependency



ACOUSTICAL CONTROL Engineers & Consultants

GUARANTEED SOLUTIONS TO YOUR NOISE & VIBRATION PROBLEMS

ACEC is one of the longest established independent acoustics companies in the UK. This year we celebrate our 50th anniversary of specifying, designing, manufacturing and installing solutions to a wide range of noise and vibration problems. We work in numerous sectors including refrigeration; HVAC; industrial noise control; OEMs; ground, air and water source heat pumps; power generation and land development. Further details about us are on our website: www.acoustical.co.uk

We are currently looking to fill two positions

Principal Engineer and Consultant

As part of our succession plan, we are looking for the right person to provide technical leadership into the next 50 years. This is a senior role based at our headquarters in Cambridgeshire. The duties will involve working with the company's senior managers to guide and develop our engineering and consultancy teams, with the intention of taking the leading technical role in the company within three to five years.

At least fifteen years' experience the noise control industry is likely to be necessary for this role and the ideal candidate will have a background in:

- Engineering design of a wide range of noise and vibration control equipment including containerised/packaged and free-standing acoustic enclosures, screens and panels, attenuated/acoustic louvres, attenuation and vibration isolation systems.
- Delivering and supervising acoustic consultancy including impact assessments, complaint investigations, diagnostic investigations and troubleshooting, OEM design assistance and product development, compliance testing and expert witness.
- Specification, costing and sales of noise control hardware.
- Taking an active interest in the development of acoustic guidance and standards.

The role will involve advocacy of our Highest Suitable Level principle, identifying potential solutions and supporting decision makers to select those which best meet their specific requirements.

Acoustic Consultant – Southeast

To increase our capacity and improve our geographical coverage we are looking for an experienced acoustic consultant based in the southeast of England. The position will be nominally based at our headquarters in Cambridgeshire, but we have a well-established system of remote working so the successful candidate will be able to work from home if they wish.

It is expected that the successful candidate will have at least five years' experience of acoustics consultancy including:

- Conducting noise surveys.
- Preparing acoustic assessments against relevant guidance (a good knowledge and understanding of acoustic legislation, guidance and standards will be essential).
- Making acoustic predictions (some experience of modelling software would be desirable).
- Excellent communications and report writing skills.

We offer a competitive flexible package of benefits commensurate with the level of experience and competence required for each role.

For further information please contact Richard Collman – RichardAC@acoustical.co.uk

(No agencies)

Finally, most of the parameters in Figure 2 are nonlinear and depend on the instantaneous state and vary with coil displacement x, velocity v, current i, sound pressure p_{Box}, and volume velocity q_p in the port. For example, a large voice coil displacement can easily reduce the instantaneous electro- dynamical force factor $B_l(x,t)$ to a quarter of the value at the rest position. At the same time, the mechanical stiffness $K_{MS}(\omega,x,t)$ becomes four times higher, as illustrated in the nonlinear parameters in Figure 2. The lossy inductance shows a multi-variant dependency on current i, displacement x, and frequency f, as shown in the contour plot on the left-hand side in Figure 2.

Distributed Parameter Modelling

The cone vibration and sound radiation at higher frequencies require models with distributed parameters, as illustrated in Figure 3. The modal expansion separates the total vibration into independent modes. Each mode behaves as an independent mechanical resonator with a natural frequency f_n, a modal loss factor η_n, and a characteristic vibration pattern (mode shape ψ_n) becoming more complex with rising order $_n$. Each mode contributes to the total sound radiated with a characteristic directivity. The modal vibration becomes nonlinear if the mechanical structure's geometrical deformation is high and causes the variation of the effective radiation area $S_D(\omega,x)$ versus displacement x in the lumped parameter modelling.

A second acoustic model based on a spherical wave expansion explains the sound propagation from the near-field to any point in the 3D space, as illustrated on the right-hand side in Figure 3. This expansion uses basic functions (spherical harmonics, Bessel and Neumann) that are wave equation solutions and separate the angular and radial dependency. Laser vibrometry and acoustical near-field scanning provide the free parameters modal and spherical wave expansion. The nonlinearities in the sound propagation from direct-radiating loudspeakers can be neglected because the sound pressure is relatively small. On the contrary, the high SPL in the horn-loaded compression loudspeaker can cause wave steepening and significant distortion.

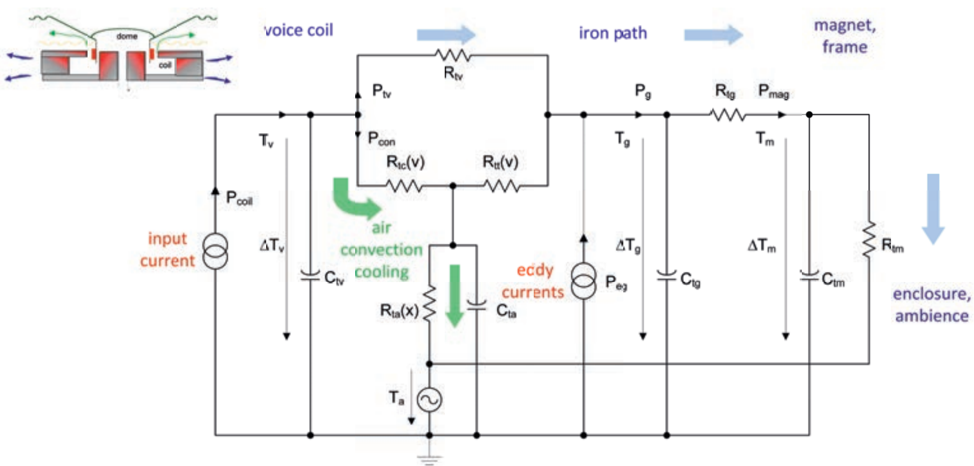
Thermal modelling

Since direct-radiating loudspeakers usually have low efficiency, most of the electrical input power heats the voice coil. The equivalent circuit in Figure 4 models the heating, cooling and transfer into the ambiance. The thermal capacities C_{tv}, C_{tg}, and C_{tm} and the thermal resistances R_{tv}, R_{tg}, and R_{tm} of the coil, gap, and magnet, respectively, determine important time constants of the thermal dynamics. Air convection cooling is a bypass from the coil to the ambiance, which depends on the voice coil displacement and velocity nonlinearly.

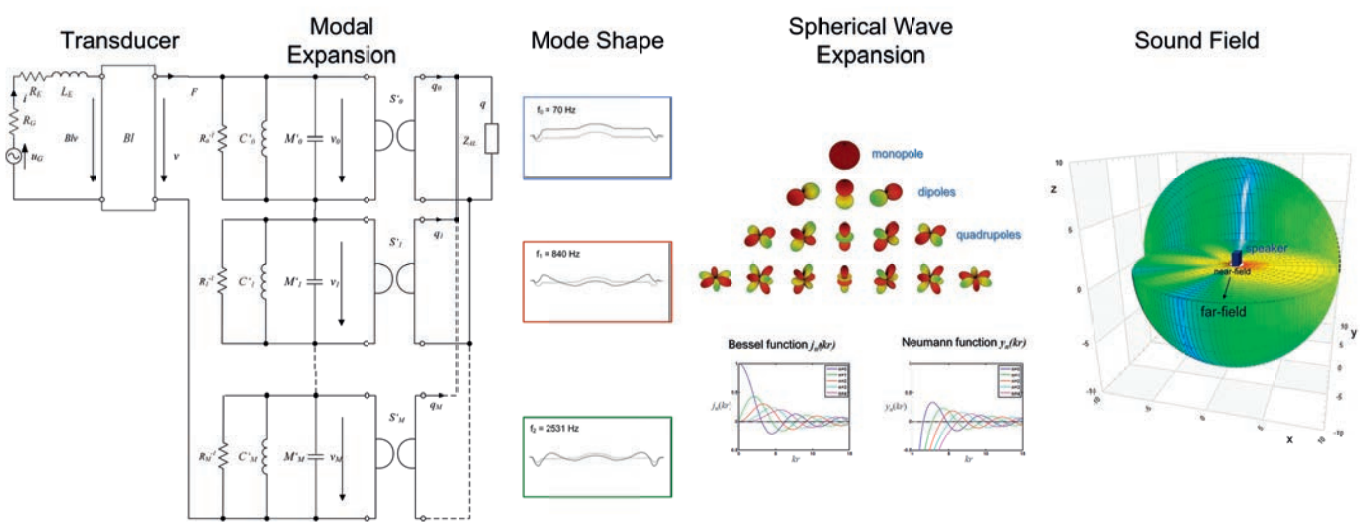
Consequences for control

Loudspeaker modelling provides valuable information for selecting the optimum control scheme providing maximum benefit for the user with a minimum cost (DSP). P58

Below:
Figure 4: Equivalent circuit representing the heat sources, power flow, and local temperatures in loudspeakers



Below:
Figure 3: Distributed parameter modelling using modal expansion of mechanical vibration and spherical wave modelling required at higher frequencies




BY
YOUR
SIDE®

Below: Table 2: Impact on performance, cost, and active loudspeaker control rated in four stages (-, *,**,***) from negligible to high rated by the author

Model parameters and other characteristics	Max SPL	Audio quality	Spatial sound	Reliability	Cost	Size, weight	Active control
Resistance $R_e(t)$	***	-	-	-	-	-	***
Inductance $L_E(\omega,x,i)$	*	**	-	*	**	*	***
Force factor $Bl(x,t)$	***	**	-	**	***	**	***
Stiffness $K_{ms}(\omega,x,t)$	**	*	-	***	-	*	***
Moving mass M_{ms}	**	-	-	-	-	-	*
Mech. resistance $R_{ms}(\omega,v,t)$	-	*	-	-	-		*
Front and rear air compliances $C_{AB}(x, p_{Box})$ and $C_{AR}(x, p_{rear})$	*	*	-	-	-	**	*
Port resistance $R_P(q_p)$	*	*	-	*	-	**	*
Modal compliances $C_n(t,x)$ and resistances $R_n(t)$	*	*	*	-	-	-	*1
Effective radiation area $S_D(\omega,x)$	***	*	*	-	*	**	*1
nth-order mode shape ψ_n	*	*	**	-	-	*	*1
Directivity, spatial transfer function $H_L(f,\mathbf{r})$	*	**	***	-	-	*	**2
Thermal resistances R_{tv}, $R_{tc}(v)$, $R_{ta}(x)$, R_{tg}, R_{tm}	**	-	-	**	*	*	**
Thermal compliances C_{tv}, $R_{tc}(v)$, $R_{ta}(x)$, C_{tg}, C_{tm}	**	-	-	**	*	*	**
Impulsive distortion (rub&buzz)	**	***	-	***	*	*	*

[1] requires active control of multiple electromechanical transducers (shakers), exciting the radiator
[2] requires active control of multiple electro-acoustical transducers in one loudspeaker

Table 2 summarises the impact of the model parameters and standard characteristics on essential dimensions of the loudspeaker performance, weight, size, and cost, and opportunities for virtually improving the loudspeaker by active loudspeaker control. The maximum sound output represented by max SPL as defined in IEC 60268-21 [4] is limited by the electro-acoustical efficiency of the loudspeaker, primarily determined by the motor efficiency factor Bl^2/R_e, the moving mass M_{MS} and the effective radiation area S_D.

The voltage sensitivity of the transducer matched to the maximum current and voltage capabilities of the amplifier also limits the short-term SPL generated by the loudspeaker system. Conductive shorting materials (e.g., copper rings) placed close to the coil reduce the voice coil inductance $L_E(x,i)$ to improve the linearity of the speaker and the voltage sensitivity. The nonlinear dependency of force factor $Bl(x)$ and stiffness $K_{MS}(x)$ limits the maximum peak displacement X_{max} and the bass performance. Voice coil heating changing the resistance $R_e(t)$ and abnormal sound measured as impulsive distortion according to IEC 60268-21 [4] are essential limits for max SPL.

Impulsive distortion has a disastrous impact on audio quality and impairs the reliability of the loudspeaker because it indicates an overload or defect of the speaker. Intermodulation distortion generated by $Bl(x)$ and $L_e(x,i)$ spread over the entire audio band and cause an unnatural roughness in the reproduced sound, which is more critical than the common nonlinear distortion generated by $K_{MS}(x)$ limited to lower frequencies.

The DC displacement caused by $Bl(x)$, $L_e(x,i)$, $K_{MS}(x)$, and other loudspeaker nonlinearities shifts the voice coil away from the optimum working point usually defined by the rest position. This DC displacement can generate an unstable behaviour that reduces max SPL, causes unacceptable distortion, and damages the loudspeaker, reducing the product's reliability in the target application.

The modal parameters $C_n(t,x)$, $R_n(t)$ and $S_D(\omega,x)$, the mode shape of the mechanical vibration ψ_n, and the spatial transfer function $H_L(f,\mathbf{r})$ represented by the coefficients of the spherical wave expansion is essential for the 3D sound applications.

The force factor characteristic $Bl(x)$is very sensitive for the application's cost, size, and weight, depending on the magnet material used. The effective radiation area $S_D(x,f)$ and the acoustic parameters of the vented or sealed enclosure with and without passive radiators define the loudspeaker's size and weight. A larger port diameter reduces the nonlinear distortion and modulated noise from air turbulence.

The last column in Table 2 shows that active transducer control provides new opportunities for virtually modifying all critical speaker parameters and detecting irregular distortion in the target application. The measurement or modelling of the instantaneous voice coil temperature T_v allows active compensating for the amplitude compression caused by the time-varying resistance $R_E(t)$ while providing thermal loudspeaker protection.

Adaptive nonlinear control can reduce time-variant and nonlinear distortion generated by the transducer nonlinearities represented by the lumped parameter model in Figure 2. This linearization requires an active stabilization of the voice coil position and mechanical protection. Thus, the passive transducer can safely operate in the nonlinear region, giving more max SPL from smaller speakers while using less input power and resources.

The active corrections of the spatial transfer function $H_L(f,\mathbf{r})$ require multiple exciters to control modal vibration on a sound radiating surface (e.g., baffle) or use various speakers for beamforming and other spatial sound control techniques.

Active control cannot cancel abnormal sound with random properties, but the protection system can operate the transducer in the intended working range to avoid irregular vibration generation.

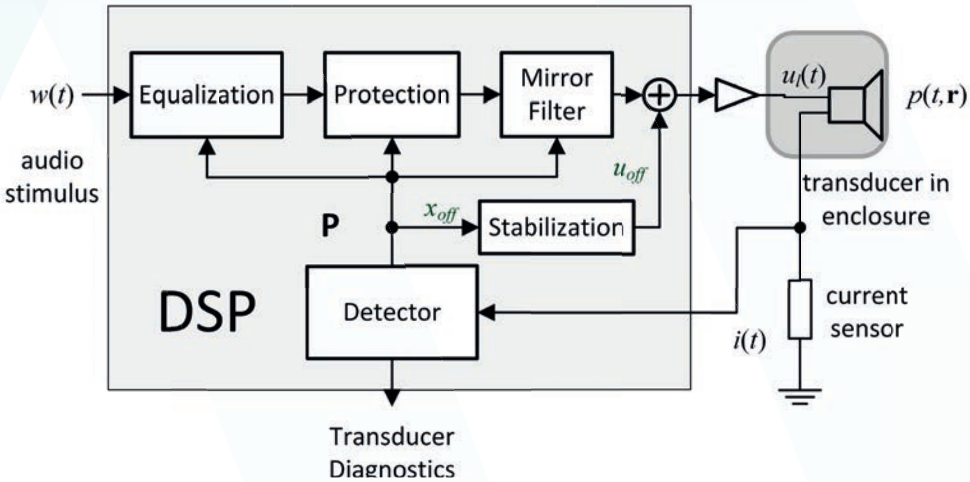
Adaptive nonlinear control

This section shows how the results of loudspeaker modelling can be used for adaptive nonlinear control of moving-coil transducers and complete loudspeaker system based on current sensing, as illustrated in Figure 5.

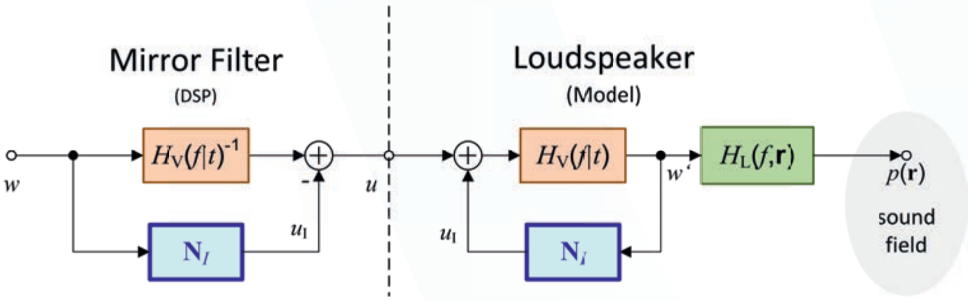
The KCS technology [10] uses the mirror filter to compensate for time-variant and nonlinear distortion modelled by lumped parameters in Figure 2.

The mirror filter [8] uses two subsystems in a feed-forward structure. The first subsystem $H_V(f|t)^{-1}$ is the inverse function of $H_V(f|t)$ in the loudspeaker model and compensates for the linear time-varying loudspeaker behaviour. The nonlinear subsystem N_l generates the same equivalent input distortion u_l subtracted from the linear signal. The digital input signal w becomes identical with w' at the input of the spatial transfer function $H_L(f,\mathbf{r})$, and the undesired nonlinear and time-variant distortions are reduced at all points in the sound field. Typically the distortion reduction is about 6 dB ... 20 dB depending on the test stimulus, the loudspeaker, and other measurement conditions.

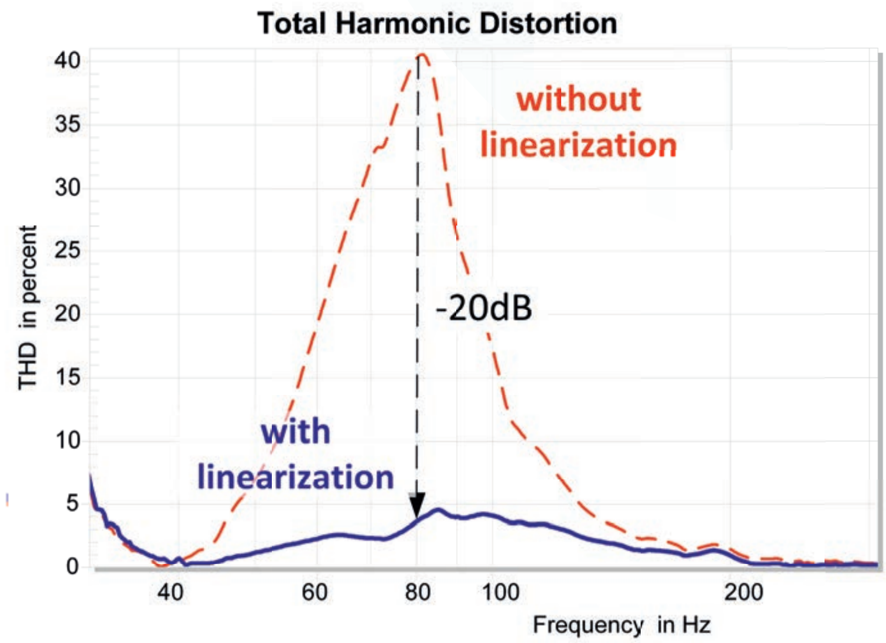
For example, Figure 7 shows a total harmonic distortion (THD) measured on a woofer operated in a sealed enclosure. The plain loudspeaker without linearization generates about 40% distortion at an excitation frequency of 80 Hz, where a high voice coil displacement activates the nonlinear parameters $Bl(x)$, $K_{MS}(x)$, and $L_e(x, i)$. The mirror filter cancels the dominant distortion leaving a residuum of 5% caused by unmodelled dynamics. P60



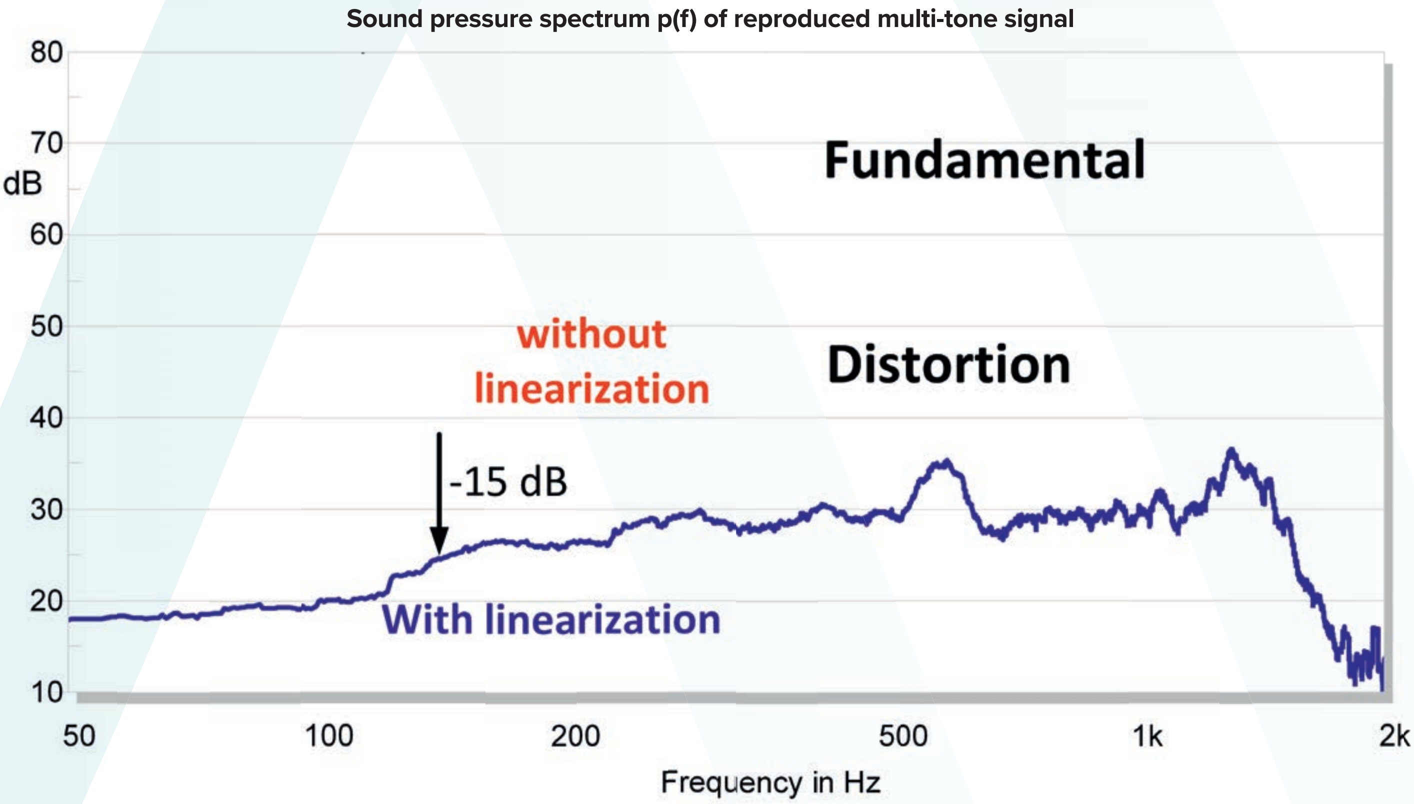
Above:
Figure 5:
Block-diagram of an active loudspeaker system with adaptive, nonlinear loudspeaker control [1] based on KCS-technology



Above:
Figure 6:
Active compensation of the nonlinear and time-variant loudspeaker distortion by the mirror filter



Above:
Figure 7:
Total harmonic distortion in the sound pressure output of a woofer measured without and with linearisation using the mirror filter [1]



Above:
Figure 8:
Fundamental components and nonlinear distortion in a multi-tone test stimulus without and with linearisation using the mirror filter [1]

The conventional measurement of the total harmonic distortion with a single tone at a particular frequency reveals the most critical excitation frequency. Still, it does not assess intermodulation distortion generated only by multiple spectral components in music. Figure 8 shows the distortion reduction of the same woofer reproducing a multi-tone stimulus simulating typical program material. The active linearisation can reduce all distortion by more than 10 dB over a wide frequency range.

The mirror filter generates no additional latency, is stable, and requires a low processing load. The control parameters **P** in the mirror filter correspond to the lumped parameters in Figure 2 and Figure 4. Production variances, aging, climate, and other influences require a permanent measurement of the model parameters while reproducing any audio signal in the target environment.

A detector shown in Figure 5 optimally estimates the loudspeaker parameters **P** and checks the parameter's physical plausibility before they update the control parameters in the mirror filter. Such an adaptive control scheme needs a sensor for sensing the transducer's electrical, mechanical or acoustical state. A mechanical sensor requires access to moving parts (e.g., diaphragm) and additional hardware, increasing costs. Sound pressure measurements, performed with inexpensive MEMS microphones in the near-field, are corrupted by ambient noise, disturbing the parameter measurement. P62

Akustik + Sylomer® floor mounts and Acoustic hanger Tests

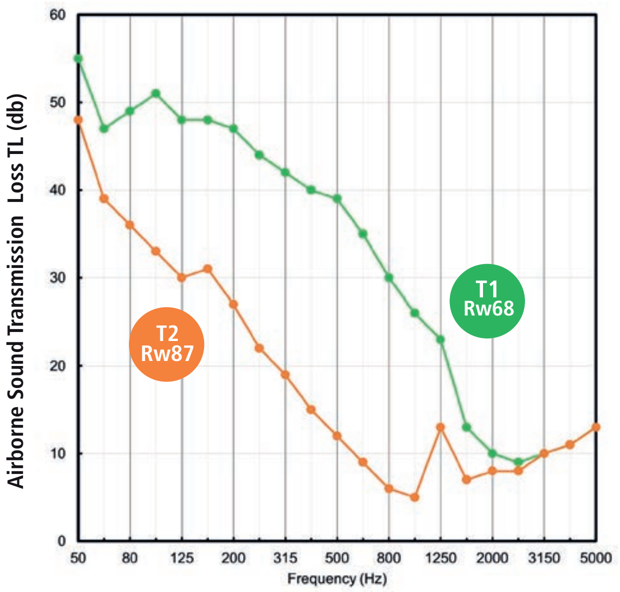
Test results for the **Akustik + Sylomer® Floor Mount 25** on a 150mm concrete slab, achieving values of Rw=68 and Lnw=41.

Adding the **SRS25 + Sylomer® Acoustic Hangers** to the assembly allows us to achieve values of Rw 87 and Lnw 23.

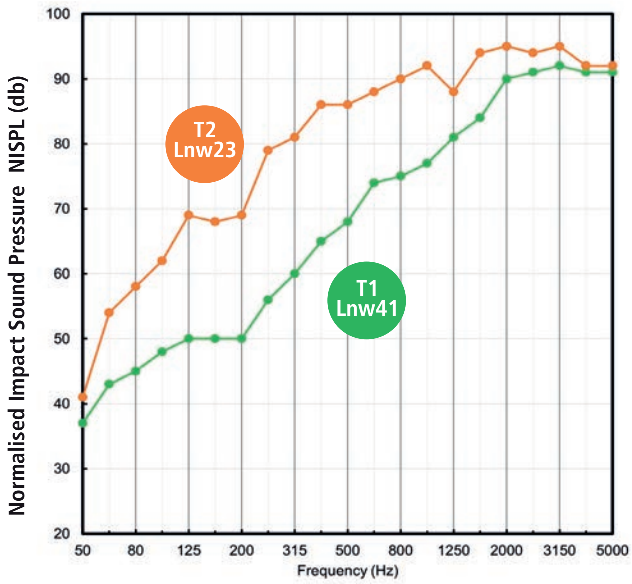
AMC MECANOCAUCHO UK

Manufacturing **solutions** for architectural acoustics and vibration problems **since 1969**

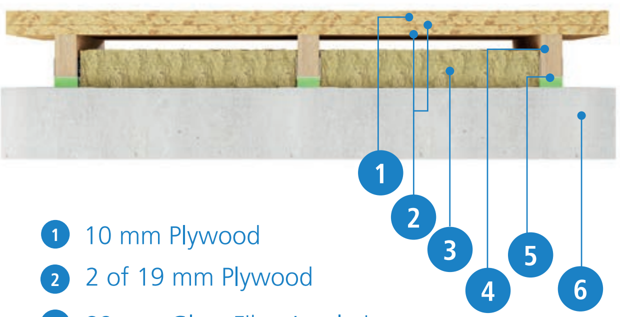
Airborne Sound Transmission Loss



Normalised Impact Sound Pressure Levels

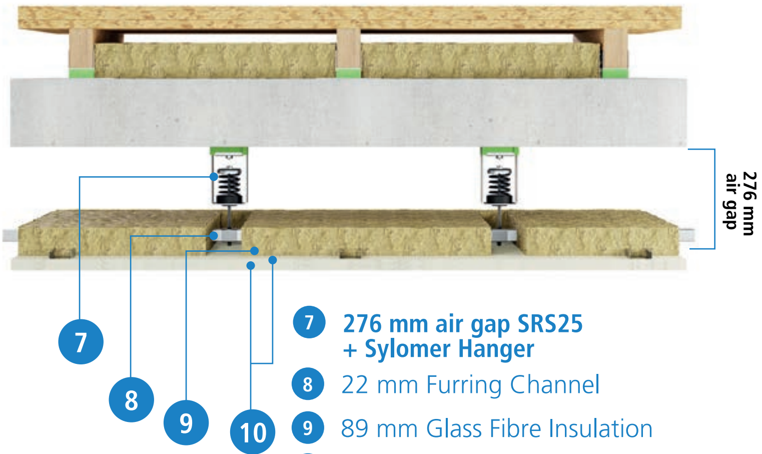


T1 Akustik + Sylomer® Floor Mount 25



1. 10 mm Plywood
2. 2 of 19 mm Plywood
3. 89 mm Glass Fibre Insulation
4. 2 x 89 mm Wooden battens
5. **67.5 mm Akustik + Sylomer Floor Mount 25**
6. 150 mm Precast Concrete Slab

T2 Akustik + Sylomer® Floor Mount 25 and SRS25 +Sylomer® Acoustic Hanger



7. **276 mm air gap SRS25 + Sylomer Hanger**
8. 22 mm Furring Channel
9. 89 mm Glass Fibre Insulation
10. 2 of 16 mm Type X Gypsum Board

Lewis Metcalf
Applications Engineer – UK & Ireland

www.amcuk.co.uk
www.akustik.com
lewis.metcalf@amcuk.co.uk
Leicester, UK
+44 (0)7523118007

Download Lab test report

Therefore, monitoring the electrical voltage and current at the speaker terminals is a robust and cost-effective alternative. Suppose that the power amplifier supplies the terminal voltage with a linear and time-invariant transfer behaviour. In this case, it is sufficient to measure only the current and use a predicted voltage, as shown in Figure 2. The transducer operated in the loudspeaker as an actuator also becomes a sensor for its mechanic and acoustic states. The back EMF generated as a voltage

$Bl(x)v$ on the electrical side reveals the velocity distorted by the nonlinear force factor modulation $Bl(x)$. Thus detector in Figure 2 has to compensate for those nonlinearities to accurately estimate the speaker parameters, voice coil displacement, velocity, and other acoustic variables in the equivalent circuit in Figure 2. This part of the KCS technology is widely used as a measurement instrument (LSI in KLIPPEL Analyzer System) to identify the nonlinear speaker parameters.

The detector measures the instantaneous voice coil offset X_{off} from the initial rest position caused by production variance, fatigue, and external influences [1]. A stabilisation system in Figure 5 generates an electrical DC voltage U_{off} and shifts the coil back to the optimum working point. The active X_{off} compensation ensures full peak-to-peak displacement giving maximum bass, high efficiency, and reduced peak voltage requirements.

The protection system uses the updated transducer parameters to automatically adjust the maximum peak displacement X_{max} and other protection limits to ensure reliability during product life. A close link between online diagnostic and protection is essential to cope with the changes in the mechanical suspension, increasing the risk for rocking modes, voice coil rubbing, and other subsequent faults. The status of the natural aging process is a piece of essential diagnostic information to replace a transducer module in time.

Linearisation, stabilisation, protection, and diagnostics are required to cope with time-variant and nonlinear speaker properties. An equaliser shown in Figure 5 can be applied to the input signal to correct the SPL response at a particular point r in the sound field, the mean SPL in an acoustical zone, or the total sound power radiated from the loudspeaker.

An automatic system alignment provides a desired target system function (e.g., *Butterworth* with a specified cut-off frequency) for any transducer and enclosure type. A protection system copes with the bass boost and keeps the displacement, terminal voltage, and voice coil temperature in permissible limits for any input signal supplied to the loudspeaker.

Active transducer module

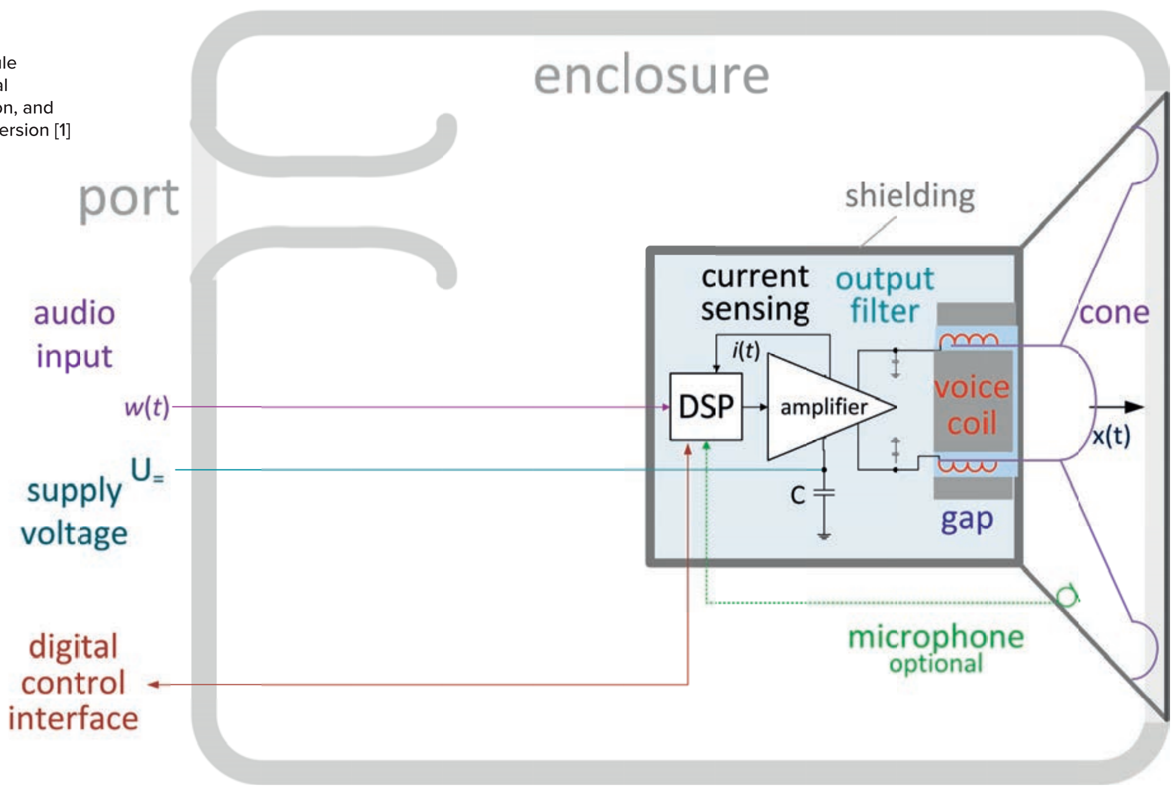
The new software opportunities provided by adaptive, nonlinear control accelerate changes in the hardware components. DSP, amplification, and transduction will eventually merge into one active module, as illustrated in Figure 9.

The hardware changes are motivated by the *Green Speaker Design* paradigm [3], maximising the electro-acoustical efficiency without increasing cost, size, or weight:

Placing the amplifier and voice coil closer together reduces electrical losses in the cables. The Class D amplifier uses a simplified output filter compliant with EMC because the iron path, magnet, and frame provide sufficient shielding. A reduced coil resistance (R_e < 2 Ohm) improves the voltage sensitivity of the transducer required to generate the maximum SPL for a limited peak voltage and peak current provided by the power amplifier. The amplifier tolerates a varying supply voltage caused by a relatively thin wire diameter.

A short voice coil overhang exploiting the fringe field outside the air gap increases the motor efficiency factor $(Bl)^2/R_e$ and

Right:
Figure 9:
Smart transducer module comprising digital signal processing, amplification, and electro-acoustical conversion [1]



reduces the moving mass M_{MS}. The iron path and inexpensive shorting material reduce the voice coil inductance and improve the voltage sensitivity at higher frequencies. The mechanical suspension has a reduced stiffness $K_{MS}(x)$ in the intended working range $-X_{max} \leq x \leq X_{max}$ while keeping imbalances in mass and stiffness distribution and rocking modes small. This design sacrifices transducer linearity for efficiency and requires active nonlinear control to cope with the increased nonlinear distortion and endurance.

A few meaningful characteristics listed in Table 3 describe the acoustic performance of the active transducer module mounted in an infinite baffle giving perfect half-space condition. The spatial transfer function $H_L(f,\mathbf{r})$ represents the sound pressure output at any point $\mathbf{r}$ in the sound field over the product life for any signal amplitude as long as the transducer needs no active protection. The directivity index $D_I(f)$ is a far-field characteristic that compares the sound generated on-axis with the total sound radiated in all directions. The directivity index depends on the geometry of the radiating surface, is time and production invariant, and cannot be changed by controlling one transducer module.

Max SPL, rated according to IEC 60268-21 [4], describes the maximum output generated with a broadband stimulus. The product of effective radiation area S_D and maximum displacement X_{max} limits the bass performance of direct radiating loudspeakers. The active transducer module operated in a sealed box can generate the peak displacement X_{max} if the enclosed air volume is larger than V_{mBox}.

The transducer module can only generate the max SPL if the power supply complies with the voltage and current requirements of the transducer module. The active protection system prevents an overload of the transducer and amplifier and limits the maximum output if the battery needs charging in portable applications. Finally, the weight, size, and cost must be considered to select a suitable active transducer module for a particular application.

Below:
Table 3: Important characteristics of the transducer module

Characteristics	Condition
Spatial transfer function $H_L(f,\mathbf{r})$	Transducer operated in free field in a half-space (2π) at small and high amplitudes (protection not active)
Directivity index $D_I(f)$	free field, far-field, half-space (2π)
max SPL	Maximum SPL (IEC 60268-21 [4]), on-axis, 1 m distance, free-field measured in a short-time test with a pink noise stimulus in the rated frequency range, short-time measurement (1 min), endurance tested with the same stimulus for 100 h
Effective radiation area S_D	below cone break-up
Maximum displacement X_{max}	with adaptive, nonlinear control (linearization, stabilization, and protection)
Minimum box air volume V_{mBox}	transducer mounted in a sealed enclosure with internal air volume V_{mBox} generates X_{max} for a low-frequency stimulus
Voltage supply range $u_{=min} < u_{=} < u_{=max}$	required for generating max SPL
Maximum supply current $i_{=max}$	required for generating max SPL at minimum voltage supply $u_{=min}$
Weight, size, cost	without enclosure

Below:
Table 4: Additional characteristics of the transducer module required for system design

Characteristics	Condition
Displacement transfer function $H_{w,u}(f,\mathbf{r}_r)$	describes the relationship between control input w and displacement x at the point $\mathbf{r}_r$ on the radiation surface at small amplitudes
Linear and time-invariant lumped parameters	electric, mechanic, acoustic and thermal parameters of the active transducer with adaptive, nonlinear control
Nonlinear lumped parameters	loudspeaker nonlinearities $Bl(x)$, $L_E(x,i)$, $K_{ms}(x)$, $R_{ms}(v)$, $R_{AP}(q_p)$
Maximum amplifier output peak voltage U_{AMP}	provided by the power amplifier under normal supply voltage and current
Maximum voice coil temperature	rated by the transducer manufacturer in Celsius

Loudspeaker system design

The selected transducer module can be operated in any enclosure type, sealed, vented, or with or without an additional passive radiator (drone). An automatic measurement on a prototype identifies the acoustical load and generates the control parameters required to create the optimal system alignment in all manufactured units.

However, a numerical simulation based on additional module characteristics in Table 4 can optimise directivity, max SPL, size, weight, energy consumption, and heat transfer in the loudspeaker system before finishing the prototype. For example, the displacement transfer function $H_{w,u}(f,\mathbf{r}_r)$ measured by laser vibrometry according to IEC 60268-22 [7] is required for boundary element analysis (BEA) to find the optimal geometry of the enclosure surface and horn shape. The lumped parameters of the transducer module are essential for designing port and passive radiator. The nonlinear transducer parameters and maximum values of the amplifier output and voice coil temperature are the basis for defining the limits of the active protection system. P64

Self-test

The active, nonlinear control compares the measured and predicted electrical input current and generates an error signal from lumped parameter modelling to reveal any electrical, mechanical or acoustical problem in the loudspeaker. However, the electrical measurement is less sensitive for detecting irregular vibrations causing impulsive distortion in the sound pressure output. At least one microphone placed behind the cone, as illustrated in Figure 9, measures reliable symptoms of the loudspeaker defects with a good signal-to-noise ratio. The combination of electric and acoustic sensors is sufficient to perform a comprehensive quality assurance test in manufacturing the transducer module and the complete loudspeaker system and regular maintenance in the target application or at a service station. An artificial test stimulus (e.g., sinusoidal chirp) provides the most critical excitation and simplifies the detection of the impulsive distortion following IEC 60268-21 [4]. Online loudspeaker monitoring of abnormal sound while reproducing any audio signals in the target application requires adaptive modelling of the microphone signal, which requires additional processing load in the DSP.

Conclusion

Combining DSP, amplifier, transducer, and sensor in one active transducer module provides new software opportunities to improve the performance of the loudspeaker hardware:

- DSP algorithms reduce undesired signal distortion and generate a desired (linear) relationship between electrical input and acoustical output,
- Sensors monitor voice coil displacement, temperature, and other internal transducer states and external influences,
- The transducer protects itself against mechanical and thermal overload generated by the electrical input signal,
- The monitored information adaptively corrects production spread and other time-variant properties over product life for any audio stimulus,
- Online diagnostic detects hardware malfunction,
- Self-testing simplifies end-of-line testing and maintenance.

The active transducer module with the new intelligent features becomes a partially autonomous system that simplifies the design, manufacturing, and integration in more complex sound systems.

Green Speaker Design [2] increases the acoustic output (max SPL) from smaller, lighter, and more cost-effective transducers by maximising efficiency in the passive components and actively compensating for nonlinear signal distortion.

There is also more freedom for the design of the port, enclosure, and other acoustic loads by providing an automatic alignment of the overall transfer function. Beamforming, wave field synthesis, and other 3D sound applications using many loudspeakers can assume that the loudspeaker properties are identical and time-invariant.

The adaptive compensation of parameter variances allows less tight limits for fundamental resonance and voice coil rest position caused by the mechanical suspension. Thus, manufacturing can focus on irregular vibrations causing abnormal sound and impairing the product's reliability.

Online diagnostics and self-testing provide valuable information over product life to replace a transducer module before a total failure occurs. This collected data is beneficial for suppliers and manufacturers to select, for example, better suspension materials reducing fatigue and improving endurance under harsh climate conditions.

The active transducer module is beneficial for professional equipment used on stage and fixed installations and for automotive, home, and other consumer applications.

References

[1] W. Klippel "Novel Loudspeaker and Headphone Design Approaches Enabled by Adaptive Nonlinear Control" J. Audio Eng. Soc., vol. 68, no. 6, pp. 454–464, (2020 June.). DOI: https://doi.org/10.17743/jaes.2020.0037

[2] W. Klippel, "Green Speaker Design (Part 1: Optimal Use of System Resources)," presented at the 146th Convention of the Audio Eng. Soc. in Dublin (March 10, 2019), paper 10138.

[3] W. Klippel, "Green Speaker Design (Part 2: Optimal Use of Transducer Resources)," presented at the 146th Convention of the Audio Eng. Soc. in Dublin (March 10, 2019), paper 10139

[4] Sound System Equipment – Part 21: Acoustical (output-based) Measurements, IEC 60268- 21

[5] W. Klippel, "Loudspeaker Nonlinearities – Causes Parameters, Symptoms," J. Audio Eng. Soc. vol. 54, no. 10, pp 907 – 939 (Oct. 2006).

[6] W. Klippel, "Nonlinear Modelling of the Heat Transfer in Loudspeakers," J. Audio Eng. Soc. vol. 52, no. 1/2, pp. 3-25, (2004).

[7] Sound System Equipment – Part 22: Electrical and Mechanical Measurements on Transducers, IEC 60268-22

[8] W. Klippel, "The Mirror Filter - a New Basis for Reducing Nonlinear Distortion Reduction and Equalizing Response in Woofer Systems," J. Audio Eng. Soc. vol. 32, no. 9, pp. 675-691, (1992).

[9] Sound System Equipment – Electro-acoustical Transducers – Measurement of Large Signal Parameters, IEC 62458

[10] KLIPPEL Controlled Sound (KCS), **https://www.klippel.de/products/klippel-controlled- sound.html**

IOA awards and medals deadline reminder

The IOA annually honours people whose contributions to acoustics or to the Institute have been particularly noteworthy.

The medals and awards programme is wide-ranging in its acknowledgment of academic achievement, practical engineering applications and innovations, student achievement and contributions to the Institute and to the world of science and technology.

Time is running out for nominations for the 2023 Medals and Awards. The closing date is 1 October 2022.

Nomination forms are at
https://www.ioa.org.uk/about-us/awards

All nominations for the 2023 Medals and Awards must be received by
1 October 2022

Decisions will be made by Christmas and the winners will be announced early 2023.

BRANCH NEWS

Central Branch

By Matt Torjussen, IOA Central Branch Secretary

It's been a busy 2022 so far for the Central Branch with events covering building isolation, tranquility and soundscaping, air source heat pumps, low frequency noise from transformers, and noise camera research for roadside vehicle noise measurement.

We are fortunate to have the IOA's headquarters in our patch, which means its videoconferencing facilities have been available to us for all of our events. This has allowed us to roll out a hybrid meeting agenda, where attendees and speakers can join meetings online or in-person. Now the Central Branch can reach its members more easily, with the option of continuing our technical discussions after a presentation over a meal for those attending in person. This has led to meeting attendance peaking at over 300.

We also record and post most of our meetings on the IOA's members' videos page. You can visit this page and view these videos here **https://www.ioa.org.uk/members/videos** (if you're viewing this as a pdf), or scanning the QR code on this page. (You'll need to be logged in for the link to work.)

Our programme for Branch meetings from September 2022 will include presentations from building isolation suppliers, a soundwalk of Milton Keynes and a hands-on session from instrumentation suppliers.

We strongly encourage those local to Milton Keynes to attend meetings in person, as it is an excellent opportunity to meet others in the industry and discuss the presentation. If you have not joined us before, we're ever such a friendly bunch and we're keen to welcome new faces.

To make sure you receive alerts about our events, sign up to the Central Branch in the 'My Details' section of your IOA account online.

The Central Branch is also still seeking a new Early Careers Officer to join the committee. For those who are interested, please contact our Chairperson, David Trew at **dtrew@bickerdikeallen.com**

Yorkshire and North East Branch

Soundwalk in the Ouseburn Valley, Newcastle upon Tyne

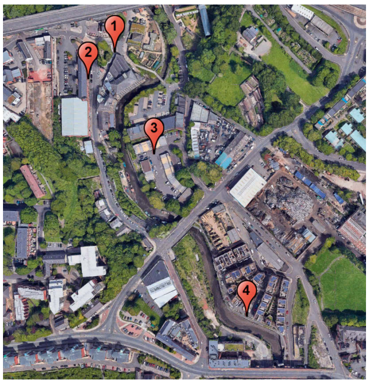
By Dr Julija Smyrnowa, Seena Sajeev and Jack Harvie-Clark

On a warm, sunny evening in July, Apex Acoustics Ltd organised a fantastic event – a soundwalk, led by Jack Harvie-Clark, in the Ouseburn Valley, Newcastle upon Tyne, that was truly engaging and educational.

Seena Sajeev designed the questionnaires and carried out data analysis, and Rebecca Romeo Pitone made simultaneous binaural measurements. The team's work in the field of soundscape was awarded Highly Commended in the Environmental Noise category at the 2021 ANC Awards.

The Ouseburn Valley was recently voted by Time Out magazine as 'one of the coolest neighbourhoods on the planet' for food, fun, culture and community. Busy pubs, outdoor music events, music rehearsal rooms, commercial, industrial and residential premises now co-exist in this busy and vibrant area. More residential developments in the area are also in the pipeline.

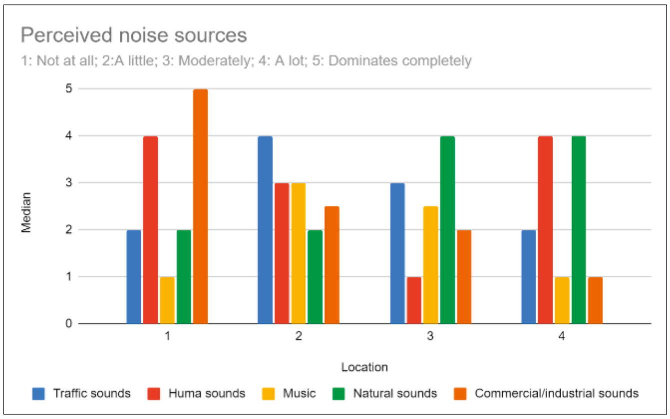
During the soundwalk the participants were asked to listen to the sound environment at four locations across the valley; the first location was a public recreation area, while at the other three locations the context was for residential amenity. Location 1 was outside The Cluny – a famous local bar with outdoor seating areas. Surprisingly, at this location sound from the kitchen extract fan was the most dominant sound source. Location 2 was just across the road from the first and at which the same bars were still very visible but sounds of passing trains and cars were much more noticeable. At Location 3, only distant traffic and distant sounds of music were audible. At the final location, the sound of rustling leaves was nearly dominant except for sounds of speech from occasional passers-by.

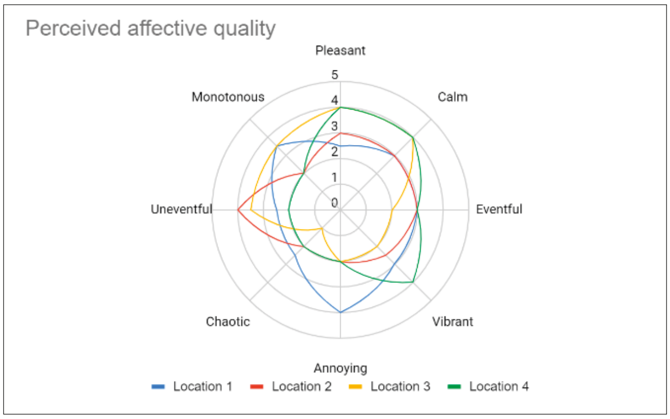


The soundwalk locations are illustrated on the left.

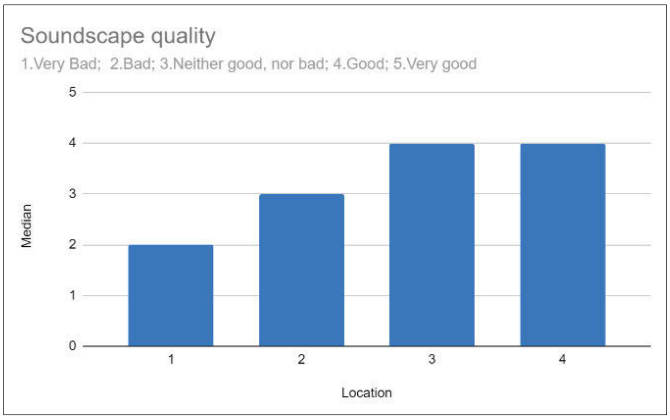
The participants recorded their responses in a questionnaire, which followed Method A of ISO 12913-2 'Acoustics – Soundscape – Part 2: Data collection and reporting requirements'. The participants were from a variety of backgrounds and disciplines, including noise regulators, acoustic consultants, a landscape architect and academic, students and the public, which could be considered as a representative sample for a soundscape assessment. This provided an opportunity for responses and discussions from a wider perspective. The qualitative data gathering via the questionnaires were supplemented with binaural recordings via a dummy head, recommended in ISO 12913-2 as a method of quantitative data collection.

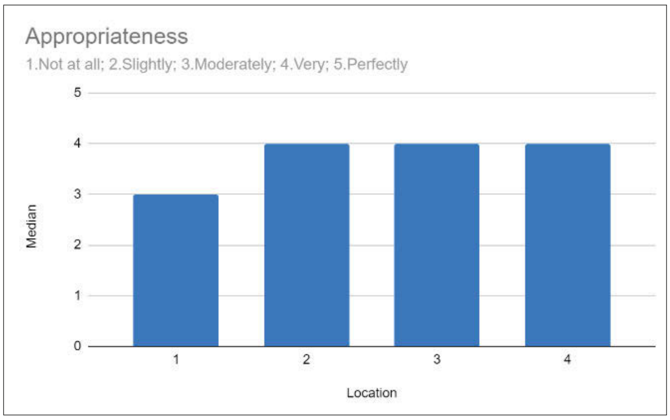
The questionnaire responses were analysed following ISO 12913-3. Median values of the responses are used as a measure of central tendency, following the standard. Median values of the responses to the perceived noise sources and perceived affective quality at the soundwalk locations are shown below.





Median values of the responses to the soundscape quality and appropriateness of the sound environment at the soundwalk locations are shown below.





From the comments and informal discussions following the soundwalk, it was understood that the responses to Location 1 were entirely determined by the kitchen extract noise. The location was considered most 'annoying' and received the lowest scores on soundscape quality and appropriateness. The music sources perceived at Location 2 were from The Cluny, which was right next to Location 1. Due to the comparative dominance of the kitchen extract noise, music was less perceived at Location 1. Participant comments also indicated that Location 1 would be considered 'pleasant' and 'vibrant' in the absence of the extract noise.

At Location 3, while most participants found the music from nearby rehearsal rooms out of place and annoying, some considered the location ideal for urban living. Responses to this location demonstrates the varied nature of human perceptions of sound environments, and poses the question of inclusivity – should our designs focus on the average or more sensitive group?

Locations 3 and 4 received most positive responses for perceived affective quality; the soundscape quality was considered 'good', and the sound environment considered 'moderately' appropriate. Natural sounds dominated the sound environment in these locations as indicated by the median responses to the perceived noise sources. The responses are consistent with research, which indicates that natural sounds generally tend to reduce perceived annoyance and improve pleasantness.

The soundwalk provided an engaging and collaborative way to help understand the sound environment of the valley. As an emerging field, soundscape has great potential in revealing aspects of sound environments which would otherwise not be evident. A future can be envisaged, where soundscape enables and promotes participatory and sustainable designs. Further research and guidance are however still required to bridge the gap between soundscape theory and practical design.

The Yorkshire and North East Branch thanks Apex Acoustics for a very well received and informative event, and will encourage other branches to organise similar events which would particularly promote the value of soundscape for urban planning and design.

Acoustic scheme for historic Standon Hall

CMS Danskin Acoustics (part of SIG plc) has specified and supplied acoustic products to reduce the impact of airborne and impact sound transmission in the Grade II* listed, Standon Hall, in Staffordshire.

During the course of redeveloping the early 20th Century country house into a wedding and business venue, CMS Danskin Acoustic's technical team conducted a site assessment in order to prevent noise transfer between ground floor functions rooms and nine bedrooms and suites above. The resulting acoustics strategy involved the installation of 600m^2 of Smartspan floor panels, Karma TNF70 high density stone-fibre batt and REGUPOL acoustic isolation strip.

Challenges included the need to work from above to avoid disturbing fine, moulded lath and plaster ceilings below and the necessity to specify high performance acoustic materials of a thickness that would not increase bedroom and bathroom floor levels.

CMS Danskin Acoustics had to avoid disturbing the fine moulded ceilings of Standon Hall's ground floor function rooms *(image courtesy of Standon Hall)*

Keeping ancient artefacts safe from vibration

The Parthenon Marbles

The delicate Parthenon Marbles (aka Elgin Marbles) have been in the British Museum in London since 1816. They, and all treasures in museums, require protection from potentially harmful sources of vibration and in this article, Kyriakos Papanagiotou, founder and director of KP Acoustics, explains why curators and conservators should consider working with an acoustics consultancy to eliminate the vibration risks to their collections.

The most common source of vibration is footfall in the building or visitor circulation (ambient vibration) and although rarely likely to cause major problems, is still sensible to monitor. Studies have found that when coupled with certain floor types, the vibration generated by visitor circulation has the potential to reach levels that can cause damage to objects, especially those with pre-existing weaknesses.

In fact, one study of ambient vibration levels at the National Museum, demonstrated that 'ambient vibration levels from visitors on wooden floors approach the damage levels identified and could pose a risk in some circumstances.'

Vibration from demolition and construction activities is especially problematic and poses a higher risk. Whether the construction work is part of a renovation of the museum itself, or is taking place on an adjacent building, extreme care must be taken.

Unfortunately, there is generally a lack of reliable data on what levels of vibration objects can withstand. However, risks include objects 'walking' on smooth surfaces, where they might fall off the edge of a shelf or display unit. Other risks stem from the resonance of objects with natural frequencies similar to construction vibrations, and from the vibratory motion of objects that are very fragile or have existing weaknesses.

Whenever any construction work is involved, the first step is in planning and testing, where different tools and demolition or construction methods can be tested in different locations to assess which creates the least vibration. Testing can also help reveal whether a particular shelf design or pedestal shape and material are especially prone to amplify vibration. During this initial phase, a monitoring system is put in place bearing in mind that while testing and planning is key, it is quite likely that a construction project will produce unforeseen vibration and mitigation approaches will have to be adopted.

After the testing, mitigation strategies can be developed. For some objects that might mean isolators and dampeners to lessen the impact of vibration. It is preferable that, as far as is possible, displays and galleries remain open. With the correct acoustic treatment, this is often possible for many objects. However, in other instances it might be determined that it is safer to move the objects altogether.

Before any construction work begins, vibration trigger levels are established. Continual monitoring of vibration takes place, and if the agreed vibration levels are exceeded, it is important that construction work is brought to an abrupt halt. Most modern equipment will automatically alert users when a threshold level has been exceeded and for monitoring in museums, multiple accelerometers are usually deployed to ensure continuous and accurate measurements and data.

Curators might also consider the benefits of upskilling their staff to better prepare them for vibration monitoring.

SPECIALIST GROUPS

HEAD acoustics NVH Simulator User Group meeting: Exchange between experts

HEAD acoustics is hosting a user group meeting on the PreSense NVH Simulator, the interactive tool for virtual engineering and prototyping.

The meeting will take place at the HEAD acoustics headquarters in Herzogenrath on 24 November 2022, directly after the Aachen Acoustics Colloquium (November 21-23, 2022, in Aachen). Participants will be able to share their experiences, exchange ideas, get to know the HEAD acoustics solutions' application potential and strengths, learn about trends in automotive NVH simulation, and help shape future developments in direct exchange with the NVH Simulator team.

They can also attend presentations by PreSense users from Honda, Mercedes Benz, Toyota, and Volkswagen about how they use HEAD acoustics' NVH Simulation tools.

Stolen equipment

Item one

A SVAN-959 type 1 sound and vibration level meter and analyser, with serial code 12976 has been stolen from a site in Alderley Edge, Cheshire.

If you have come across it, please contact Dominic McCann on **01617621055,** or by email at **dominic@acousticsuk.com**

Item two

A 01dB Solo sound level meter, serial no 65445 has been stolen. It was chained to a road sign on Church Lane, South Hiendley, Barnsley and was taken between 10:00 and 12:00 noon on 5 August 2022.

If you have come across it please contact Darren Lafon-Anthony on **0114 321 5151** or 07496 950010, or by email at **darren.lafon-anthony@enzygo.com** or **d.lafon-anthony@outlook.com**

Senior Members' Group

By Peter Jackson

On Wednesday 29 June 2022 , members of the IOA Senior Members' Group came together via Zoom for a presentation by Ron Sauro, President of NWAA Labs Elma, Washington, United States, on 'Myths in absorption and diffusion and what testing has revealed'.

Ron described the work that has taken place at his lab in its spare time over the past 14 years to research the effects of the edge effect on the measurement of absorption in reverberation chambers and why the international standards have poor reproducibility.

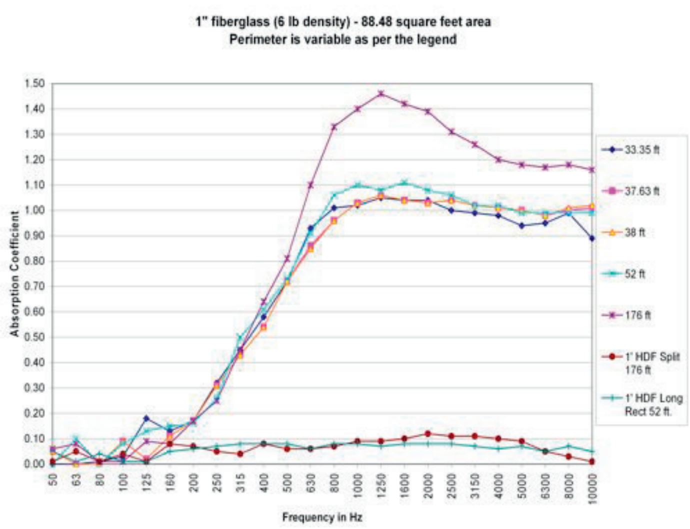
In all the standards, the absorption coefficient is measured using an area term to define the test sample. Ron showed that by keeping the area constant and increasing the perimeter, considerable differences can be seen in the data.

His lab then investigated the spacing of discrete absorption panels showing a limit on the spacing that allowed the full edge effect. Interestingly, the effect of the square samples being parallel or randomly oriented had no effect on the absorption.

Finally, a relatively simple formula was derived from the measurements that allowed the calculation of what may be termed the 'true' absorption of a material. This value could then be input into an acoustic model to accurately predict the nett absorption of a realistic installation.

Ron finished his presentation with an audience Q&A.

Diagram shows absorption coefficients of main sample materials with a common area and a variable perimeter



Institute Sponsor Members

Council of the Institute of Acoustics is pleased to acknowledge the valuable support of these organisations

Founding Key Sponsors

Brüel & Kjær

Cirrus Research plc

AcSoft Noise, Vibration & Air Quality

Acrefine Engineering Services Ltd
Aecom Infrastructure & Environment UK Ltd.
AMC Mecanocaucho
ANV Measurement Systems
Apex Acoustics
Arup Acoustics
Bickerdike Allen Partners
Campbell Associates
Cellecta ltd
Christie & Grey Ltd
Clement Acoustics Ltd
CMS Danskin Acoustics
Couch Perry Wilkes Acoustics
Direct Acoustic Solutions Ltd
Echo Barrier Limited
Emtec Products Ltd
Farrat Isolevel Ltd
GERB Schwingungsisolierungan GmbH
Getzner UK Ltd
Gracey & Associates
Hann Tucker Assoc
Hayes McKenzie Partnership Ltd
Hilson Moran Partnership Ltd
ISOMASS Ltd
KP Acoustics Ltd
Mason UK Ltd
Monarfloor Acoustic Systems Ltd
National Physical Laboratory
Noise Solutions Ltd
noise.co.uk Ltd
Nova Acoustics Ltd
Pliteq
RBA Acoustics
Rockfon
RSK Acoustics LTD
Saint-Gobain Construction Product UK t/a Saint-Gobain Ecophon
Sandy Brown Ltd
Sharps Redmore Partnership Ltd
Siderise Group,
SITMA
Sound Reduction Systems Ltd
Spectrum Acoustic Consultants
Stantec UK Limited
Waterman Infrastructure & Environment Limited
WSP
Zenita Ceiling & Grid Solutions Limited

Applications for Sponsor Membership of the Institute should be sent to Membership at the Milton Keynes office. Details can be found on the IOA website.
Members are reminded that **ONLY** Sponsor Members are entitled to use the **Sponsor IOA logo** in their publications, whether paper or electronic (including web pages).

Committee meetings 2022

DAY	DATE	TIME	MEETING
Thursday	**15 September**	**10.30**	**Council**
Tuesday	27 September	11.00	CPD Committee
Tuesday	25 October	10.30	Engineering
Wednesday	26 October	10.30	Engineering
Thursday	27 October	11.00	Publications
Tuesday	1 November	10.30	Research Co-ordination (London)
Thursday	3 November	10.30	Meetings
Wednesday	9 November	10.30	CCBAM Examiners
Thursday	10 November	10.30	Diploma Tutors and Examiners
Thursday	10 November	13.30	Education
Thursday	17 November	10.30	Membership
Monday	21 November	10.30	CCWPNA Examiners
Monday	21 November	13.30	CCWPNA Committee
Tuesday	22 November	10.30	ASBA Examiners (Edinburgh)
Tuesday	22 November	13.30	ASBA Committee (Edinburgh)
Wednesday	23 November	10.30	Executive
Thursday	24 November	13.30	CCENM Examiners
Thursday	24 November	13.30	CCENM Committee
Wednesday	**7 December**	**10.30**	**Council**

Institute Council

Honorary Officers

President
A Somerville HonFIOA

President Elect
Prof D C Waddington MIOA
University of Salford

Immediate Past President
S W Turner HonFIOA
ST Acoustics

Hon Secretary
F Rogerson MIOA
Arup Acoustics

Hon Treasurer
Dr M R Lester HonFIOA
Lester Acoustics LLP

Vice Presidents
J Hill MIOA
AAF Ltd

Dr P A Lepper MIOA
Loughborough University

H Notley FIOA
Defra

Ordinary Members

Dr C Barlow MIOA
Solent University

Dr B Fenech MIOA
Public Health England

D Goodhand MIOA
Goodhand Acoustics

Prof G Heald FIOA
Dstl

Dr K R Holland MIOA
ISVR

A Lamacraft MIOA
dBx Acoustics Ltd

Dr Y Liu FIOA
AECOM

R Mahtani MIOA
Sandy Brown Associates

P Rogers FIOA
Sustainable Acoustics

Chief Executive

A Chesney
Institute of Acoustics

The Environmental Instrumentation Experts

NOISE VIBRATION WEATHER DUST

Contact Support

Dedicated support gets you the help you need fast

- Available for purchase & hire
- A truly web-based solution
- No software required
- Fully certified and site proven hardware

Leq VDV PPV Met PM10

New Features!

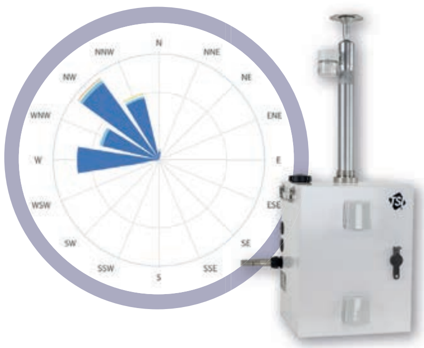
Just a few examples of the many features that have been recently introduced

AUDIO

- Triggered when individual limits are exceeded
- Separate audio-only trigger option available
- Audio-on-demand function for recalling any audio within the previous 24-hours
- Control .wav recording on the meter remotely

POLLUTION ROSES

- Daily, weekly and monthly pollution roses

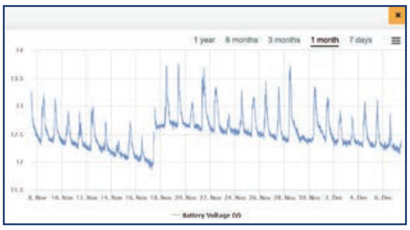


POWER

Monitor the power consumption and battery status of each position.

New PowerSave option:

- Units buffer and upload data once per hour
- Easy-to-use scheduler can be used to control when PowerSave is enabled
- Up to 50 hours with a single 12Ah battery and 2 weeks with a 100Ah battery
- Solar options available to power noise, vibration, weather and dust 24/7/365



Existing customers Contact us now to begin enjoying these new features free of charge

WWW.NOISE-AND-VIBRATION.CO.UK

INFO@NOISE-AND-VIBRATION.CO.UK

01908 642846

ilac-MRA UKAS CALIBRATION 0653