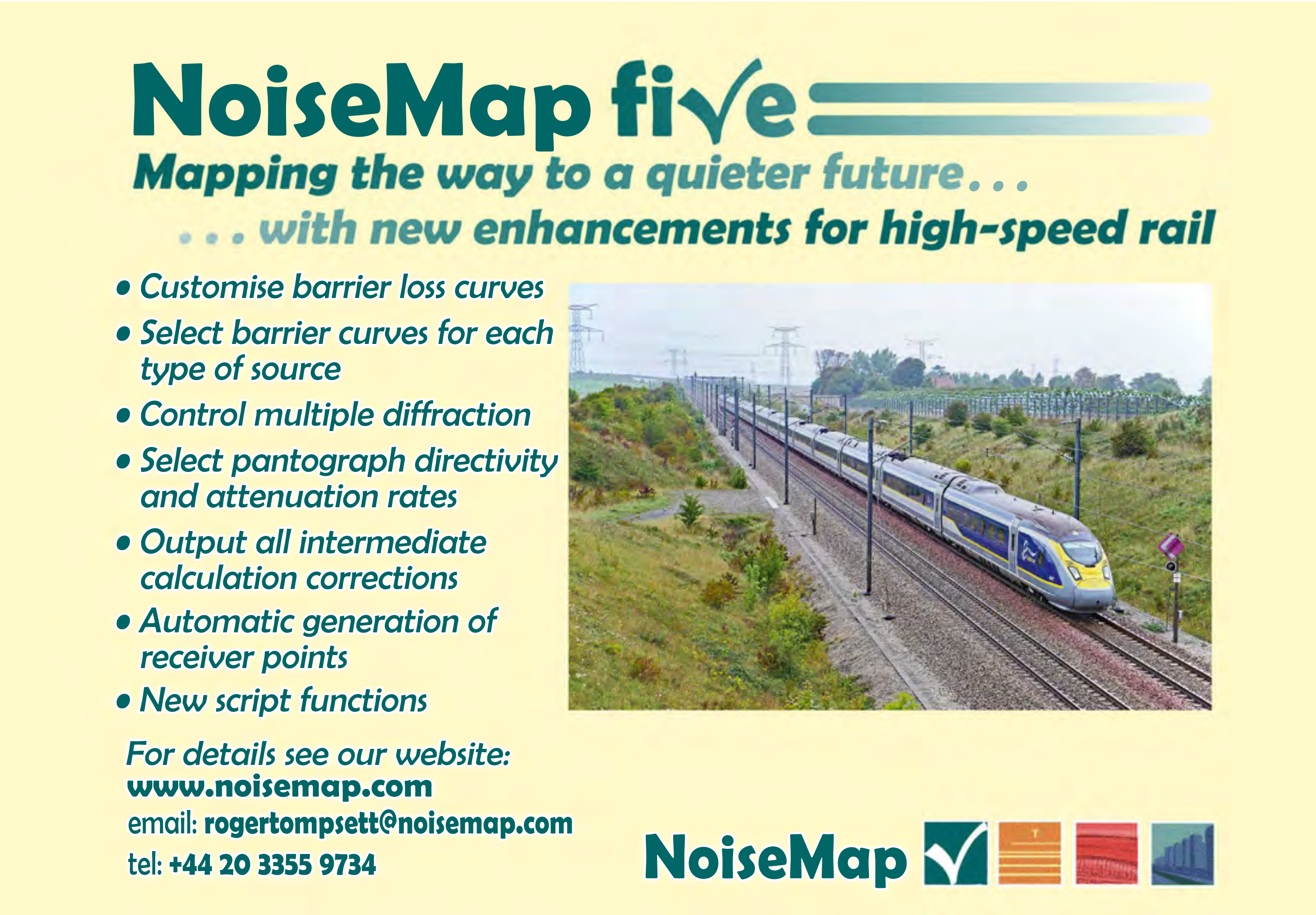
Volume 47 No 3 May/June 2021

ACOUSTICS BULLETIN

Image courtesy of NASA/JPL-Caltech

Institute of **Acoustics**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ACOUSTICS BULLETIN

Acoustics Bulletin Volume 47 No 3 May/June 2021

Institute affairs

General news

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.

Cover image:
Perseverance Hazcam First Drive
Our cover image was captured while NASA's Perseverance rover drove on Mars for the first time on 4 March 2021. One of Perseverance's Hazard Avoidance Cameras (Hazcams) captured this image as the rover completed a short traverse and turn from its landing site in Jezero Crater.

Features

Regular

Institute of **Acoustics**

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

It was on the 12th March 2020 that the Institute held its last in-person meeting before of the first lockdown occurred. The meeting explored the appetite for revising or replacing the Calculation of Road Traffic Noise and the Calculation of Railway Noise through an initiative by the British Standards Committee on Transportation Noise.

The one-day meeting took the form of presentations and a workshop discussion, and was scheduled to be held at the Jurys Inn hotel in Milton Keynes (just over the road from our headquarters).

As the date of the meeting approached, concern about COVID was increasing daily. This included some delegates saying that their employer would not permit travel to the meeting because of the risks involved. So, the Institute faced a dilemma – we did not want to cancel the meeting but yet, how were we to engage with those members who wanted to attend but couldn't?

The outcome was a blended meeting using the Zoom facilities we have in the conference room at HQ. The presentations took place there, with about 40 to 50 people attending in person and with about a dozen delegates watching remotely. The attended workshop session was held at Jurys Inn with those online split into a couple of groups and discussing the issues with each other remotely.

We all came together again in HQ for the final feedback session. With a lot of hard work and goodwill from everyone involved, it worked.

What we have learned from online meetings

Now we have the prospect of the restrictions easing, we are having to think very carefully about our future meeting plans. The enforced use of Zoom (other similar online tools are, of course, also available) has helped us to learn a lot. In no particular order they are:

- Online meetings enable us to reach members who would otherwise, because of their location, find it really difficult to attend any IOA meetings, and certainly not the traditional evening Branch meetings;
- Online Branch meetings and webinars can be easily held at lunchtime or in the early afternoon (as opposed to the evening) meaning that members with childcare responsibilities can attend;
- Live online presentations work and good debates can occur both with the speaker and between delegates through the chat function. Those live presentations also do come with the added frisson of whether the wi-fi will co-operate throughout the event.
- We can hold online multi-session conferences, but to be held robustly and effectively they do come at a cost; and
- Although we can have some form of online networking, it has never been the same as being in a bar or a pub with fellow delegates, even if individuals sorted out their own refreshment.

What do we do in the future?

There are some who argue that all future meetings should remain online – they are time-efficient, more accessible to all and save on travelling. Conversely, there are others who are missing being able to meet up at attended events and wish to see a rapid return to that format. There is also a further group of members who are advocating blended events like the one held last March – but will members physically attend an event if they can watch it online instead?

And, as mentioned above, any conference, be it attended (as had been planned for Acoustics 2020 in Chester in May last year) or online as Acoustics 2020 became last October, attracts a cost to set up – a cost the Institute has to recover from the delegate fee. So whatever event is proposed, some certainty has to be secured over the number of delegates that would pay to attend.

Trying to come up with a plan is the challenge currently facing members of our Meetings Committee, chaired by Chris Turner. The Executive Committee is working closely with them. In addition, there are some other members who are also kindly helping to identify both the technical opportunities and constraints that we need to take into account when determining our approach to meetings. Most importantly, we must understand what you, the members, want us to do.

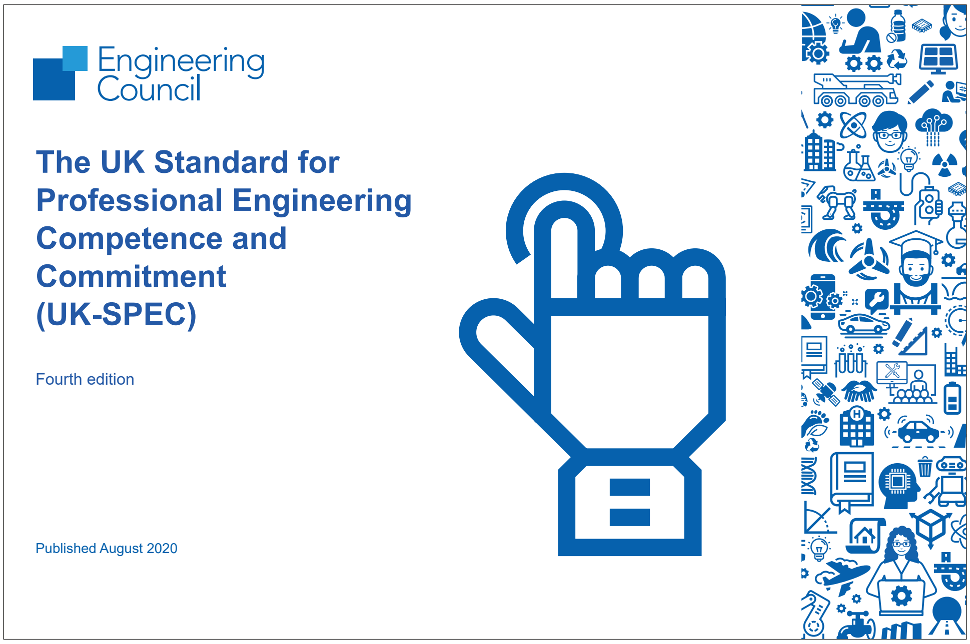
One of the immediate issues is whether Acoustics 2021 can be held in person in October this year. At the moment, all that can be said is that there WILL be an event, but the format has yet to be decided. So please make sure you have 11th and 12th October 2021 in your diary.

In the meantime, stay safe

Engineering Division

The IOA Engineering Division will support you through the process to help you become one of almost 225,000 registrants that hold international professional recognition.

By Blane Judd BEng FCGI CEng FIET FCIBSE, Engineering Manager


Engineering Council

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

Fourth edition

Published August 2020

Above: Work continues to draw up the new documentation to comply with the new UK-SPEC version four

We are still observing the lockdown rules and the majority of our activity is being conducted while working from home. The interviews we held in February went very well and on the facing page you can read about two of the candidates who were successful. Candidates are provided with guidance material when they first apply, and we are always ready to comment on the content of their professional review report prior to them submitting their final draft.

Work continues to draw up the new documentation to comply with the new UK-SPEC version four and are looking to start implementation in the middle of the year. If you want to learn more about the new version, visit the Engineering Council website at **https://bit.ly/3cEALQu**. Those already working on their submission will be able to use UK-SPEC version three up to the end of the year. From July onwards, however, we will be encouraging candidates to work to version four. The Engineering Council are expecting us to have made the transition by December 2021. Since on average it takes six months to complete the process, July is considered to be a suitable start point for transition.

Help and support

Emma Lilliman is doing a great job in managing the process remotely, we are working hard to keep response times down to a minimum while working remotely so please bear with us. Neil Ferguson continues to help us with academic equivalence support for those candidates who do not have exemplifying qualifications. You can check for yourself if your qualifications meet the required specification by visiting the Engineering Council website **www.engc.org.uk**. But please don't panic if your specific qualification is not listed, as we can still help you through the process on the individual route. Each institute has an Engineering Council liaison officer who comes from another institute as a volunteer to help and support colleagues. We are delighted to have Malcom Carr-West from the Institute of Agricultural Engineers as our new officer. Some of you may meet him, as on occasions he might sit in on interviews.

Interviews

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

Academic qualifications

The requirements for academic qualifications for CEng and IEng changed in 1999. Pre-1999 an honours degree at 2:2 or above was required for CEng or a higher diploma/certificate for IEng. Post-1999 this changed and for CEng a master's degree was required or an ordinary degree for IEng.

There are two routes:

1. **standard route** if you have the appropriate EC-accredited qualification (also referred to as an exemplifying qualification) in acoustics; and the
2. **individual route**, which requires further preparatory work from you before submitting evidence of your competence.

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

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

The Institute recognises the IOA Diploma course and the several masters 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.

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

The opportunity is there, and we are ready to support you through it, so that you can become one of almost 225,000 registrants that hold International professional recognition.

Candidate profiles

Matthew Robinson BSc, PhD, CEng, MIOA

I studied audio technology at Salford University, graduating in 2008, with a year in industry spent at the Building Research Establishment. Following this I applied for research funding for a PhD at the University of Liverpool Acoustic Research Unit. My work focused on the prediction of sound and vibration in buildings from transient and quasi-transient sources using transient statistical energy analysis. After graduating I took on a post-doc research project, working with HMG Communications Centre, developing methods for assessing speech security. In 2013, I moved from academia to commercial consultancy and started working at Sandy Brown in Manchester. In the intervening years I have worked on a wide variety of schemes in the northwest, London and internationally.

I first considered starting the registration process a few years ago and the IOA were helpful in confirming that I would need to proceed with the 'standard route', as my PhD would serve as an alternative for an accredited engineering degree. In discussions with the IOA, I realised that I needed to gain more experience in commercial consultancy prior to applying.

The process of writing the professional review interview (PRI) report was useful in a few ways as I had to review my input for a number of projects and evaluate the design guidance, decisions and technical methods. The process also allowed me to look at how the work that I do relates to the UK Standard for Professional Engineering Competence (UK-Spec) assessment criteria, which was essential preparation for the interview. Though for myself, like many engineers, writing this much about my own abilities was odd and took a while to get used to.

The overall experience of professional registration has been useful, but daunting at times. Nonetheless, I would encourage all those practicing acoustics to consider applying.

Jon Lee CEng, IOA corporate member

After becoming an Incorporated Engineer in 2013 I was advised on the next steps to take towards chartership, one of which was keeping an active and up-to-date CPD record. This was one of the greatest benefits to my application, saving me hours of retrospective record keeping and I would recommend keeping on top of it to ultimately obtain chartership. The application process, despite COVID-related delays, was relatively straightforward and the support of the IOA certainly helped in developing a qualifying submission.

The interview was held remotely over Zoom, which considering I live overseas was very helpful. There were some challenging questions raised by the panel, a couple of which I actually followed up with a bit of personal research post-interview to solidify my knowledge further in those areas.

I would highly recommend the process to those acousticians wanting to develop their career.

The IOA Diploma during the pandemic

Thanks to the efforts of many people, the Diploma has continued to be offered throughout the pandemic, by distance learning (DL) and at accredited centres.

By Professor Keith Attenborough, IOA Education Manager

In the Diploma year from September 2019 to December 2020, there were 56 DL and 51 centre-based candidates. However, the continuing pandemic has restricted the number of candidates registered during the Diploma year that started in September 2020 to 38 DL and 36 centre-based.

Accredited centres were able to adapt efficiently to an online mode of delivery. For example, the University of Derby used Blackboard Collaborate to deliver online lectures and enable group tutorials in breakout rooms. Pre-recorded lectures and mini-bite problem solving sessions were uploaded onto the Blackboard platform and MS Teams was used for individual tutorials to support students. Derby, Solent and Leeds Beckett offered live laboratory classes subject to COVID safety measures. London South Bank arranged for the issue of sufficient equipment to enable their Diploma candidates to carry out laboratory work at home.

Feedback from the September 2020 centre-based Diploma cohort has generally been extremely positive, with students appreciative of the efforts made by academic staff and the technical support teams at centres. Similar provisions are in place for the current centre-based Diploma cohort at Derby, Leeds Beckett and London South Bank.

However, in February 2021, Solent decided to close its acoustics teaching. We are grateful to Chris Barlow and Juan Battaner-Moro for acquiring the necessary equipment and arranging facilities to enable transfer of the Solent area Diploma teaching to a consultancy. They have been recently accredited (online) for delivering the Diploma and the Environmental Noise Certificate course.

Below: Diploma candidates during laboratory exercises

Exams

The main changes for distance learning candidates during 2019/20 were time-restricted ‘at home’ examinations and a greater proportion of online tutorials. The more open book nature of the examinations required extra efforts by the examiners to reduce the proportion of questions that could be answered simply by copying from books. Despite this change in the nature of the examinations, the proportions of passes and merits following moderation in August 2020 were much the same as in previous years.

Although some Diploma candidates were able to pursue the Diploma projects they proposed in February 2020, many had to amend their plans, since COVID restrictions in the summer months prevented measurements and/or access to facilities. Accordingly, tutors and the IOA office were lenient in allowing changes even at the last minute and new marking criteria were drafted for projects; based essentially on literature review and desktop activities. Similar provisions are in place for the current cohort.

Virtual home-based laboratory experiments

During the current year, the examinations will be time-restricted ‘at home’ again. But another important change has been the introduction of virtual home-based laboratory experiments for candidates who would otherwise have had face-to-face laboratory schools at Liverpool and Dublin. P10

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Above: John Kennedy, Diploma tutor at Trinity College Dublin, devised experiments involving home-based measurements of reverberation time and audiometry

The laboratories in Dubai took place as normal. The virtual laboratory schools show videos devised by the tutors at Liverpool and candidates watch the videos during a Zoom meeting for up to three hours for each of the experiments. They make subjective assessments of the effects of any noise control measures introduced to complement the objective measurements displayed on the instruments. The videos are shown as a series of short clips followed by group discussion of the implications of what has been shown. Candidates take detailed notes in a laboratory notebook, which they use as the basis for reports that they submit for assessment. In a related development, John Kennedy the Diploma tutor at Trinity College Dublin, devised experiments involving home-based measurements of reverberation time and audiometry. DL candidates are required to write up at least one of these for assessment.

Although the home-based and virtual laboratory exercises were developed as a consequence of force majeure during the pandemic and they cannot substitute completely for hands-on and group laboratory experiences, there will be discussions at the upcoming meetings of tutors and examiners and education committee in July of whether a version of the virtual laboratories could be offered to DL candidates, for example, those based overseas (apart from the Middle East), in the future. This might help the planned drive to recruit more overseas candidates for the Diploma. Already, there are 13 applications (resulting in five registrations so far) from overseas for the Diploma year starting in September 2021.

Blended learning videos

The online provision for the tutored distance learning version of the Diploma has been much enhanced by the series of blended learning videos produced last year. The videos for the General Principles of Acoustics and the Specialist Modules on Regulation and Assessment of Noise, Environmental Noise and Building Acoustics are an integral part of the tutorial programme already and it is planned that those for the Noise and Vibration Engineering Control Module which are still in production will be available in time for the start of the next Diploma year.

Images

The image on the first page of this article was taken before lockdown in March 2020.

The Space Industries Act 2018 Consultation on draft guidance to the regulator on environmental objectives relating to the exercise of its functions under this Act

The Space Industry Act 2018 (the Act) and regulations made under it are a critical part of the Government's commercial spaceflight programme. Spaceflight has the potential to affect climate change, local air quality and environmental and underwater noise impact which can affect human health, biodiversity and the wider environment. The IOA responded to the Department for Transport Consultation in March and we publish the response in full here.

The IOA welcomes the approach of setting environmental objectives for the spaceflight regulator and for providing guidance on those objectives.

The IOA response focuses on two aspects of the draft guidance, namely:

1. Noise – pages 15 – 20 of the draft guidance
2. The noise aspect of the marine environment

It can be seen that the Institute has various comments on these issues.

The IOA would be happy to liaise with officials in order to assist in developing the noise-related guidance over the coming months.

Noise

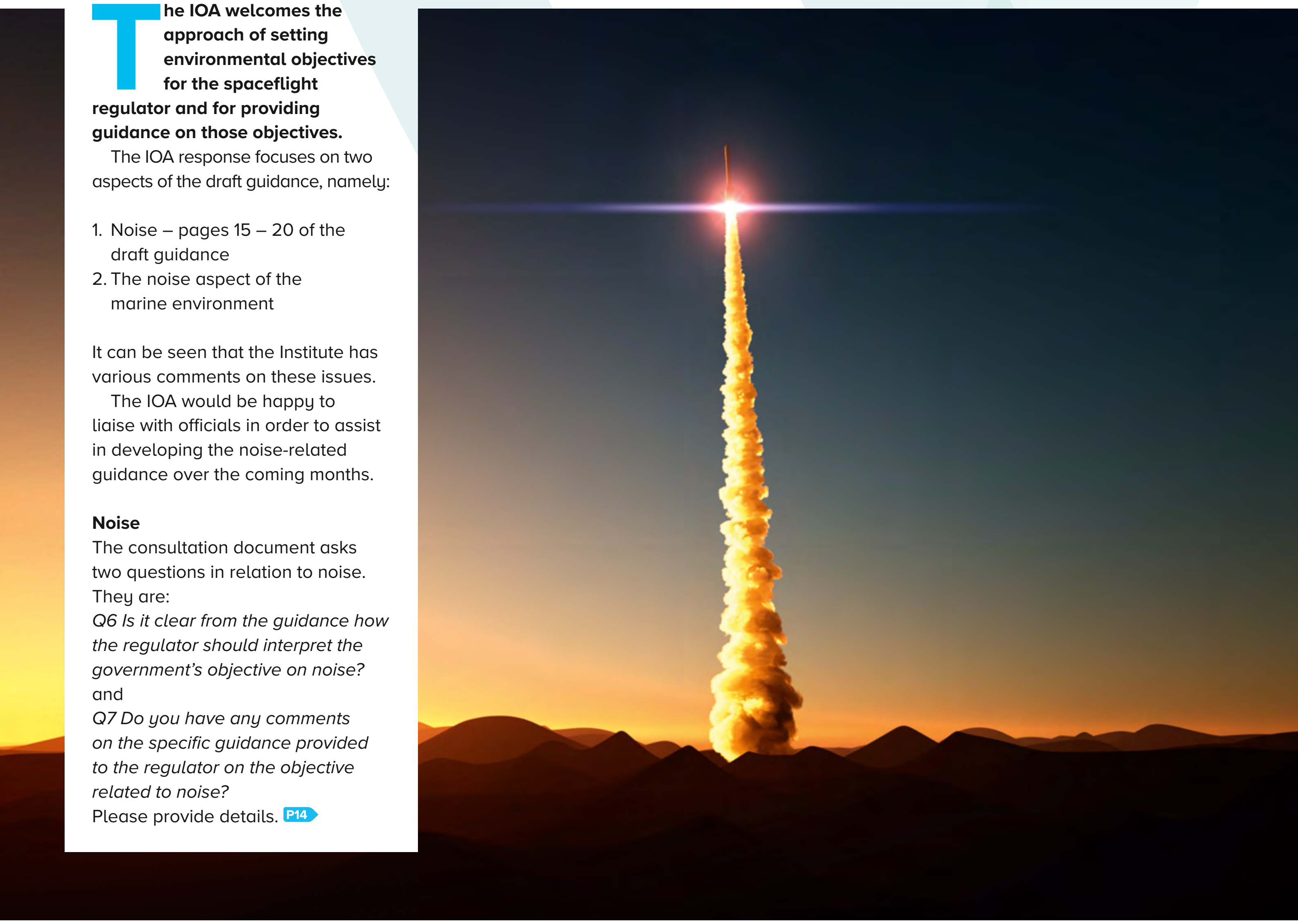
The consultation document asks two questions in relation to noise. They are:

Q6 Is it clear from the guidance how the regulator should interpret the government's objective on noise?

and

Q7 Do you have any comments on the specific guidance provided to the regulator on the objective related to noise?

Please provide details. P14



The Institute's responses are:
Question 6 No
Question 7 Yes – please see below

Further details

It is understood that the guidance is required to address the assessment of noise impacts from a new spaceport and the impact of space flights associated with the spaceport. Therefore, when providing guidance, it is convenient to divide the issues into four elements:

- Policy, legislation and guidance;
- Prediction;
- Assessment;
- Mitigation.

The Institute's comments below are set out under those headings.

Policy, Legislation and guidance

Some of the information given in the draft guidance document really has no bearing on the issues to be addressed in the Assessment of Environmental Effects (AEE) of such a development. Such information includes:

- The reference to the Environmental Noise Directive, and presumably the associated transposing regulations. When considering the development of a new spaceport – this legislation has no bearing; and
- The Environmental Protection Act 1990 (EPA1990). This legislation would only potentially apply once the spaceport has been built and should a noise source at the spaceport, which falls under the terms of the EPA1990, be thought to be causing a statutory nuisance. Furthermore, noise from aircraft in flight are excluded from the ambit of this legislation and spacecraft could fall under the definition of an aircraft.

The overarching policy for noise management in England is set out in the Noise Policy Statement for England (NPSE), which is mentioned on page 16 of the guidance.

In terms of setting environmental objectives for the management of noise on people, the aims of the NPSE should become the Environmental Objectives set by the Secretary of State. These aims apply to all noise sources.

Following this approach would not only provide consistent noise management, but are familiar concepts with practitioners. The aims are:

Through the effective management and control of environmental, neighbour and neighbourhood noise within the context of Government policy on sustainable development:

- *avoid significant adverse impacts on health and quality of life;*
- *mitigate and minimise adverse impacts on health and quality of life; and*
- *where possible, contribute to the improvement of health and quality of life.*

The National Planning Policy Framework would also apply to the new spaceport. It includes the policy that states:

Planning policies and decisions should contribute to and enhance the natural and local environment by:

e) preventing new and existing development from contributing to, being put at unacceptable risk from, or being adversely affected by, unacceptable levels of ... noise pollution;

This policy would also apply, and, therefore, should also be part of the Environmental Objectives.

The Planning Practice Guidance on Noise includes a Noise Exposure Hierarchy Table which provides assistance for implementing these policies. That table can be found here: **https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/820957/noise_exposure_hierarchy.pdf**

Using these three documents provide the Environmental Objectives for the Regulator and the associated guidance for meeting them when developing a new spaceport.

As noted on page 16 of the draft guidance document, similar approaches to the management of noise can be found in the devolved administrations. Where appropriate, therefore, the guidance needs to be refined to reflect any detailed policy differences in Wales, Scotland and Northern Ireland.

Prediction

During the planning phase of any space related development there will be a need to predict noise from the scheme. Despite the increase of rocket launches in the past years and the commercialisation of their operations, little work has been published assessing the community noise impacts from rocket operations. However, before the community noise impact can be assessed and, if necessary, mitigation considered, noise prediction and modelling studies are needed to help better understand the potential noise exposures of the surrounding communities from rocket launches at spaceports.

It would be helpful if these studies were required to produce outputs in formats that build on and can be integrated with existing aviation noise data, e.g., airport noise contours. This would particularly be the case if spaceports might be developed at existing airports or airfields as well as where new sites are proposed.

Spacecraft noise has characteristics that make it different in how the sound propagates compared with other noise sources e.g., the distance at which the sound waves' transitions from relative low rates of decay to more rapid decline can be longer than for other sources. Consequently, many of the established methods for predicting noise propagation are not as accurate as they may be for other sources.

Some of the approved spaceports in the USA have followed empirically derived NASA noise prediction methods for evaluating the acoustics, vibration and blast environment when selecting the location of a potential spaceport. However, these methods are dated and do not take into account the new types of spacecraft designs and take off methods that are to be found. With recent technological advancements, the concept of horizontal launch vehicles is quickly becoming a new category of spacecraft. Although various noise prediction models have been developed and used for spaceports, there is no single unified approved method.

Consequently, the IOA suggests that the guidance also requires that the Scoping for any Environmental Statement (or equivalent where the EIA regulations may not apply), for a spaceport should include a comprehensive review of available models and methods for prediction of space travel related noise and a detailed explanation of the reasons for using a preferred chosen method.

Furthermore, the guidance should encourage sensitivity tests using, where available, alternative methods but based on the same inputs as used for the preferred method, so that the uncertainty of the prediction work can be understood.

The IOA agree with the draft documents' advice that relying solely on the $L_{eq,T}$ noise metric time averaged over long periods to predict and assess impacts is not the most appropriate method to use.

In addition, indicators including the following are also recommended:

- The maximum noise level in a noise event i.e., launch or recovery of an individual spacecraft e.g., L_{Amax}.
- The overall noise energy in a noise event e.g., the SEL (the Single Event Level) and $L_{Aeq,T}$ (the total noise energy over the event period, T).
- The degree to which the noise event exceeds the typical prevailing sound levels at receptors.
- The frequency content of the noise event and the prominence of any dominant frequencies compared to the prevailing sound.
- The onset time of the noise i.e., how quickly the sound level goes from relatively low level to maximum and vice versa.
- Assessing the likely effects of the above acoustic impact data by contextualising it in terms of factors including the number, duration and timing of noise events per day, week, month and year.

CAP 1766 *Emerging Aircraft Technologies and their potential noise impacts* indicates that the CAA's Environmental Research and Consultancy Department (ERCD) has been playing a part in the work of the International Civil Aviation Organisation developing noise standards for supersonic aircraft, and the IOA suggest that ERCD could provide noise emission levels for the prediction of noise from spaceports in the UK.

Assessment

The draft guidance mentions the World Health Organization (WHO) guidelines. Whilst the WHO guidelines provide a useful body of knowledge on the likely health effects of noise, the spaceport guidance should avoid implying the WHO guidelines can be used as set standards to be achieved. Any such standards or thresholds to be used should be set by national or local authorities taking account of the local and national context in order to achieve the relevant policy requirements.

The consultation documents also refer to a WHO guideline for L_{Amax} levels to avoid hearing damage. The IOA believe it would be more consistent to refer to the Control of Noise at Work Regulations 2005 which quote a lower exposure action value of a peak sound pressure of 135 dB (C-weighted).

As mentioned earlier, the noise from spacecraft can be quite different from other sources. It is usually intermittent but can last for up to several minutes when it happens. It also can occur at extremely high source sound levels, meaning it can propagate over long distances and affect a wide area. It often contains a strong low frequency element, including infrasound (see below), which leads to enhanced propagation, triggers different annoyance and sleep disturbance responses to noise without such features, and can have indirect effects such as causing resonant vibration in lightweight structures and building elements. Consequently, reliance on the advice and recommendations of standards and guidance that are appropriate for sounds without such content, such as, BS 8233 and the WHO Guidelines, may not be appropriate.

Infrasound is noise energy at or below 20 Hz. At normally encountered environmental levels infrasound is not audible to most people. But spacecraft can produce very high levels of sound, including at infrasonic frequencies that may be so high they can become audible relatively near to the source. Whilst the risk of significant adverse effects from infrasound is small, it is worthwhile noting that it is a perennial issue which is often misunderstood and/or misused in regard to various forms of development, and that addressing the issue early in the development of policy may help avoid protracted and polarised debate and opposition, which might delay or distract from achieving policy aims. P16

Status: This version of this Act contains provisions that are prospective.
Changes to legislation: *There are outstanding changes not yet made by the legislation.gov.uk editorial team to Space Industry Act 2018. Any changes that have already been made by the team appear in the content and are referenced with annotations. (See end of Document for details) View outstanding changes*

Space Industry Act 2018

2018 CHAPTER 5

An Act to make provision about space activities and sub-orbital activities, and for connected purposes. [15th March 2018]

BE IT ENACTED by the Queen's most Excellent Majesty, by and with the advice and consent of the Lords Spiritual and Temporal, and Commons, in this present Parliament assembled, and by the authority of the same, as follows:—

Regulation of spaceflight etc

1 **Introduction**

(1) This Act has effect for the purpose of regulating—
(a) space activities,
(b) sub-orbital activities, and
(c) associated activities,
carried out in the United Kingdom.

(2) For the purposes of this Act, a person carries out a space activity or sub-orbital activity if the person causes it to occur or is responsible for its continuing.

(3) In section 1 of the Outer Space Act 1986 (activities to which that Act applies)—
(a) omit "whether carried on in the United Kingdom or elsewhere";
(b) at the end of the existing text (which becomes subsection (1)) insert—
"(2) This Act does not apply to activities carried on in the United Kingdom (and accordingly does not apply to activities requiring authorisation under section 3(1) of the Space Industry Act 2018)."

(4) In this Act—
"space activity" means—
(a) launching or procuring the launch or the return to earth of a space object or of an aircraft carrying a space object,

The consultation document correctly notes that noise could impact both humans and wildlife, including domesticated animals and livestock. There is little UK specific guidance on assessing the effect of noise levels on animals, and it may be helpful for the regulator or another body (e.g., CAA or ICCAN) to suggest any internationally available material that might be used.

Finally, on page 17 there was an inconsistency in the metrics used. The IOA propose that the wording should say:

To avoid and minimise the risk of structural damage, the maximum noise levels (L_{Zmax}) should never exceed 110 dB.

The IOA recommend that the advice should include a statement that, *Where possible the maximum noise level should be mitigated to less than 90 dB L_{Zmax} to minimise the risk of induced resonant vibration in lightweight structures and building elements e.g., windows.*

It is also recommended that it is made clear that these values relate to a location outside the potentially affected properties.

Mitigation

The hierarchy of noise controls shown in Figure 1 is not recognised as a mitigation hierarchy for environmental noise management. Furthermore, it is arguably not correct in its details.

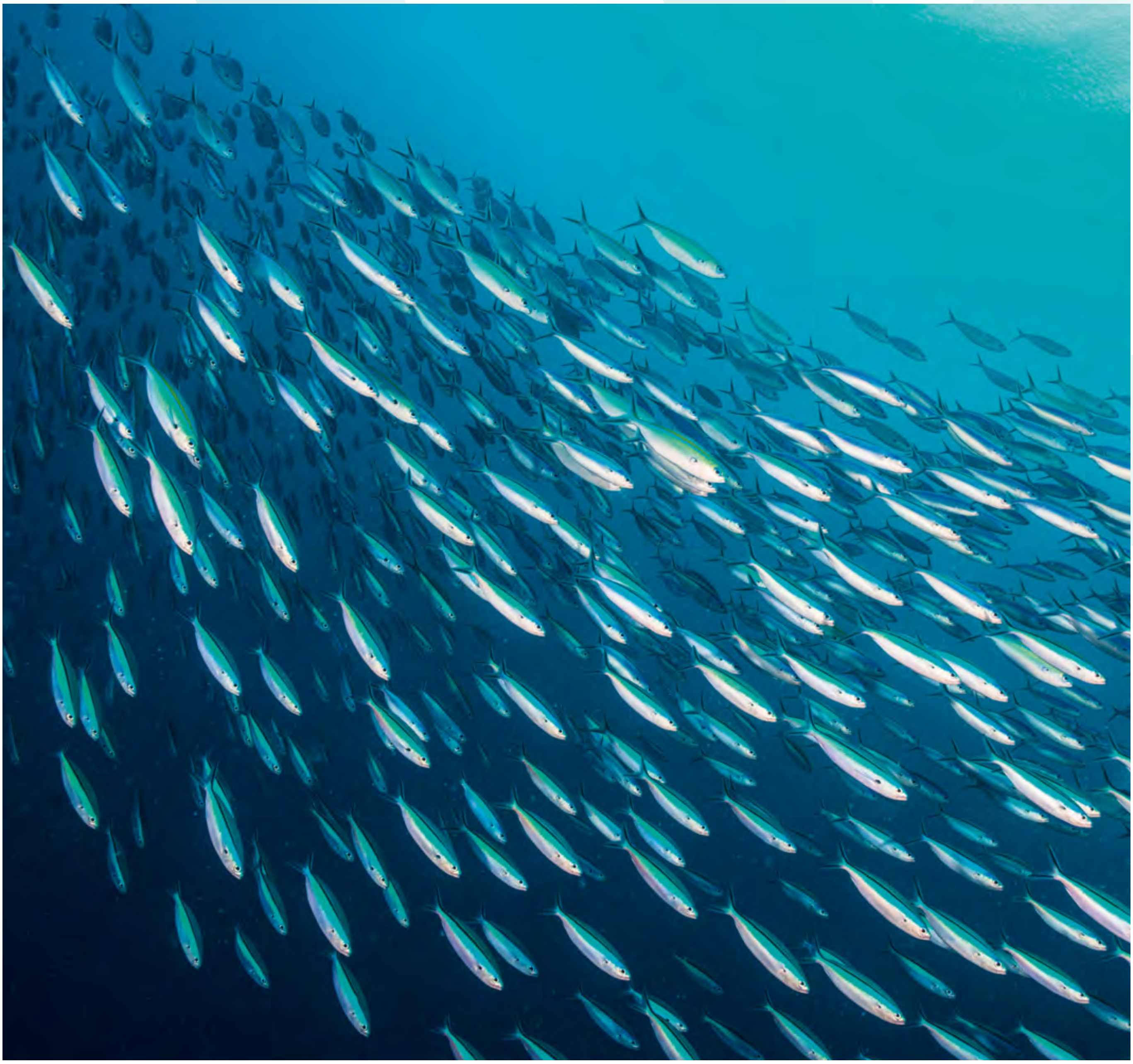
Instead, with regards to when the spacecraft are in the sky or about to take-off, the IOA suggests that the ICAO Balanced Approach should be mentioned, i.e.:

- noise at source;
- land use planning;
- operating procedures; and
- operating restrictions.

The consultation document notes that due to impacts on civil aircraft operations and for meteorological reasons, operators may prefer to launch at night. It is very well recognised, however, that the potential impact of noise at night on human health can be great.

Given that the draft guidance notes that noise from spaceflight activities is anticipated to be one of the biggest environmental concerns for both the impacts on human and wildlife receptors, the IOA would suggest that spaceports

Below: Currently, the regulatory basis for protecting the noise environment in the oceans is ill-defined. This guidance has the opportunity of taking the lead in beginning to define good practice



should be located sympathetically with civil aviation flight paths so that there is no need to operate at night.

There is a strong case for the Regulator to state that there should be no night operations as a specific operational restriction for planned spaceport operations.

Noise – conclusion

The IOA are of the view that the aims and objectives of existing noise policy and guidance suitably account for spacecraft related noise. However, standards and guidance commonly used in the UK for other noise sources are only partly suitable for spaceport related noise.

Therefore, it is suggested that the Government should commission a study to collate and review evidence on the effects of space travel related noise. This could then inform development of suitable guidelines and standards incorporating Government policy aims and objectives which seek to balance the negative effects of noise with the positive economic and social benefits of development.

The noise aspect of the marine environment

The consultation document asks two questions in relation to noise. They are:

Q6 Is it clear from the guidance how the regulator should interpret the government's objective on the marine environment? and *Q7 Do you have any comments on the specific guidance provided to the regulator on the objective related to the marine environment?* Please provide details.

The Institute's responses are:

Question 6	No
Question 7	Yes – please see below

Further details

The draft guidance provided to the regulator on the marine environment is vague. It makes many suggestions for top level strategy, but does not consider actually what should be done or how to do it. Currently, the regulatory basis for protecting the noise environment in the oceans is ill-defined. This guidance has the opportunity of taking the lead in beginning to define good practice.

The potential noise impact of developing and running the infrastructure is reasonably well understood, based on other similar developments, but the impact of the space vehicles is novel and will obviously need investigating and mitigation strategies developed. In particular shock waves due to sonic booms and their likely depth penetration must be characterised. Previous measurements on Concorde should provide helpful examples.

Before assessing any noise impact, however, the current noise environment in affected areas must be established, both due to natural sources and due to anthropogenic noise. Also required would be an assessment of the species present in the area under consideration (including possibly human divers) and their sensitivity to noise disturbance.

Finally, the potential for debris falling from space vehicles and impacting marine life on or near the surface, oil rigs, and other offshore installations would require assessment.

IOA Early Careers Group

By Tom Galikowski, Group Chair

The Early Careers Group (ECG) has continued to organise events forming a series of webinars prepared in response to COVID-19.

The University Fair, held on 8th February received good feedback from both attendees and the speakers. On 8th March, the ECG organised an 'Ask Anything' event encouraging members of the IOA to submit questions for which answers are not easily found on the web or by asking colleagues. (IOA members can catch up with the event here **https://www.ioa.org.uk/members-video-links-branch-group-and-other-meetings-2019-20**). We have received many interesting questions – thank you. Read below for a summary report of the event.

All webinars and events are possible due to time and effort volunteered by our guests and my fantastic ECG colleagues – Daniela Filipe MIOA from Hoare Lea, Dr Nikhil Mistry MIOA from ISVR and Josie Nixon MIOA from HA Environmental, as well as enormous help (and patience) of Linda Canty and Alex Shaida from the IOA.

We are always on the lookout for CPD ideas – please get in touch if there is a technical, career and education-related topic you would like to be discussed.

We have welcomed new ECG representatives: Zanyar Abdalrahman (Scottish Branch), Chris Duffill (Welsh Branch), Jonas Lopez Montoro (London Branch) and George Taylor (Noise and Vibration Engineering Group). There are still vacancies at Central Branch, Research Committee and Physical Acoustics Group – if you are interested, please get in touch with the ECG or the relevant groups.

On 1st April we started a mini-series of webinars building on the popular 'The Art of Being a Consultant'. Five bi-weekly discussions were organised focusing on topics not usually discussed during the in-person event, such as the role of mistakes, networking, working remotely or designing calculations. A summary of the event will be published in the July-August issue of Acoustics Bulletin.

ECG 'Ask Anything' webinar

The event aimed to encourage members to ask unusual questions about acoustics. We invited experts in their fields to help us answer some of the more interesting ones and take part in a discussion. They were: Professor Keith Attenborough (Open University, IOA Diploma), Dr Amelia Gully (University of York, ECG rep in the IOA Speech and Hearing Group), Dr Nikhil Mistry (ISVR, ECG rep on the IOA STEM Committee) and Dr James Talbot (University of Cambridge). We also received contributions from Professor David J Thompson (ISVR) who emailed his response and Matt Robinson (Sandy Brown) who pre-recorded his answer.

Question: What is the most pressing issue in all of acoustics right now?

This open-ended question was interesting as it did not focus on a specific discipline. Therefore, we asked our experts, what issues they thought were most pressing in their relevant fields:

- Dr Amelia Gully recognised the use/misuse of machine learning techniques being applied to speech and hearing problems without understanding of the underlying systems. Interpretable AI setup is needed to use acoustics knowledge to inform the models and learn from them.
- Dr James Talbot singled out ground borne vibration as one of the areas to pay attention to. This area of acoustics is inherently difficult and does need a good understanding to accurately guide the design. There are propagation models available but, as Dr Talbot put it, a bit of knowledge is dangerous. As a result, each element needs to be boiled down to first principles to understand and manage uncertainty of the design.
- Daniela Filipe (Hoare Lea, ECG rep in the IOA Building Acoustic Group) identified overheating as the issue requiring attention. Further research is needed on how noise impacts people at home to inform recommendations for normal and overheating conditions.

Dr Nikhil Mistry, Stephen Turner and Professor Attenborough, all agreed that the profile of acoustics needs promoting to the public and private sectors. Awareness that sound and vibration are an inherent element of every aspect of our lives needs raising.

Question: What is the maximum hearing range of a human?

This was one of the questions that we come across often in our industry. As expected, the answer is not that straightforward, and even the question itself needs clarification. Dr Gully pointed out that it requires the sound pressure level to make sense. Human hearing varies at different sound levels. Starting at the bottom of the equal loudness graph, near 0dB, the hearing range is around 1 to 5kHz, broadening with the sound level increasing. Additionally, human hearing varies between individuals. As a general rule of thumb, the hearing range of 20Hz–20kHz is about right although in reality it is probably slightly smaller.

Question: When it comes to vibration from railway, why is it that often only an assessment of the VDV is required and not the re-radiated noise?

This question was jointly answered by Professor Thompson and Dr Talbot, with additional points raised by Brain Hemsworth.

It was agreed that the question is really about policy. It is true that re-radiated levels are audible rather than being felt. The legislation, however, is based on the external airborne noise levels and there are no statutory noise levels for ground borne noise, which depends on the internal conditions and properties of the building. For surface railways, the external noise levels are often up to 90 dB(A) and above, which will dominate the airborne noise within the building. Since there are more surface railways – with exception of London – the policy lends itself to VDV assessment associated with perceptibility of vibration.

VDV is coded up and is accepted for all sorts of vibration sources. Re-radiated noise on the other hand, does not lend itself to an easy codification with people being much more sensitive to low frequencies and measurements, prediction and assessment are difficult as they depend on many more factors including building response and psychology. Although there are useful guidelines including the Federal Transit Administration and the ANC guidelines, there is no international standard.

Question: Is snow a good sound absorber?

Many of us notice the difference in reduced background noise but is it caused by the snow or by less road and pedestrian traffic? Professor Attenborough provided a detailed answer, referencing a paper he co-authored with Othmar Buser in 1988[1]. Mr Buser was interested in finding out if sound can be used in predicting avalanches and as a result did a lot of measurements of snow using an impedance tube. However, since the measurements did not fit the prediction model, Professor Attenborough was approached to help interpret the results. It became apparent that the speed of sound in air at -5 degrees Celsius and at high altitude of Swiss Alps (resulting in low air pressure) was 328 m/s – much slower than the widely known 340 m/s.

Another research from 2015[2] measured different kinds of snow (e.g., new or dense) from the Himalayas and concluded that snow is indeed a good absorber. A 4cm layer of new snow is better than a 4cm layer of mineral wool or melamine foam.

Snow provides a better destructive interference at lower frequencies than grassland and this explains why it is quieter when there is snow about. Professor Attenborough referenced measurements carried out by Parkin and Scholes in 1965[3,4], demonstrating that a fresh snow cover reduced the ground attenuation frequency from 400-500 Hz to 100 Hz.

Question: What would a dinosaur's roar have sounded like?

We are all familiar with roars generated for films or embedded in toys but are they actually correct? Dr Nikhil Mistry researched various sources to find out and presented the results during the talk.

There were lots of different dinosaurs producing different sounds. Dr Mistry focused on the most iconic of them all – a T-rex. The sounds made in the Jurassic Park series were created by using lions' roar, predominantly purely for the cinematic experience. A reference was made to a BBC show[5] that explored what kind of sounds these dinosaurs were likely to have made. Some dinosaurs are related to modern birds and are the same division as crocodilians. Using the infrasound sound made by alligators, the show dropped it by three octaves, resulting in a rumbling and ominous sound.

A T-rex could not roar as it did not have a larynx. Dr Mistry referenced the project 'Rawr'[6] where a fossilised sull was used to create a physical model allowing scientists to pass air through the skull of another dinosaur and hear the sound.

Question: In sound insulation tests, what is the physical difference between airborne noise and impact noise?

The question was answered by Matt Robinson with additional information from Stephen Turner.

In both instances, a speaker and a tapping machine put a solid obstacle into motion, creating sound waves on the other side. The key difference is what is being excited. A speaker excites the air around which has the same impedance. A tapping machine on the other hand is mechanically exciting an element which has its own impedance, varying depending on its construction and thus affecting how it sounds. Airborne sound excites the whole of the partition whereas impact (like footfalls) excites primarily one area.

Question: Should we introduce impact testing for walls under Building Regulations?

Matt Robinson suggested that this was not required. Impact noises on walls come from fixed items such as lifts or ductwork and to mitigate these sources, this is often considered at design stages. Fixing would be different for different sources and, therefore, any robust testing method would need to include them all. Matt noted that the industry should focus on BS EN 14366 or BS EN 15657 instead as these look at the designs of how impact noise in walls are considered.

If you have any other burning questions about acoustics, email them to earlycareers@ioa.org.uk

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Early careers – vibration isolation

In this column, we highlight the wide range of skills, sectors and regions where early career professionals work. George Taylor of Mason UK, who has recently become the ECG rep in the Noise and Vibration Engineering Group, provides background to his career in vibration isolation so far.

"I studied mechanical engineering at Oxford Brookes Engineering which, being based in the heartland of UK motorsport, specialised in developing the next Formula 1 engineers and technicians. Most modules were based on thermodynamics, thermo fluids (CFD), material properties and stress analysis and thus my only exposure to acoustics was limited to a final year dynamics module. This module covered the basic principles of mass-spring systems and the effect of damping in an automotive context. It is quite possible these brief studies, along with my mechanical background, opened the door to a career in noise and vibration isolation.

"I joined Mason UK in 2016 and spent most of my first year gaining experience on site projects for installations such as floating floors which allowed me to gain invaluable knowledge of site logistics. Projects such as the Royal Opera House and the English National Ballet School are a couple of standout examples. I believe this is a really important part of any engineer's growth in their industry and has certainly added another string to my bow when it comes to acoustic design. I quickly realised how much I enjoyed the problem solving aspect of acoustics and the responsibility of finding suitable solutions both architecturally and structurally. Being involved throughout the project from first contact to final delivery makes it all the more satisfying.

"IOA conferences, CPDs and social networking have helped me learn more from the wider acoustics industry and is something I am keen to continue in the coming months and years." ◎

Right: George Taylor

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

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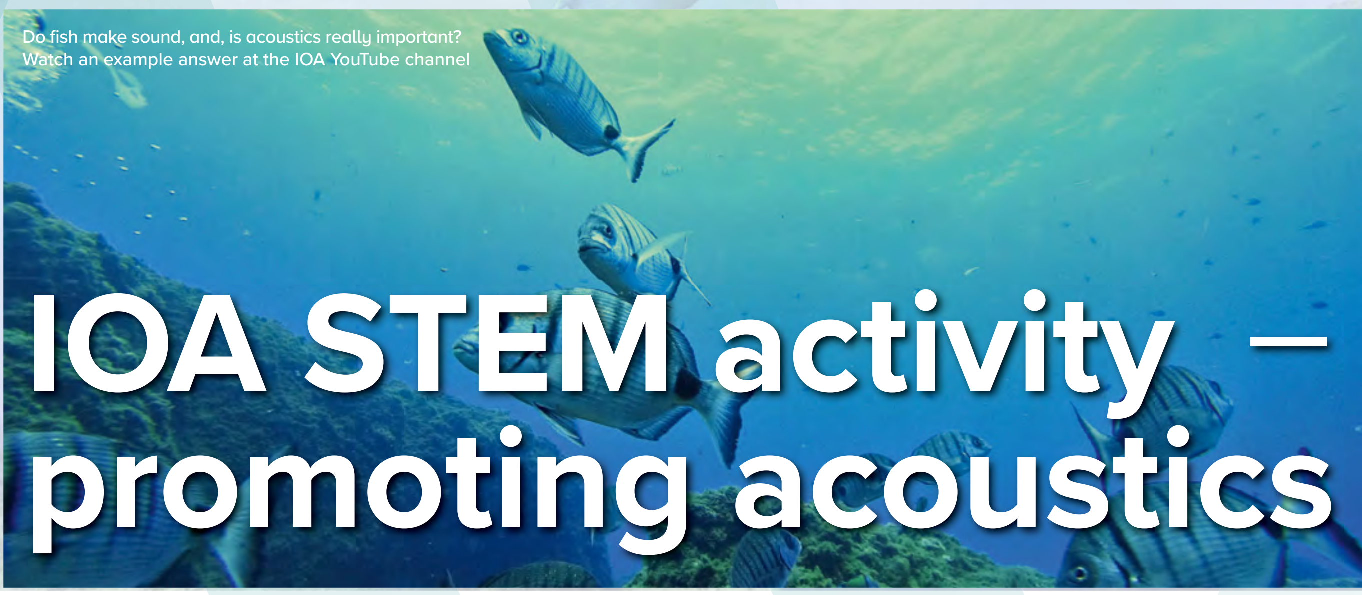

IOA STEM activity – promoting acoustics

Questions asked at the recent IOA Early Careers Group (ECG) online webinar (reported on pages 18, 19 and 20) included: Do fish make sound, and, is acoustics really important?

By IOA STEM Ambassador, Dr Nikhil Mistry

IOA members were invited to simply ask anything about acoustics and the ECG committee then sourced answers from other members, who are experts in the field of acoustics related to the question.

The aim of this event was to encourage members to speak up about misconceptions and shortfalls in acoustics knowledge, while also exploring some of the more unusual acoustic phenomena in the built and natural environment. An example of an answer can be found at the IOA YouTube channel **https://www.youtube.com/watch?v=RVl6iJgOE-4**

In opening the floor to questions, members can learn a little more about the work other people do in the industry; highlighting the breadth and depth of applications of acoustics.

Raising the profile of acoustics

Although this was an IOA event, there is great potential for this to be run at a public level, inviting people of all backgrounds to ask questions about the role and presence of sound and vibration in our lives, helping to raise the profile of acoustics in the public's mind.

At schools, the syllabus on the science of sound (pardon the overload of alliteration) is quite limited and children are rarely introduced to the idea of a career in acoustics. However, there is the danger that if we allow anyone and everyone to enter questions, we open ourselves to some controversy where political agendas could play a role in acoustics-related projects, which have the population divided in opinion. Nevertheless, there is a lot to be gained by listening to our audience and we can find an effective way to filter out the troublesome requests.

So how do we engage our audience of non-members? What can we give back to them and what can we do to raise your profile and work in acoustics? The IOA STEM committee plans to attend events, show off 'cool' acoustics and provide educational marketing for the IOA, but I feel we have an obligation to promote acoustics as a sound career choice (apologies, I couldn't help myself). Acousticians are known as those who have the 'coolest' job amongst other engineers, so let's try to show the rest of the world that!

Please email ideas and comments to **STEM@ioa.org.uk**

Taken on 5 March 2021, this colour-calibrated image from a Navigation Camera aboard NASA's Mars 2020 Perseverance rover shows tracks from the rover's first drive (darker marks in the foreground) and an area scoured by the Mars 2020 mission's descent stage rockets (lighter-coloured area in the middle ground). *Image courtesy of NASA/JPL-Caltech*

Thoughts on the sounds of Mars from NASA's Mars Perseverance

By Timothy Leighton, ISVR, University of Southampton

On 23 February 2021, news organisations ran headlines such as 'NASA's Mars *Perseverance* rover beams back first sounds ever recorded on another planet'.[1]

We know in detail what many of the landscapes on planets in our solar system look like, but decent quality data on how they sound is rare.

This not only means that movies generate unrealistic soundscapes for, say, Mars, but we miss the opportunity to infer what is happening in an alien world using complementary signals. Acoustic signals can travel around line-of-sight obstacles that block, for example, the view of a camera. They can travel through liquids and solids that are optically opaque. The bandwidth and power requirements, and weight and fragility of acoustic sensors can often be less than those of video cameras. The previously slow progress in capturing an alien soundscape[2] took a very significant step forward with the successful deployment of NASA's Mars *Perseverance*.

Most recordings claiming to be of 'sound from space' have not been – often they are the electromagnetic (EM) interference on probe instruments caused by lightning or charged particles, played back through a loudspeaker (often with some form of time stretching or condensing to get the signals in the audio spectrum, or condense a sequence of rare events into the attention span of the listener). Those signals were never acoustic in the first place. Popular examples include the EM effects on Cassini's sensors of Saturn's lightning[3] or its bow wave[4], or the EM effect of pulsar emissions on Earth-based sensors.[5] P24


Enhance your career prospects in acoustics
The IOA runs a range of certificated short courses nationwide, assessing competence in the areas shown. The courses run twice a year at accredited training centres across the UK (courses are held prior to exam dates and usually run for around five days).
To find out what's right for you and where in the UK the courses are running, contact the IOA at:
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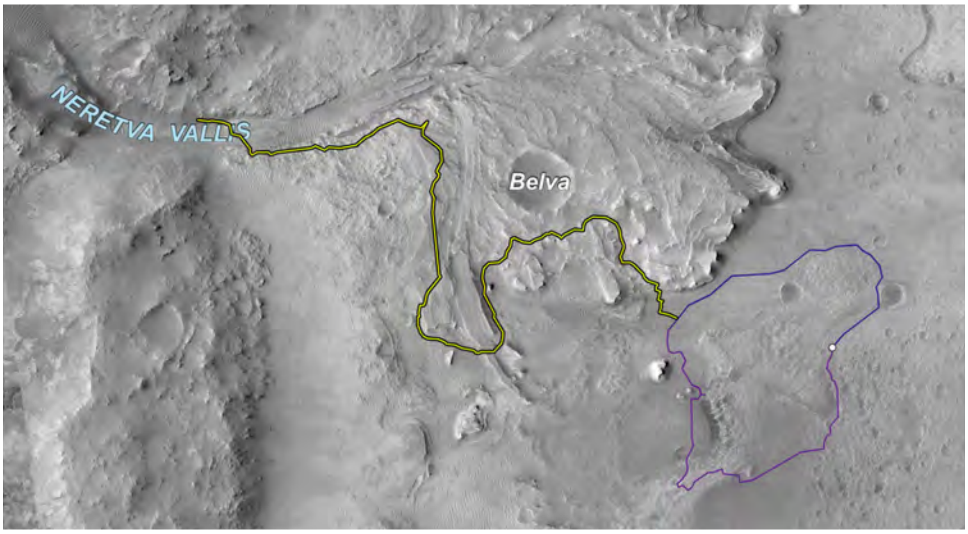
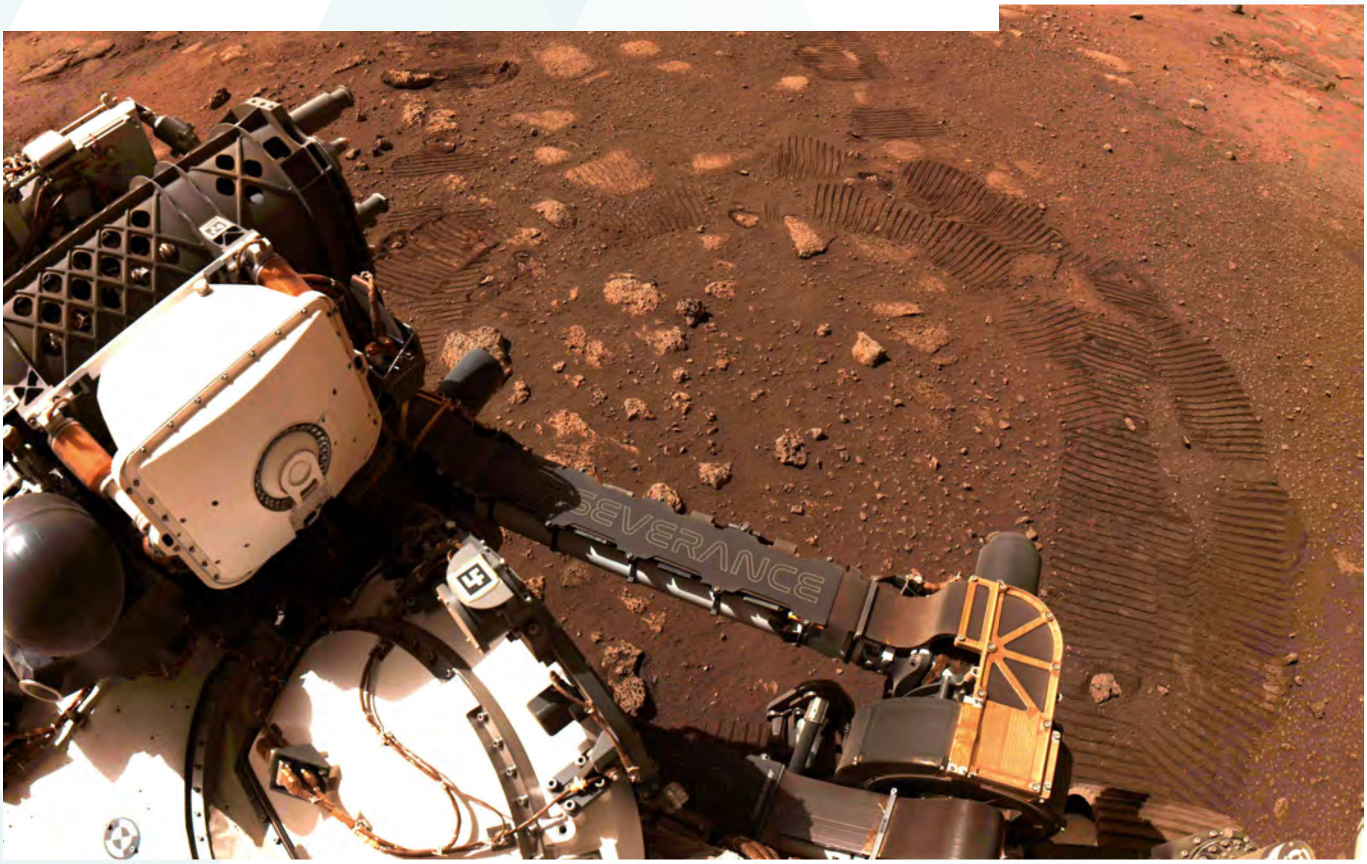


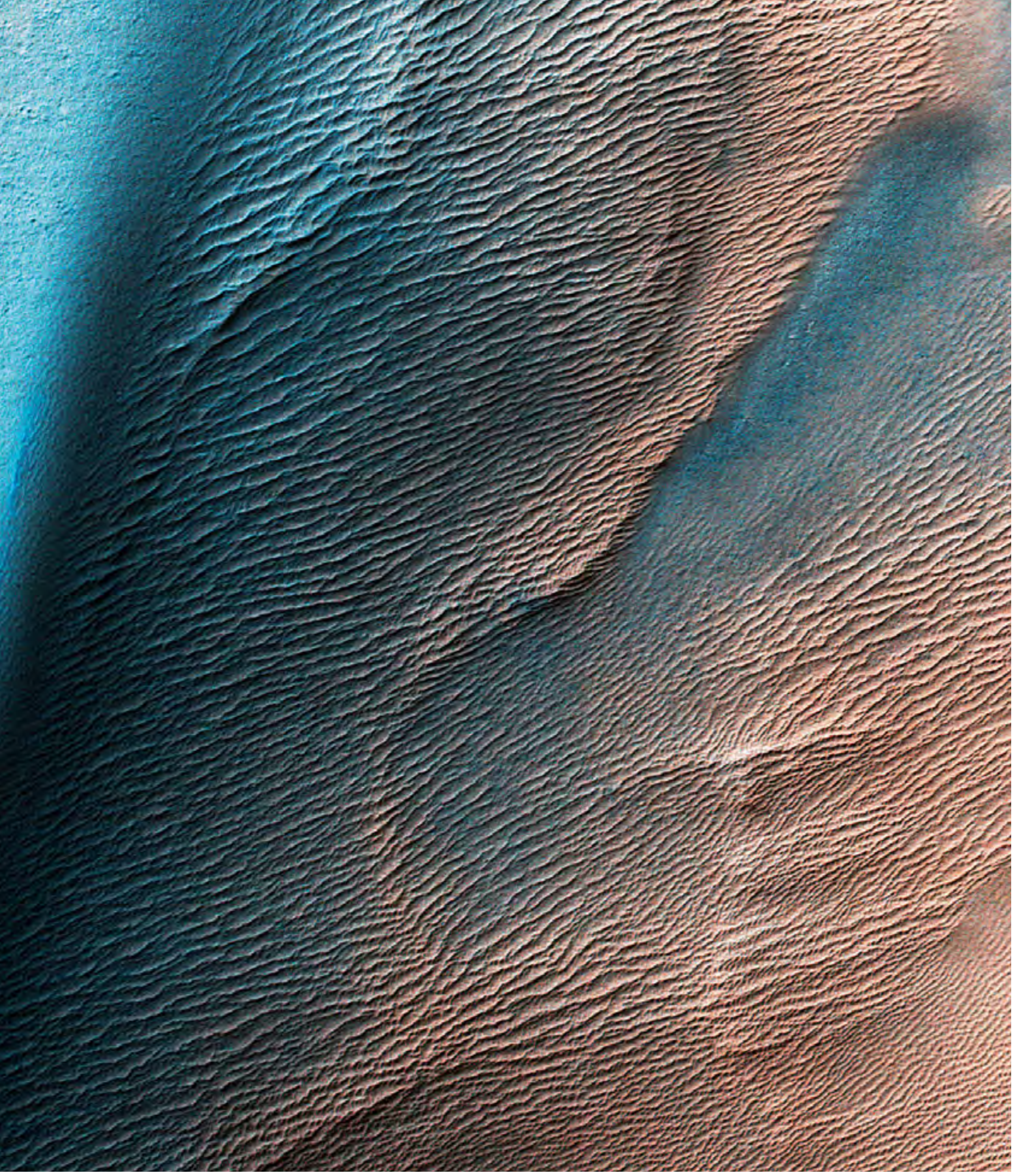
Above: This image shows two possible routes (blue and purple) to the fan-shaped deposit of sediments known as a delta for NASA's Perseverance rover, which landed at the spot marked with a white dot in Mars' Jezero Crater. The yellow line marks a notional traverse exploring the delta. The base image is from the High Resolution Imaging Experiment (HiRISE) camera aboard NASA's Mars Reconnaissance Orbiter (MRO). *Image courtesy of NASA/JPL-Caltech/University of Arizona*

History of extra-terrestrial sound recording

Tentative interest in recording genuine acoustic waves from other planetary bodies dates from the 1960s, although it was never a priority of missions and, as such, had limited success, with the exception of *Apollo's* lunar seismic data.

From 1978 onwards, the final *Venera* landers on Venus were equipped with microphones, looking for evidence of thunder, but they were only able to measure pressure fluctuations on the microphone itself generated aerodynamically by air flowing past the lander.[6, 7] To be specific, these are pressure fluctuations generated by turbulent flow passing over the microphones and are therefore generated locally rather than from some distant source. A single microphone cannot distinguish them from sound, which is why windshields are often used on outdoor microphones. Similarly, although time-series 'sounds' were published from the descent





Above:
This image shows a large sand dune with bright patches. Martian dunes near the poles often have bright patches in the spring, when seasonal frost is lingering. *Image courtesy of NASA/ JPL-Caltech/ University of Arizona*

Left:
This image was taken by the rover's Navigation Cameras during the first drive of NASA's Perseverance rover on Mars on 4 March 2021. *Image courtesy of NASA/ JPL-Caltech*

(on 14 January 2006) of the *Huygens* probe through the atmosphere of Saturn's moon, Titan, these were also aerodynamic pressure fluctuations on the microphone as the probe descended through Titan's thick atmosphere. It is also possible that these time series data were artificially constructed on Earth from purely spectral information transmitted by the probe, because bandwidth limitations are always important in such transmissions (the author would happily welcome clarification on this).[8, 9]

The *Venera* and *Huygens* microphone signals are not acoustic; they do not propagate to the microphone at the relevant acoustic wave speed from a source that is distant from the microphone. Furthermore, they do not represent the natural soundscape of the planet. Therefore, neither class as recording the sound of another world, although the *Venera* data was undoubtedly a pioneering achievement, and the *Huygens* mission was a triumph in using active acoustic signals generated by the probe itself, to measure the sound speed in the atmosphere, and the distance to the ground by reflecting sound off it.[10]

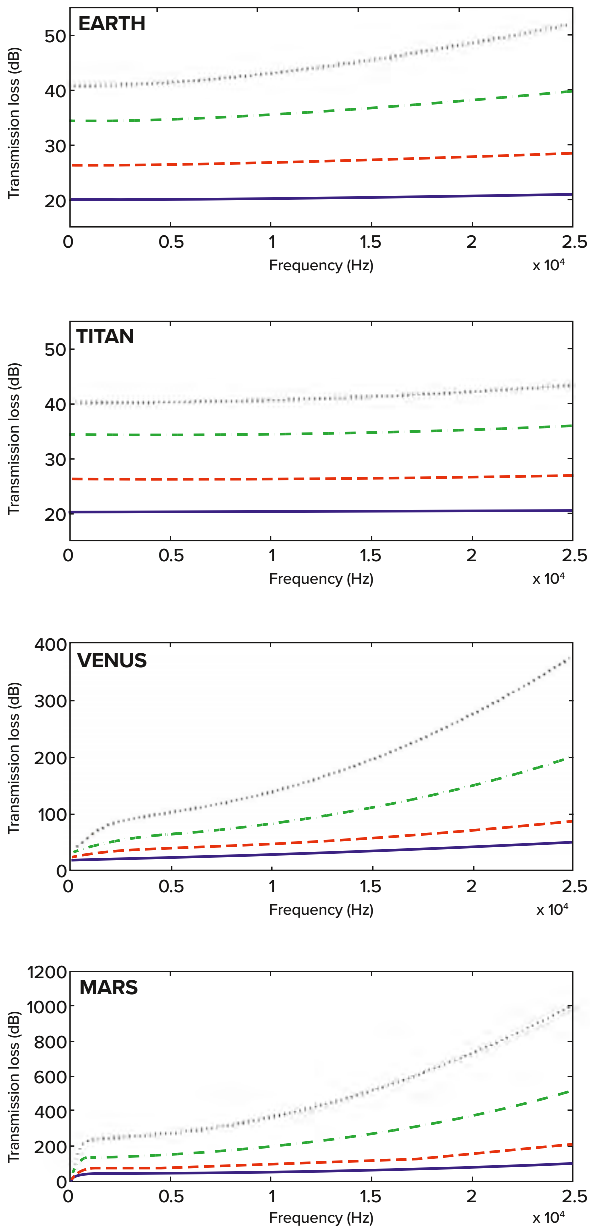
The first (and, in my opinion, most successful to date) use of acoustic sensors pre-date even the *Venera* microphones. Passive seismic sensors detected seismic waves, that were then used to infer the Moon's internal structure, in the *Apollo* 11 (1969), 12 (1969), 14 (1971), 15 (1971) and 16 (1972) missions. The data show tidally-induced moonquakes originating at depths equal to about half the Moon's radius.[11] The example of the successful detection of seismic waves in the Moon (where absence of atmosphere prevents the propagation of sound through an atmosphere, but not through solids such as transducers or moon rocks) represents the first recording of acoustic waves generated by, and directly measured on, another world. However, the frequency is lower than what most people would imagine would represent their 'hearing' a soundscape, and the medium is not atmospheric, which also is a key component of public engagement in the topic of extra-terrestrial sound.

As will be explored later, some of the success of these *Apollo* missions may relate to the closeness of the Moon to Earth (a radio signal takes around 5s to complete a two-way trip). Of course, if the sensors are on Earth itself, or in near-Earth orbit, the problem of signal delay is removed. An example of this is when acousticians successfully helped to interpret the waves resulting from the collision of Comet Shoemaker-Levy 9 with Jupiter[12, 13] in 1994. Such an opportunistic use of events still represents a major possibility for acoustic missions, whether the sensors are on Earth or in near-Earth orbit (removing the signal delay), or whether they are on a planetary probe (in orbit, atmosphere, ground or liquid) because natural phenomena replace the need for the probe to expend power generating a signal.[14]

In a much smaller-scale experiment in 1972, *Apollo* 17 detected fine lunar dust slowly migrating at sunrise through the impact of the dust on three plate microphones, orientated to face different directions.[15-17] The 2014 *Rosetta* mission[18] to the Comet 67 P/Churyumov-Gerasimenko redeveloped the successful *Apollo* lunar method[19] of counting, and inferring the velocities of, impacting particles.

A role for acousticians

There is no doubt that there is a role for expert acousticians in the design of instrumentation and missions for planetary probes. The sensors must be designed for extreme environments (the Groza-2 electromagnetic microphone on *Venera* 13 and 14 was still operational at the 800 K temperatures and 100 bar pressures of the Venus landing site). Public and policymaker engagement[20, 21] is vital to ensure there is the political will to fund acoustic packages on missions, and the understanding of the need to include expert acousticians in the planning and analysis. Acousticians themselves must understand that elements they take for granted, from our experience of using instruments on Earth, often leave us ill-equipped to cope with how differently acoustic sources and sensors, and their P26



Above: Figure 1. The transmission loss as a function of frequency, for various propagation distances. It contains contributions to sound attenuation from geometrical spreading losses and atmospheric absorption. The reference distance in the transmission calculation is 1 m from the source. The colours (line types) indicate the different source – receiver distances: blue (solid) = 10 m; red (dash) = 20 m; green (dot-dash) = 50 m; black (dot) = 100 m. (Reproduced from Leighton and Petculescu [20])

housings, behave on other worlds. Such issues include our assumptions about calibrations and references[22], end-effects and added mass[23], coupled waves[24], the engineering formulations for concepts as simple as hydrostatic pressure[25], and the extraordinary constraints that bandwidth limitations have placed on the ability to transmit even a simple time-series of data.

In transmitting a true video, instead of having scientists on Earth reconstruct a video from a sequence of stills, NASA's *Perseverance* Mars mission is a pioneer. The spectacular nature and clarity of that video testifies to the skill, teamwork and dedication of those responsible: it is difficult to overemphasise the bandwidth limitations that planetary probe missions must work under. The 'wind noise' recorded as *Perseverance's* microphone descended through Mars's atmosphere does not represent the sound of another world, since (like the signals recorded by *Venera* and *Huygens*) it represents the aerodynamic pressure fluctuations on the microphone, rather than soundscape signals that travel over distances at the local speed of sound. We may need a future probe, with a microphone array and a robust sterilised windshield, to distinguish acoustic signals propagating through the atmosphere from other microphone outputs.

Recordings from *Perseverance*

After its spectacularly successful landing, *Perseverance* has transmitted further microphone recordings, now notably made from a stationary platform. Those published to date record the sound of the device itself and a 'wind gust' on the surface. This is exciting; doubly so if the sound of the device travels through the atmosphere rather than through a solid path in the device (no details are available as yet). Aerodynamic pressure perturbations on a microphone do, on Earth, mimic what might be heard by wind on the ear, and whilst these may convect, they do not represent a soundscape in the way that the sound of, say, a distant rockfall, would. We have to wait for more data to see what of that soundscape might be measured.

Barring intermittent nearby dust devils, the natural soundscape of the planet might be very quiet. Our calculations suggest that the high proportion of carbon dioxide in the thin atmosphere of Mars absorbs sound strongly at audio frequencies (Figure 1).[20] Although the densities of Martian and Venusian atmospheres are very different at ground level (0.02 kg m^{-3} and 65 kg m^{-3}, respectively – yes, Venus' ground-level atmosphere has 6.5% the density of Earth's water!), our calculations suggest that, ironically, our two closest planets are both cursed with being quiet places because of the high proportion of carbon dioxide in their atmospheres (Figure 1). Whilst this does not rule out the detection of intermittent sounds (e.g., lightning is a known phenomenon on Venus, and – even though Mars lacks liquid-bearing clouds – lightning is a possibility in the larger Martian dust devils)[21], the sounds most commonly detected by the microphone of *Perseverance* are likely to be from very close sources. Vehicle noise is exciting (especially if it can be confirmed to travel through the atmosphere), but the sound of a natural rockfall, would be much more so. However, the acoustic absorption by the atmospheric CO_2 makes the natural soundscape so quiet that future probes and astronauts to Mars may be designed with additional ears on their 'feet' to pick up ground-borne sounds when they are not themselves moving.[14] If Mars and Venus have quiet acoustic soundscapes (note I am not including aerodynamic noise on microphones due to relative motion between probe and atmosphere), the next closest thick atmospheres would be on Jupiter and Saturn. However, both Jupiter and Saturn have strong winds and are gravity wells down to crushing pressures, without ground. Hence, on both it would be impossible to land probes in a still atmosphere, and even buoyant missions deploying microphones to capture true acoustic signals above aerodynamic noise levels would be difficult. Titan represents our only other opportunity to measure the ground-level soundscape in a substantial atmosphere, and indeed Titans' cold, thick atmosphere carries sound even better that does Earth's (Figure 1). However, as discussed earlier in the context of the *Apollo* missions, the proximity to Earth matters in such missions. Radio signals to control the probe take, even at closest approach, a little over two minutes to reach Venus and three to five minutes to reach Mars, so that making an adjustment to correct a mission is feasible before the situation becomes irretrievable (i.e., round trip travel times of under 10 minutes, assuming humans make decisions immediately on receiving the alert). The two-way travel times between Titan and Earth, at closest approach, are two to three hours. The increasing role of on-board artificial intelligence should be very useful in mitigating the limitations of that delay. Furthermore, since both Mars and Venus can be reached in under a year, the probe has technology that is only as dated P28

Sound Masking

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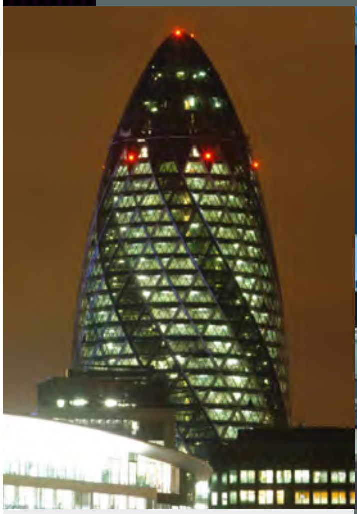
Open plan offices benefit from Sound Masking



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

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.

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Sound Masking is also known as sound conditioning or white noise systems as the delay between the design freeze and the launch. However, the journey to Titan took *Cassini* seven years, making its equipment and systems considerably more dated when the probe reached Titan's surface. Consequently, for missions to the gas giants, Earth systems are often communicating with technology that dates from the previous decade.

Further exploration

Whilst we wait for these other soundscapes to be recorded, acoustics has many roles to play. These range from the use of active acoustics in atmospheres for atmospheric active sonar[10], for windspeed measurements[26] and to infer the physical and chemical properties of those atmospheres[24,27].

Acoustics may also play a role in the passive exploration of planetary interiors through a range of long-wavelength seismic[11] and atmospheric[13] waves, and in liquids to measure the sound speed, temperature and depths of the vast water oceans that exist on Europa[25] and other icy moons[14] (and the small lakes of ethane and methane on Titan[28]).

Until we reach these louder worlds, we can marvel that the recent *Perseverance* brings us a new opportunity: a functioning microphone on a vehicle that, at times, will reside in a still atmosphere. Most recently, the sound of a laser impacting rock, around 3.1 m distant from the probe, is to be used to analyse hardness and weathering[29]. It is difficult for workers on terrestrial technology to understand what has been overcome. In 1999, a substantially 'off-the-shelf' microphone[30] was flown onboard the ill-fated *Mars Polar Lander*, which crashed during descent. The Mars Descent Imager system of the 2008 *Phoenix* lander had a microphone, designed to record descent sounds as well as any post-landing acoustic events. However, the plans to turn the microphone on were scrapped in order to avoid a technical problem that might have been potentially dangerous to the mission.[2] A testament to the grit, skill and hard work of many people, in spheres from technical to mission planning to support to outreach, the name *Perseverance* was indeed well chosen.

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Dr Trevor Hickman

It is with great sadness that we announce the recent passing of our dear friend and former colleague, Dr Trevor Hickman. He was 71.

By Dave Clarke, Director at SRL Technical Services Limited

After gaining a physics degree and then a PhD in sound and vibration at Chelsea College Trevor first worked at WS Atkins then Wimpey Laboratories before joining SRL in 1983. He stayed there for over 30 years until he retired in 2014. He worked on many high-profile projects including the Channel Tunnel and the Millennium Dome (now the O2 Arena). In the 1990s he encouraged many multiplex cinema developers to use a lightweight wall between auditoria. This will have led to a significant saving of the world's resources in terms of blockwork and aggregates generally which, in turn, made cinema construction just a little more sustainable at a time before 'sustainable' was even a word.

His expertise in vibration also set him apart from your average acoustic consultant, who normally runs a mile when anyone mentions the word.

A brilliant mind

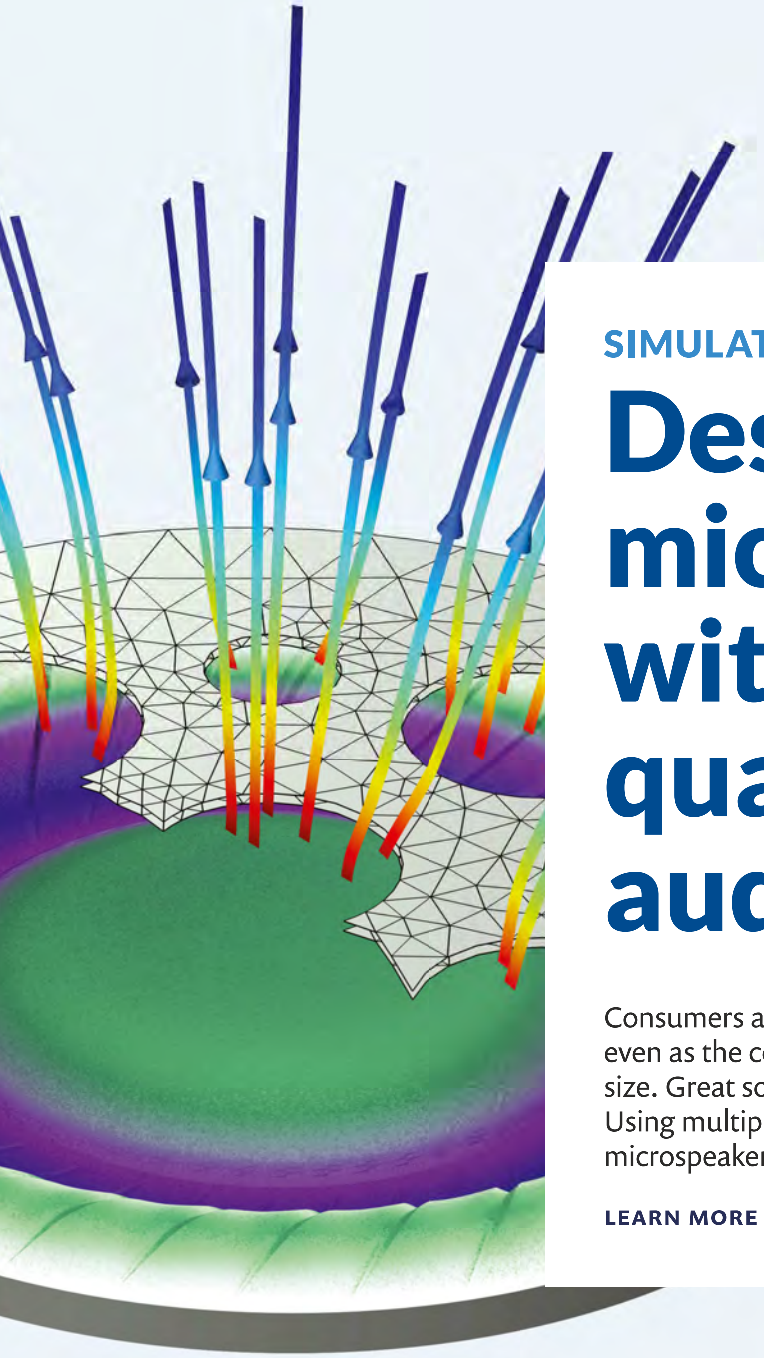
He was instrumental in maintaining the high quality of our work here at SRL, through coaching and mentoring, sharing his knowledge with all staff members, no matter how experienced they were. You never had to worry with Trevor around, as he always seemed to know the answer to even the most obscure technical question. He was our comfort blanket.

He had a brilliant mind and also one of the weirdest senses of humour you are ever likely to come across. It is said that he took more pleasure in having to explain the joke to you afterwards – when you couldn't understand it – than he did telling the joke in the first place.

Away from work, he loved playing table tennis (in fact it was at a table tennis club where he met Sue, whom he went on to marry and spend the rest of his life with). He also had a great passion for gardening and enjoyed music (yes, he went to gigs), photography and spending time with his family, especially his grandchildren.

We were so very lucky to have known him.

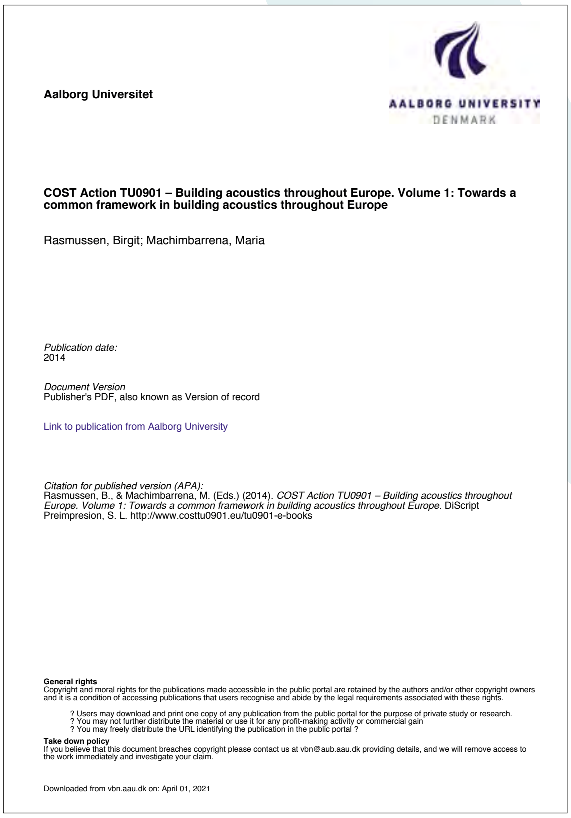
Our thoughts remain with Sue and her family.



ISO TS 19488:2021 Acoustic classification of dwellings – Coming to a construction site near you!

It is notoriously difficult to predict exact publication dates for new international standards and guidance documents and, as such, this article is an early insight. However, the expectation is that this will be published about the time you receive this edition of Acoustics Bulletin.

By Philip Dunbavin and Sean Smith



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COST Action TU0901 – Building acoustics throughout Europe. Volume 1: Towards a common framework in building acoustics throughout Europe

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This new technical specification, which was published 26 April 2021, had its origin in the European Action COST Action TU0901, (Cooperation on Science and Technology) 'Integrating and Harmonizing Sound Insulation Aspects in Sustainable Urban Housing Constructions', which ran from 2009 to 2013.

During the four years official lifetime of COST TU0901, close research cooperation and discussions took place involving more than 90 experts from 29 European countries and three non-European countries (Canada, Australia and New Zealand).

Most European countries have regulatory sound insulation requirements for dwellings, and specific sound insulation classification schemes exist in several countries. However, sound insulation descriptors, requirements and class criteria presented a high degree of diversity and, unfortunately, there was no sign of increasing harmonisation, rather the contrary. This diversity has caused confusion for the building industry and was an obstacle for trade, development and exchange of experience and construction data.

COST Action TU0901 was established to initiate changes to this situation to the benefit of people in their everyday life and for the building industry. It is believed that although regulations are a national issue within each country, if all European countries used the same descriptors and had a joint acoustic classification scheme for dwellings, each country could select a class for regulations, and all sectors involved would, in the long run, benefit from the harmonisation.

Drawing a consensus from such diverse range of experiences and views was not an easy task. The final reports of this work can be downloaded at **https://tinyurl.com/fvmvncxa**

It was originally intended that this document would be published in 2018 and was sent out as a Final Draft International Standard (FDIS) for international voting. (Please refer to the article on page 64 of the Acoustics Bulletin, January/ February 2019). Unexpectedly, the international voting disapproved this draft standard, due to some unusual tactical voting by a few countries. It was subsequently agreed by the plenary meeting of ISO/ TC43/ SC2 in Japan in November 2018 to reissue this as a draft technical specification. Technical specifications are prepared where there is no consensus, or when there is an emerging science, such as soundscapes. A technical specification can eventually be converted into a full ISO at a later date when more evidence is available or a consensus can be reached.

Scope of ISO 19488:2018

This standard describes class criteria and procedures for acoustic classification of dwellings. The main purpose of this classification standard is to make it easier for developers to specify a standardised level of acoustic quality other than the quality defined by national regulations, and for users to require or be informed about the acoustic quality.

This standard can also be applied as a general tool to characterise the quality of the existing housing stock and includes provisions for classifying the acoustic quality before and after renovations have taken place. An additional purpose of this standard is to help national authorities to define a specific class in building regulations as the minimum requirement for acoustic conditions in dwellings.

For the purpose of this standard, the term 'dwelling' refers to detached and attached dwelling-houses, flats (apartments) as well as rooms in other buildings used for residential purposes. Energy performance ratings of buildings currently use A to G classifications. For the purposes of acoustics and sound insulation, the technical specification classifications use A to F.

Acoustic classes

The classes A to F specify different levels of acoustic conditions in dwellings. Class A is the highest class, class F is the lowest class. The indication *'npd'* can be used for dwellings where no acoustic performance is required or determined, or if the performance does not meet the requirements of class F.

The classification includes criteria for the six classes A to F for each of the following five acoustic aspects:

- airborne sound insulation;
- impact sound insulation;
- airborne sound insulation of building envelopes against outdoor noise from traffic, industry or other sources;
- sound pressure levels in the dwellings from service equipment; and
- reverberation time or ratio of the equivalent sound absorption area to the walkable surface in common access areas or stairwells and corridors with dwellings opening onto them.

Airborne sound insulation

The technical specification gives class ratings for three situations:

1. Between habitable rooms in a dwelling and rooms outside the dwelling in all directions.
2. From common stairwells or access areas into habitable rooms in dwellings, where there is an entrance door in the separating wall.
3. From premises with noisy activities into habitable rooms in dwellings.

With respect to building regulations the first category is the most important.

The classes of airborne sound insulation for separating walls and floors are given in Table 1 of the standard and are:

Below: Table 1: Airborne sound insulation – Class limits

Type of space	Class A	Class B	Class C	Class D	Class E	Class F
Between habitable rooms in a dwelling and rooms outside the dwelling in all directions.	$D_{nT,50} \geq 58$	$D_{nT,50} \geq 54$	$D_{nT,A} \geq 52$	$D_{nT,A} \geq 48$	$D_{nT,A} \geq 44$	$D_{nT,A} \geq 40$

Note 1 – Different descriptors are applied to reflect use of different frequency ranges and weightings. Instead of DnT,A, DnT,w may be applied, if 2 dB is added to the limit value. If $D_{nT,A}$ is applied instead of DnT,50, 2 dB should be added to the limit value of DnT,50. For comparison between descriptors, see ISO 12354-1.

(Table extract and note reprinted from ISO/TS 19488:2021 Acoustics – Acoustic classification of dwellings.)

Applying the Note 1 corrections specified above the classes for airborne sound insulation are shown in Table 1b (below):

Type of space	Class A	Class B	Class C	Class D	Class E	Class F
Between habitable rooms in a dwelling and rooms outside the dwelling in all directions.	$D_{nT,w} \geq 62$	$D_{nT,w} \geq 58$	$D_{nT,w} \geq 54$	$D_{nT,w} \geq 50$	$D_{nT,w} \geq 46$	$D_{nT,w} \geq 42$

Above: Table 1b: Conversion to $D_{nT,w}$ airborne sound insulation – Class limits

As an example, 56 dB $D_{nT,w}$ is the minimum airborne sound insulation in Section 5: Noise of the Building Standards (Scotland) which would be Class C. It is more difficult to compare these values with the performance requirements of Approved Document E (England) such as the minimum 45 dB $D_{nT,w} + C_{tr}$. However, if the typical C_{tr} value is -5 dB[1] for a blockwork cavity separating wall, then this would be Class D.

For higher performance requirements such as found in Section 7: Sustainability (Scotland) where 'gold' level is min 60 dB $D_{nT,w}$, this would equate to Class B.

Impact sound insulation

The standard gives class ratings for three situations:

1. For habitable rooms in dwellings from other dwellings in all directions.
2. For habitable rooms in dwellings from:
   — common stairwells or access areas;
   — balconies or terraces or bath rooms not part of the same dwelling.
3. For habitable rooms in dwellings from adjoining premises with noisy activities.

With respect to building regulations the first category is the most important. P34

1 See Defra Contract NO0234, 'An investigation into the effect of historic noise policy interventions' Annex 4 – Building Regulations published in 2012.

The classes of impact sound insulation for separating floors are given in Table 2 of the standard as follows (below):

Type of space	Class A	Class B	Class C	Class D	Class E	Class F
Between habitable rooms in a dwelling and rooms outside the dwelling in all directions.	$L'_{nT,w} \leq 46$ and $L'_{nT,50} \leq 50$ 1	$L'_{nT,w} \leq 50$ and $L'_{nT,50} \leq 54$ 1	$L'_{nT,w} \leq 54$	$L'_{nT,w} \leq 58$	$L'_{nT,w} \leq 62$	$L'_{nT,w} \leq 66$

Note 1 – Experience has shown that when applying the low-frequency rating, potentially disturbing high frequency sounds are not rated appropriately, and for this reason, two descriptors are applied in order to account for both hard floor (mid frequency) impact sounds as well as low frequency footstep sounds. The limit values for L'nT,w are 4 dB lower than those specified for L'nT,50. For comparison between descriptors, see ISO 12354-2.
(Table extract and note reprinted from ISO/TS 19488:2021 Acoustics – Acoustic classification of dwellings.)

Above: Table 2: Impact sound transmission – Class limits

This would result in the building regulations being Class D (Scotland) and Class E (England).

Airborne sound insulation of façades

The classification of airborne sound insulation against exterior noise is somewhat different to the procedures normally adopted in the United Kingdom.

The minimum 'class' values for sound insulation are shown in Table 3, which is reproduced below, for a specific environment as characterised by L_{den} for the relevant outdoor sound sources.

L_{den}, is the A-weighted free field sound level for the relevant outdoor sound sources with weighting of the day, evening, night period over the frequency range from 50 Hz to 5,000 Hz as defined in the END (European Noise Directive) for outdoor sound.

In case the dominant sources of noise on the outside has a different spectrum than C_{tr}, a more relevant spectrum adaptation term than C_{tr} is to be applied to calculate the weighted single number, $D_{nT,A,tr}$, in order to have similar sound pressure levels in the habitable rooms. The index 'tr' may then be replaced by a more descriptive index for the actual type of source.

Below: Table 3: Sound insulation in dwellings against exterior noise – Class limits[1, 2]

	Type of space	Class A	Class B	Class C	Class D	Class E	Class F
1	Façades and roofs of habitable rooms in dwellings; in specific environment with sound sources characterized by L_{den}	$D_{nT,A,tr} \geq L_{den} - 20$	$D_{nT,A,tr} \geq L_{den} - 24$	$D_{nT,A,tr} \geq L_{den} - 28$	$D_{nT,A,tr} \geq L_{den} - 32$	$D_{nT,A,tr} \geq L_{den} - 36$	$D_{nT,A,tr} \geq L_{den} - 40$

1 *The sound insulation values are expressed as a weighted standardised sound level difference with a spectrum adaptation term for road traffic noise. For other types of sound source than road traffic noise, DnT,A,tr shall be determined from the relevant level and spectrum of the sources. $D_{nT,w} + C_{tr,50-3150}$ may be used, where low frequency sound influences the indoor sound pressure level. e.g. where the sound comes from mechanical equipment placed outside the building.*
2 *$D_{nT,A,tr} \geq 30$ dB applies as a minimum requirement to classes A–D.*

(Table and notes reprinted from ISO/TS 19488:2021 Acoustics – Acoustic classification of dwellings.)

During the development of this standard there was considerable debate about the appropriateness of using Lden in this application because it is not what might be measured at any particular site. It represents the average over a 24-hour period rather than what the actual occupants will experience at various times throughout the day.

It is important to note that ISO standards are developed on a consensus basis and most acousticians will not necessarily agree with all the contents of any particular standard. In this case the standard says:

"All requirements for a class shall be fulfilled in order to obtain a certain class designation. A classification can be made for a whole residential building, only if all dwellings in the building fulfil the class criteria. Dwellings in a building can also be assigned different classes. Classification can also be made for an individual dwelling or even for an individual room or a specific characteristic, e.g., airborne sound insulation, separately. The classification applies as long as there are no adverse changes in building constructions or environment. If such changes have occurred, e.g., by new roads nearby, the classification should be reconsidered."

(This extract is reprinted from ISO/TS 19488:2021 Acoustics – Acoustic classification of dwellings.)

This was a compromise and it is possible to not use some of the specific characteristics. P36

Sound from building service equipment

The maximum values of the classes for A-weighted time-averaged, or the maximum sound pressure levels due to service equipment are shown in Table 4 (below).

	Type of space and sources[1,2]	Quantity	Class A	Class B	Class C	Class D	Class E	Class F
1	In habitable rooms in dwellings from outdoor and indoor service equipment producing continuous sound	$L_{A,eq,nT}$	≤ 22	≤ 26	≤ 30	≤ 34	≤ 38	≤ 42
2	In habitable rooms in dwellings from outdoor and indoor service equipment producing intermittent or irregular sound, from neighbouring spaces	$L_{AF,max,nT}$ [3]	≤ 26	≤ 30	≤ 34	≤ 38	≤ 42	≤ 46

1 *Requirements relate to sounds that occur more than occasionally due to service equipment in neighbouring dwellings, equipment serving the whole building and service equipment within the dwelling for normal ventilation/heating/cooling.*
2 *Sound with tonal components may be perceived more annoying and may be subject to national regulations.*
3 $L_{AS,max,nT}$ *may also be used, provided that 4 dB stricter limits (lower sound levels) are fulfilled, i.e. the same as the* $L_{Aeq,nT}$.

(This table is reprinted from ISO/TS 19488:2021 Acoustics – Acoustic classification of dwellings.)

Above:
Table 4: Sound from building services equipment – Class limits

Below:
Table 5: Reverberation time T and sound absorption A – Class limits

Reverberation time

Reverberation time was another somewhat contentious issue. At one point in the development of the standard the committee considered relegating this to an informative annex. The problem was to specify either measured values or a calculated value of absorption.

The maximum values for reverberation time and minimum values of equivalent sound absorption area in stairwells and access areas adjacent to habitable rooms are shown in Table 5 (below).

	Type of space	Class A	Class B	Class C	Class D	Class E	Class F
1	In access areas (except common stairwells)[1]	$T \leq 0{,}6$ s	$T \leq 0{,}9$ s	$T \leq 1{,}2$ s	$T \leq 1{,}5$ s	$T \leq 1{,}8$ s	$T \leq 2{,}1$ s
2	In common stairwells[1, 2]	$T \leq 0{,}9$ s or $A \geq 0{,}45 \times S_{floor}$	$T \leq 1{,}2$ s or $A \geq 0{,}35 \times S_{floor}$	$T \leq 1{,}5$ s or $A \geq 0{,}25 \times S_{floor}$	$T \leq 1{,}8$ s or $A \geq 0{,}20 \times S_{floor}$	$T \leq 2{,}1$ s or $A \geq 0{,}15 \times S_{floor}$	$T \leq 2{,}4$ s or $A \geq 0{,}10 \times S_{floor}$

(This table is reprinted from ISO/TS 19488:2021 Acoustics – Acoustic classification of dwellings.)

Note 1 – The limits for reverberation time are maximum values, and the limits for equivalent sound absorption are minimum values, in both cases for each of the octave bands 500 Hz, 1000 Hz and 2000 Hz.

Note 2 – For practical reasons, as an alternative to the requirement of a reverberation time in these type of spaces, a corresponding amount of equivalent sound absorption area according to EN 12354–6 has been added, using the equivalent absorption area $A \geq 0{,}16\ V / T$ *and an approximately 0,3 s longer T-value, compared to the first row.*

The compromise was to specify both measured values and calculated absorption values despite the fact that they may not necessarily be equal in many situations.

Verification of compliance

Verification can apply to an entire residential building, an individual dwelling, a specific habitable room or even a specific acoustic characteristic, which are referred to as a 'unit'.

Two alternative verification procedures are described, Procedure A and B, and either procedure may be applied. When verifying the acoustic class of a unit, the general principle is that a sufficient number of rooms should be selected for testing in order for the result to represent the unit and each relevant acoustic characteristic should be evaluated for this unit.

Acoustic calculations and measurements are performed according to the relevant standards specified in the main body of this international standard. Unoccupied (unfurnished) rooms offer favourable measurement conditions, but the results are corrected to represent furnished rooms (as occupied). The persons or organizations that are appointed to make the relevant design calculations or performance estimations, visual inspections or measurements shall be qualified for the tasks. The contents of a report of acoustic classification are given in Annex A.3 of the technical specification.

Procedure A

Procedure A is verification by calculations, visual inspections, and field measurements. This is a three-stage process:

1. In the design stage of a building the performance can be calculated using the ISO 12354 series or from estimations from known typical performance.
2. In the construction stage of a building sufficient visual inspections are conducted to ensure that elements are installed correctly.
3. In the completed building 5% of the building is to be field tested.

Procedure B

Procedure B is verification by field measurements only. This requires that 10% of the building separating walls and floors etc are tested.

The standard covers all the necessary detail on what to measure, relevant ISO standards, and what should be in a report. This article can only cover the highlights.

Uptake

It is important to note that this standard is in addition to Approved Document E (ADE) or Section 5: Noise of the Building Standards (Scotland) and does not replace them. All residential developments must still comply with these minimum airborne or maximum impact standards or approved document guidance.

This technical specification may appeal to the high-end builders who are constructing houses and apartments for a market that targets significantly better than the 'minimum standard' provided by building regulations. This process is partly already available through the robust details process, the published credits for the previous Code for Sustainable Homes (CfSH), and the Section 7: Sustainability Scotland silver and gold performance levels. However, a future uniformity across the UK in approach for sound insulation criteria may also help architects, product manufacturers and developers who operate pan-UK.

A key factor for all designers over the coming years will be the net zero ambitions for a construction project and the level of technical specifications for non-energy areas and embodied carbon. It is likely that designers may take a judgement on whether an 'A' rating is still desirable if it conflicts with the need to provide significantly enhanced specifications, which may (not always) impact on net zero outcomes. It is not yet clear how many of the European countries may adopt or use the new classification scheme but it will be an interesting future factor to follow. ◎

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Avoiding sleep disturbance and minimising carbon emissions through sustainable airport operations

Climate change will have far-reaching implications for the aviation sector if it does not address carbon emissions from aircraft operations. For airports to demonstrate that their operations are truly sustainable, they must also address other environmental challenges which impact on communities surrounding airports; such as noise. It is not appropriate to consider noise issues in isolation. Fully integrated and holistic solutions are needed for matters related to carbon management and community compensation.

By Colin Cobbing, Pinnacle Acoustic Consultants Limited
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This article explores if it is technically feasible and sustainable to avoid adverse effects on sleep in communities exposed to aircraft noise.

Before turning to steps that can be taken to minimise and avoid adverse effects from sleep it will be necessary to explain how exposure to aircraft noise events can adversely impact on the health and quality of life of humans and what is meant by 'objective sleep disturbance'.

1. Scientific evidence on sleep disturbance

There is clear evidence that chronically disturbed or curtailed sleep is associated with a number of negative health outcomes. Studies have shown that noise can affect sleep in terms of immediate effects (e.g., arousal responses, sleep state changes, awakenings, body movements, total wake time, autonomic responses), after-effects (e.g., sleepiness, daytime performance, cognitive function) and long-term effects (e.g., self-reported chronic sleep disturbance).

It is important to recognise that we as humans are not conscious of our own bodies when asleep and that noise can impact on our bodies and sleep patterns even though we might not be aware of it. It is for this reason that self-reported sleep disturbance is considered to be a poor indicator of sleep disturbance and associated health effects. Nonetheless, self-reported sleep disturbance is an important indicator of community annoyance resulting from night-time operations.

The gold standard for measuring sleep is polysomnography, which is the simultaneous measurement of (at least) brain electrical potentials (electroencephalogram, EEG), eye movements (electrooculogram, EOG) and muscle tone (electromyogram, EMG). The night is usually divided into 30 s epochs and a sleep stage (or awake) is assigned to each epoch based on typical patterns in the EEG, EOG and EMG according to standard criteria. Rapid eye movement (or REM) sleep is differentiated from non-REM stages S1 through to S4. Stages S3 and S4 (or N3) are also called deep or slow wave sleep. The deeper sleep stages (NREM stage 3 and 4 and REM sleep) are considered the most important in terms of the restorative effects of sleep. The average sleep cycle lasts between 90 to 110 minutes and an individual experiences between four to six sleep cycles per night. It is usual for people to move between NREM sleep stages several times before undergoing REM sleep.

The German Aerospace Centre (DLR) carried out a large field study on aircraft noise sleep disturbance using polysomnography[1]. It was found that the reactions of sleeping humans to noise cannot be differentiated from spontaneous reactions using polysomnography. In the DLR aircraft noise study about 24 spontaneous awakenings on average were observed using electroencephalograms (EEG awakenings). Dr Mathias Basner conducted a review of the evidence and published exposure response relationships for road, rail and aircraft[2]. P40

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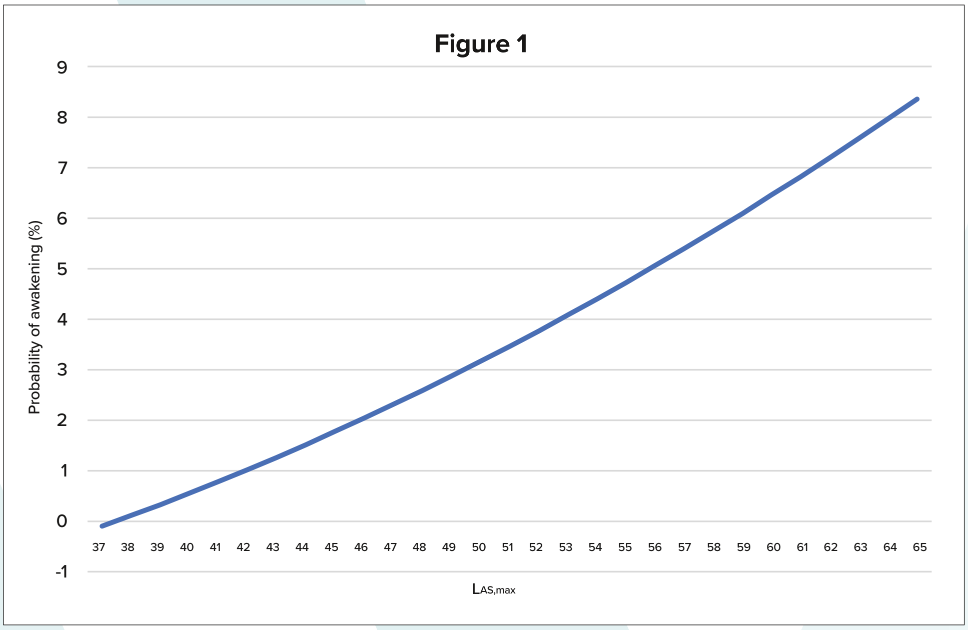
Basner's equation for the probability of noise-induced awakenings for an aircraft noise event is:

Equation 1: Probability of Wake or S1 = −3.0918 − 0.0449 – $L_{AS,max}$ + 0.0034 –$(L_{AS,max})^2$
This relationship is shown in the figure on the right.

The long-term health consequences of noise-induced EEG awakenings are not fully understood. There are some suggestions that humans may be able to adapt to a certain level of noise-induced awakening without negative health consequences. In this context, it is necessary to consider the level of impact on sleep resulting from noise-induced EEG awakenings in comparison to those that would naturally occur in the absence of noise. For example, one additional awakening per night is a value that has been suggested by Basner *et al.*[1] in the health protection scheme for the Leipzig/Halle airport in Germany. To manage the risk of sleep disturbances associated with aircraft noise. Basner *et al* recommended that:

- On average there should be less than one additional EEG awakening induced by aircraft per night, and
- Awakenings recalled the following morning should be prevented as much as possible, and
- There should be no relevant impairment to the process of falling asleep again.

In order to prevent recalled awakenings Basner *et al* proposed that the maximum noise level inside the bedroom should not exceed 65 dB. The impairment to the process of falling asleep again is suggested to be dependent upon the number of events and the time interval between events.
Table 1. (right) Shows the probability of additional sleep stage changes to awake or S1 in a 90 s time window following a noise event at a specific maximum indoor sound pressure level ($L_{AS,max}$)



Above: Figure 1: Probability of additional sleep stage changes to awake or S1 in a 90 s time window following a noise event onset depending on the maximum indoor sound pressure level ($L_{AS,max}$) for aircraft sound events

$L_{AS,max}$ (indoors)	Probability of sleep stage change to awake or S1 (%)	Number of movements needed to induce one additional awakening
38	0.1	896
39	0.3	304
40	0.6	181
41	0.8	128
42	1.0	98
43	1.3	79
44	1.5	66
45	1.8	56
46	2.0	49
47	2.3	43
48	2.6	39
49	2.9	35
50	3.2	32
51	3.5	29
52	3.8	27
53	4.1	25
54	4.4	23
55	4.7	21
56	5.1	20
57	5.4	19
58	5.7	17
59	6.1	16
60	6.5	15
61	6.8	15
62	7.2	14
63	7.6	13
64	8.0	13
65	8.4	12

and number of events needed on average per night* over a year to induce one additional awakening.

There is nothing to suggest that one additional awakening on average per night is the correct number for the protection of health. It was simply suggested as a precautionary concept based on the fact that one additional awakening on average per night is a small number compared to the number of spontaneous awakenings that occur per night. Basner has, however, suggested that the noise-induced awakenings could have more of a detrimental effect on sleep quality compared to spontaneous awakenings[2].

Within the context of policy on sustainable development it would be necessary to consider both the economic benefits associated with night flights, the positive effects on health and quality of life resulting from that economic activity and the negative effects on health and quality of life resulting from aircraft noise at night. The Basner concept could provide a useful and cautious starting point for any noise protection policy. P42

* The night period is typically defined as the period between 23:00 and 07:00

2. Cardiovascular health and noise

It has been shown that long-term exposure to transportation noise may increase the risk of heart disease; individuals exposed to higher levels of noise are exposed to the greater risk, especially at daytime noise levels outdoors above 60 dB. There are uncertainties on the relative importance of exposure during the day and night periods and the importance of sleep disturbance as a mechanism that leads to cardiovascular disease. Biological models on cardiovascular disease would suggest that sleep disturbance is important in terms of cardiovascular health[3].

3. Other determinants affecting health and quality of life

Noise is one of a number of factors or conditions affecting sleep and the wider health and well-being of people whilst indoors. These include ventilation, overheating, excessive cold, security, internal air quality, damp and mould growth, lighting and connectivity with the external environment.

A number of these factors are closely interrelated, for example having to keep windows closed to reduce noise levels indoors could result in poor indoor air quality and overheating. It is important therefore to consider all the factors associated with living conditions to understand the overall effect on health and quality of life.

Factors affecting health, wellbeing and comfort are also closely related to the way in which people use buildings and this could also have significant implications in terms of heat conservation, energy use and carbon emissions. All of these factors need to be considered to address the challenges of climate change.

4. Steps that can be taken to avoid the adverse effects of aircraft noise on sleep

The International Civil Aviation Organization (ICAO) Balanced Approach to aircraft noise has four principal elements for managing aircraft noise:

1. Reduction of noise at source
2. Land-use planning and management
3. Noise abatement operational procedures, and
4. Operating restrictions.

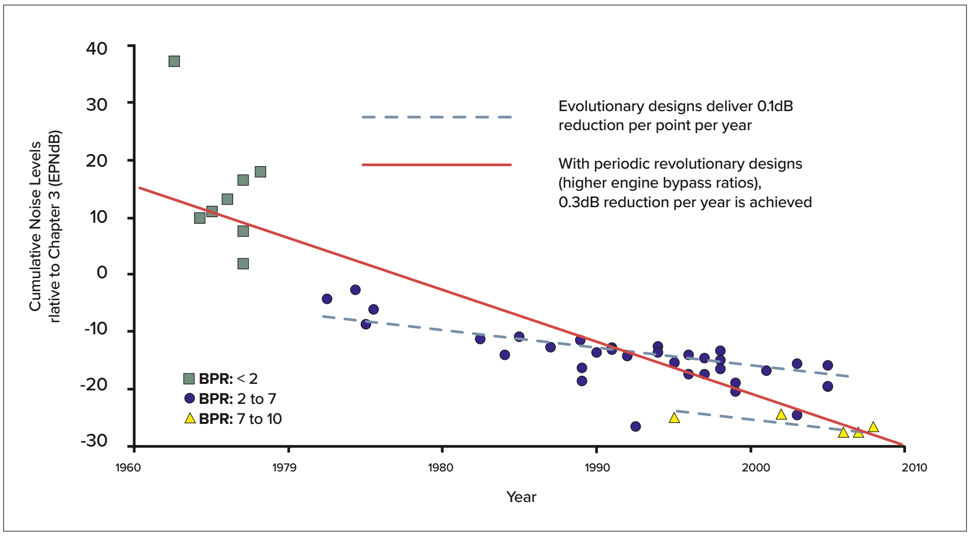
This serves as a good framework for considering the steps that can be taken to avoid adverse effects of aircraft noise on sleep.

Technology

Since ICAO started to set noise emission limits for civil jet aircraft, significant cumulative reductions in aircraft noise emissions have been achieved over the past 50 years or so as a result of increases in engine bypass ratio, continuing improvements in noise reduction technologies and reduced aircraft weight.

In 2011 the European Commission's High-Level Group on Aviation Research published a vision for aviation in 2050 called 'Flightpath 2050'[5]. The associated noise goal is equivalent to a 15 dB reduction in cumulative noise (combined take-off, side-line and approach noise level established using the ICAO noise certification procedures) by 2050 relative to year 2000 technology (the equivalent of a 0.3 dB improvement per aircraft operation per year). Achieving reductions of this scale in the future will require significant developments in low-noise technology, probably associated with novel aircraft configurations such as blended wing

Below: Figure 2: Historic trend in aircraft noise reduction (reproduced from Sustainable Aviation Noise Road-Map)[4]



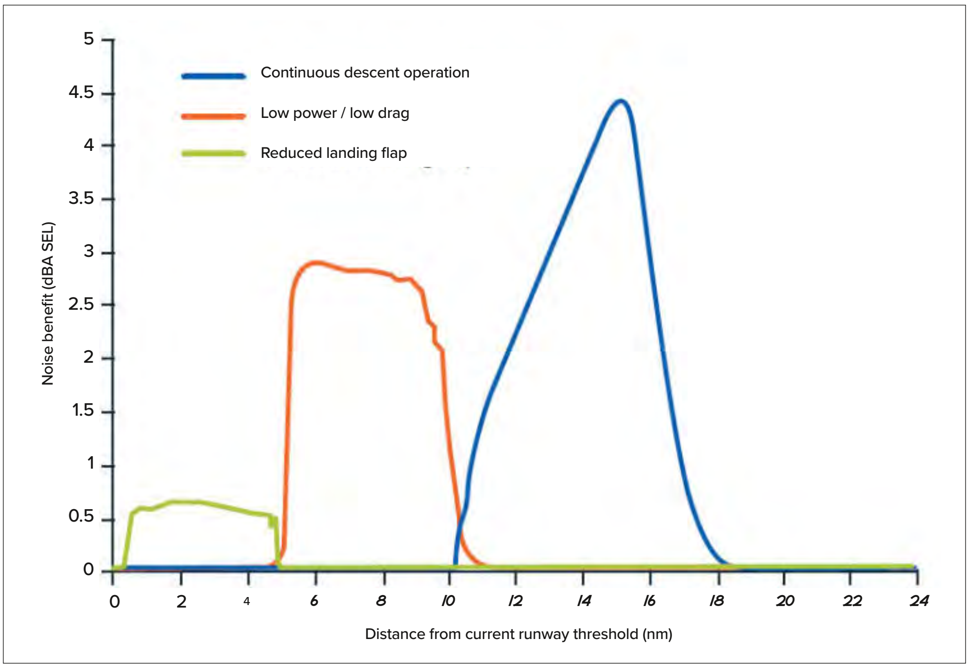
aircraft and aircraft configurations that shield the engines when they fly overhead. It is worth noting that these trends are forecast using Estimated Perceived Noise Levels and may not necessarily reflect trends in L_{Amax} levels.

Aircraft performance

Displaced landing thresholds and operational procedures such as continuous descent approaches, low power low drag, steeper climb out profiles and steeper landing approaches can deliver noise reductions at various distances away from the airport.

Figure 3 (reproduced from the CAA)[6] shows the benefit of different landing operational measures at different distances from the runway threshold.

The benefits provided by operational procedures are incremental and do not tend to provide noise reductions that are, by themselves, necessarily noticeable or valued.



Below: Figure 3: Comparison of benefits of individual arrival noise measures (reproduced from CAP1165)[6]

When considered on a cumulative basis however, operational procedures can provide important benefits that contribute to an effective noise management regime.

If we consider landing aircraft as an example, Table 2 provides representative L_{Amax} data as a function of aircraft height above ground for different groups of aircraft across three UK airports (Heathrow, Gatwick and Stansted). The Boeing 747-400 represents the 400 seat aircraft and the Airbus 380 represents the 500 seat aircraft. It is worth noting that the vast majority of remaining 747 aircraft operating in the UK were retired last year and that Airbus have stopped manufacturing the A380. The general trend is away from four engines to twin engines and the fleet mix for longer-haul aircraft is more likely to be dominated by the 250 to 350 seat groups. The 250 to 350 seat twin-aisle jets are therefore likely to be more representative of medium and long-haul flights landing at night.

It can be seen that the highest L_{Amax} for these groups of aircraft landing at 1,000 feet and above is on average 84 dB. For departures the equivalent level is 92 dB. This suggests that the vast majority of people exposed to aircraft noise will not experience average L_{Amax} values greater than 90 dB at night. P44

Height (ft)	Turboprop	50 seat regional jet	70-90 seat regional jet	125-180 seat single-aisle 2-eng jet	250 seat twin-aisle 2-eng jet	300-350 seat twin-aisle jet	400 seat 4-eng jet (B747)	500 seat 4-eng jet (A380)
1,000-2,000	79-70	73-63	77-67	77-69	84-74	83-73	86-77	85-78
2,000-3,000	70-66	63-56	67-61	69-64	74-68	73-67	77-71	78-72
3,000-4,000	66-64	56-55	61-57	64-61	68-64	67-63	71-67	72-68
4,000-5,000	64-62		57-56	61-59	64-60	63-60	67-64	68-65
5,000-6,000	62-61		56-55	59-57	60-58	60-57	64-61	65-62
6,000-7,000	61-59			57-56	58-56	57-56	61-59	62-60
7,000-8,000	59-57			56-55	56-55	56-56	59-57	60-58
8,000-9,000	57-57					56-55	57-56	58-56
9,000-10,000	57-56						56-56	56-55
10,000-11,000	56-55						56-55	

Above: Table 2. Arrivals L_{ASmax} levels by aircraft grouping (reproduced from NATS)[7]

Using the probability of awakening relationship given in equation 1 and allowing 15 dB attenuation for a partially open window and assuming an external L_{Amax} of 60 dB; the maximum number of aircraft noise events (ANEs) inducing one additional awakening on any given night would be 56 movements. The number of ANEs would reduce to 21 if the external L_{Amax} increased to 70 dB. Conversely, there would be no noise-induced awakenings if the if the external L_{Amax} decreased to 52 dB.

These examples are based on simple assumptions for a partially open window and numbers of events over an individual night. The number of additional awakenings over a year will depend on the spatial distribution of aircraft and the amount of time that windows are opened over the period of a year. Awakening contours can, however, be calculated using typical flight path information averaged over a year. It may also be possible to calculate awakening contours based on internal noise levels derived for different land use patterns and occupancy data about the amount of time windows are opened and closed during the night.

Airspace design

As explained earlier, disturbance to sleep at a specific location is strongly dependent on the number of overflights and the maximum noise level of individual events. Airspace modernisation and the introduction of performance based navigation (PBN) has the potential to significantly reduce sleep disturbance because the greater certainty of an aircraft's position and 4D flight path can be used to maximise dispersion. For example, by allowing aircraft to fly a larger number of different arrival and departure routes, aircraft can be spread more evenly/fairly across a larger geographic area. For two or more runway airports this dispersion could be maximised even further if the movements could be distributed across the runways. It is worth acknowledging that greater dispersion may result in marginally longer flight paths below 7,000 ft, which could result in a fuel burn/CO_2 disbenefit. provided this disbenefit is not disproportionate however, it will be in line with current government altitude-based environmental priorities.

Maximising dispersion will only work for communities situated further away from airports and not for areas closer to airports, located under final approach paths i.e., where aircraft need to line up parallel with the runway during the later stages of landing, or immediate take-off before aircraft can start to vector. Even so, it is possible that PBN could shorten the distance required for final approach compared to ground-based navigation methods and deliver more departure route options.

It can be seen from Table 2 that an aircraft landing from a height greater than 10,000ft, at a considerable distance from the airport has the potential for causing some disturbance to sleep quality. At these altitudes, however, the numbers of overflights are unlikely to reach a point where the number and level of events would cause adverse effects on sleep.

At 5,000ft and above, one additional awakening could be avoided on average per year if the number of events was below 56 movements on average per night (assuming 250 to 350 twin jet aircraft).

Above 3,000ft this would reduce roughly to 20 movements on average per night. Aircraft are likely to be on final approach at altitudes between 2,000ft and 4,000ft. The actual distance will depend on local factors and the type of navigation. It can be seen from this rough exercise how airspace design could provide a useful means of mitigating sleep disturbance before the aircraft start to join final approach.

Variability in noise exposure at night is an area of sleep disturbance that is not well understood. There is some evidence, however, to suggest that large variability in night-time operations could increase objective sleep disturbance[8]. It will not always be practical to avoid variability because the direction in which aircraft need to land and take off is primarily influenced by the wind speed and direction. Measures that can be used to minimise variance should be carefully considered. For example, for airports with more than one runway it may be better to consistently distribute aircraft movements across the runways rather than rotate movements between the runways on different nights or different times of the night.

The industry is exploring ways in which improved navigation accuracy can deliver predictable respite from noise during the day when aircraft noise is perceptible. Respite measures could help to improve daytime annoyance if it is implemented effectively. It is important to recognise, however, that the mechanisms associated with daytime annoyance are materially different from those associated with objective sleep disturbance. There is a possibility that the introduction of predictable periods of respite during the night could actually make objective sleep disturbance significantly worse. It is important therefore, that airspace management measures used to reduce night-time impacts are considered separately from those deployed when people are awake. Daytime respite arrangements could potentially constrain airspace designs during the night and vice versa. It is important therefore that the overall effects on health and quality of life are considered using the best available scientific evidence so that the best balance between daytime and night-time measures can be achieved.

Land use planning

Land use planning has typically been viewed as zoning around airports. Such measures have not been particularly effective, not least because there is a high demand for housing and other development around airports.

Airports have implemented large-scale community sound insulation schemes, where existing windows are treated with secondary P46

glazing or they are replaced with new double-glazed windows incorporating laminated glass. There can be significant drawbacks associated with such measures because they rely on windows being closed to be effective and having to keep windows closed can give rise to negative effects on indoor air quality, overheating and other factors affecting wellbeing.

Supplementary ventilation is normally provided as part of sound insulation packages but these might not always be sufficient to avoid potential overheating and tend to be unpopular because residents feel they are unsightly, or make unwanted noise. Supplementary ventilation is also provided to mitigate the effects of having windows closed, but there is a lot of evidence that people still prefer to keep windows open in high noise exposure areas for a variety of reasons that are not fully understood.

Innovative window designs can overcome a lot of the drawbacks associated with sound insulation schemes. An example of this is the Hafencity window, which can achieve an R_w of 46 dB with windows in a partially open position and, at the same time, provide reasonable levels of passive ventilation[9]. The actual level of attenuation will depend on the frequency spectrum of the sound and the direction of the incident sound. The R_w is a reasonable measure of the level of attenuation for maximum noise levels from aircraft noise events.

Levels of attenuation in the order of 45 dB can be used to reduce maximum noise levels from 90 dB outside the building to 45 dB or lower inside bedrooms, which is considered to represent a good acoustic design target in the UK for maximum noise levels[10]. It can therefore be seen that innovative window systems can be used to avoid sleep disturbance from aircraft noise events for the majority of noise exposure cases found around airports, but without the negative effects normally associated with having sealed up façades.

Such measures would also provide wider benefits in terms of health and quality of life because the sound insulation packages will reduce noise levels indoors from other sources of transportation noise.

The benefits associated with retrofit schemes could be enhanced further if the schemes were designed to minimise carbon emissions and improve other aspects of health and quality of life in addition to noise. For example, retrofit measures that improve thermal insulation would reduce the adverse health effects associated with cold temperatures. Measures used to provide shading could help to minimise overheating during summer months.

The UK Government recently attempted a scheme to improve thermal insulation and energy efficiency in homes in order to address climate change. This scheme has been seen as a failure and this may be explained, in part, by structural issues associated with the scheme and the renewables sector. Such schemes would be far more efficient and effective if airport operators worked in partnership with government, local authorities and other agencies involved in reducing carbon emissions to co-ordinate or even unify the different retrofit schemes. More importantly, such schemes could provide greater social value if the goals were widened to improve health and quality of life, noise and sustainability performance. In this way, the value of retrofit schemes could be significantly enhanced compared to the benefits of retrofit schemes that solely aim to reduce noise or carbon emissions.

Innovative window and façade systems can also provide significant advantages in the design of new noise sensitive development around airports and overcome current design shortcomings i.e., only achieving good internal noise design criteria with windows closed. The windows can be designed as part of a total solution for good acoustics, ventilation and overheating using passive ventilation techniques. This could help to avoid dependencies on mechanical cooling and minimise energy consumption, thereby minimising carbon emissions.

Evidence-based decision-making

A number of policies and intervention strategies for night-time noise are based on the L_{Aeq} parameter. Reducing the number of ANEs at night by 50% whilst keeping the L_{Amax} value unchanged would mean that the energy equivalent continuous sound level L_{Aeq} will decrease by 3 dB. Criteria based on the L_{Aeq} parameter would therefore signify that the effects of aircraft noise on sleep are simultaneously diminished by 50%, an example of this being the number of awakenings induced by aircraft noise is halved. This is not consistent, however, with the relationship for the probability of noise-induced awakenings. Awakening contours could provide valuable evidence that could be used to inform decision-making.

Night-time restrictions are applied at most European airports P48

e.g., UK aircraft noise classification (QC) and movement number limits. EU Regulation 598 (2014) is based on the ICAO Balanced Approach and sets the rules for the introduction of noise-related operating restrictions at EU airports. To ensure that noise management measures are sustainable, regulations require that noise operating restrictions be only applied as a measure of last resort and only after thorough consideration of the other measures of the balanced approach described above. This consideration must include a thorough evaluation of the cost-effectiveness of the noise mitigation measures. Cost-effectiveness is typically evaluated using noise impact analysis (see for example the impact assessment for night flight restrictions at the designated airports is on UK Government website: **https://tinyurl.com/ysh24dzb**)

These assessments do not consider the effectiveness of the noise intervention measures on health and quality of life; this is because there is little or no robust quantitative evidence on the effect of interventions on health and quality of life. This situation could, however, be easily resolved and would not necessarily require large, expensive studies.

Before-and-after studies provide a reliable means of measuring and quantifying changes in health and quality of life resulting from different types of intervention, which are typically deployed by airport operators to mitigate the effects of aircraft noise. The application of standardised methodologies to conduct before-and-after studies would allow the systematic evaluation and comparison of different intervention measures in terms of their effectiveness to improve health and quality of life. The application of standardised methodologies would also enable evidence obtained from relatively small case studies to build towards a larger body of evidence that can be used to inform decision-making. It follows from this that it may not always be necessary to spend significant amounts of money on large and powerful research studies. What is needed most is for the aviation sector to co-operate and use standardised methods and approaches to study the relative effectiveness of different types of intervention and then to pool that information so that the data can be systematically analysed.

Such relatively simple steps could bring about a step change in informing decisions on the most sustainable means of controlling and mitigating the effects of aircraft noise.

Conclusions

This article illustrates how airport operators and those responsible for land use planning around airports can implement noise control strategies that will sustainably avoid adverse effects on sleep. It goes further to demonstrate how noise management strategies can be developed to:

- Provide wider benefits on health and quality of life and build social value for communities living and working around airports, and
- Offset carbon emissions from aviation.

Finally, recommendations are made to drive the changes needed to develop and build the evidence base in order to improve decision-making on the cost-effectiveness of different noise management interventions and combinations of interventions.

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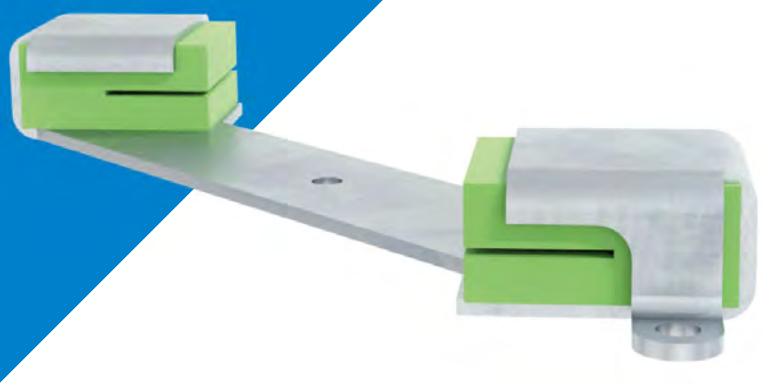

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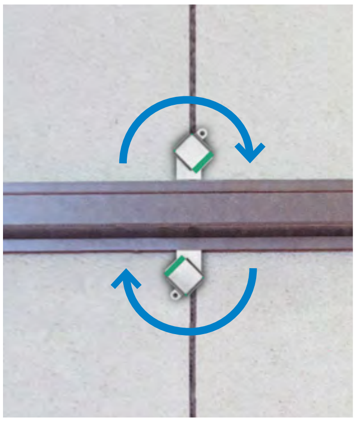
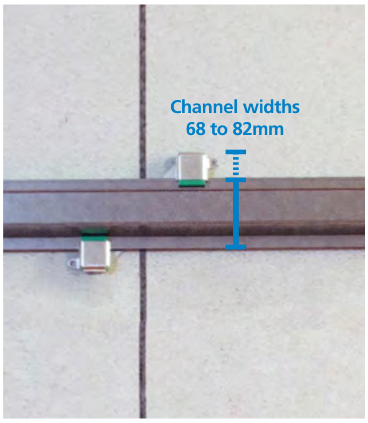
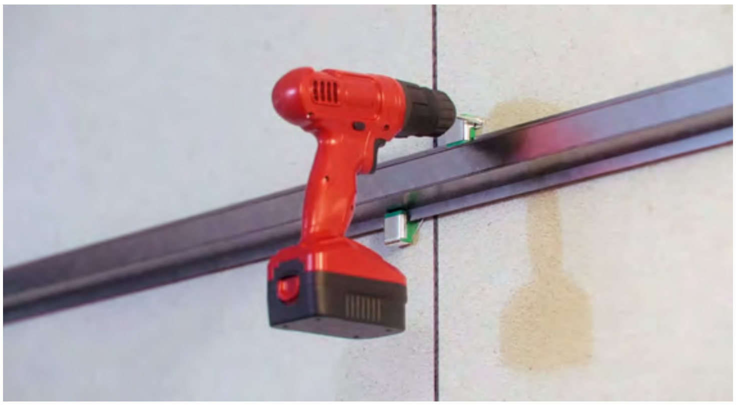


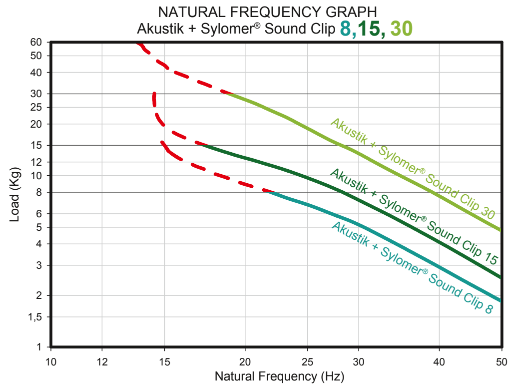


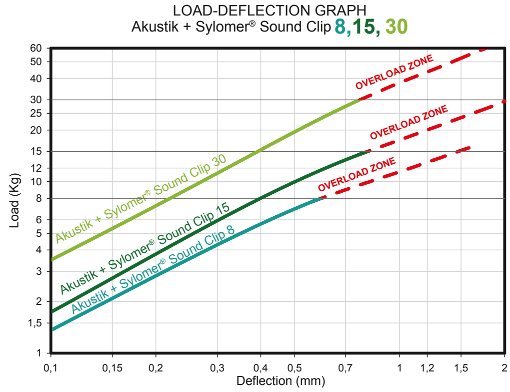
Install the furring channel in the centre, rotate the **Akustik + Sylomer® Sound Clip** to firmly hold it in place.

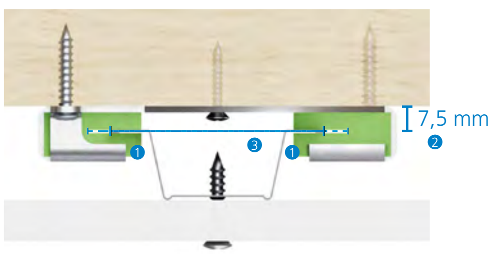


Fasten the **Akustik + Sylomer® Sound Clip** to the wall using the lateral holes to secure the installation.

ELASTICAL PROPERTIES (3 densities)







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How much is our hearing actually worth?

Are all meters equal? We subject a range of low-cost meters claiming to meet IEC 61672 to a periodic test to see how well they performed.

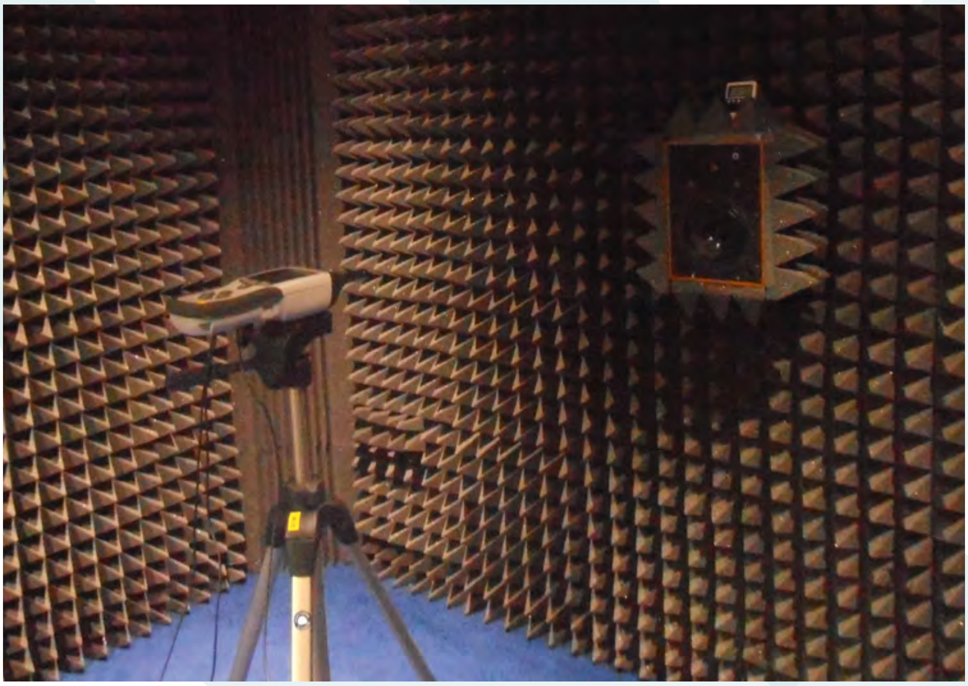
By John Campbell and Martin Williams

It can be tempting to buy the cheapest tool for the job, especially if it claims to meet all the relevant requirements. But can these claims be trusted, should the buyer take these statements at face value or with a heavy pinch of salt? Six meters were randomly selected and tested at two independent, accredited ISO 17025 UKAS laboratories. All six meters failed at least one test, with a number failing multiple tests and basic requirements for providing the relevant information to perform a periodic test.

This may seem a bit strange as a contribution to a technical paper in a learned journal as they are not the tools that a professional would choose. They will, however, come across instruments in use by people who have acoustics as a secondary or tertiary job function who may well have chosen instrumentation that is marked with the established standard numbers because of price. With acoustic measurements, the important factor is that they are fit for purpose; if the objective is to set up a domestic hi-fi then any sound level indicator would do. However, if a meter is to support a statutory nuisance claim or part of a hearing conservation programme then the measurement must be to a certifiable standard with a specified level of accuracy to provide comfort and a reasonable level of uncertainty that the measured data is sampled accurately. The measuring instrument is a key element of this uncertainty so for any measurement that is in support of statutory or regulatory requirements its performance must be well understood. The International Standard BS EN IEC 61672 covers sound level meters; it specifies what they should do (the specification, part 1) tests that are design related (pattern evaluation, part 2) and tests that are use related (periodic verification, part 3).

- **1. Specification:** This sets out what the instrument must do and how accurately these objectives are to be realised. It allows for two classes of instruments, class 1 (precision) and class 2 (general purpose). Both have the same design goals, but wider tolerances are allowed for class 2 instruments. It is the manufacturer's responsibility.
- **2. Pattern evaluation:** Here, fundamental matters are dealt with concerning how well the specification has been realised. In addition, the performance over the wide range of environments, i.e., anywhere humans live or work, as well as the effects of electromagnetic interference; all of these functions need very specialised facilities to verify. In addition, the acoustic effects of the instrument housing and front-end accessories such as windscreens need to be verified. This will provide the user with correction information to allow for regular calibration and give a full understanding of how the instrument performs in the field. Again, the manufacturer's responsibility but the data should be confirmed by testing at an independent national laboratory.
- **3. Periodic verification:** Sometimes referred to as 'calibration' is normally a biennial check based on a restricted range of parameters that are designed to show any drift or damage during use. These tests are carried out at close to reference conditions and make use of correction data confirmed during the pattern evaluation. This is the user's responsibility and for legal metrology applications carried out by an accredited laboratory. P52

Below: Free-field acoustic testing in an anechoic chamber



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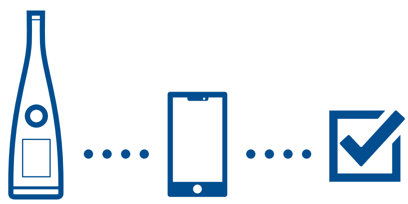

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If both parts 2 and 3 have been carried out successfully then a calibration certificate becomes a certificate of conformance to the standard with results defendable in any court, tribunal or enquiry. If part 2 tests have not been carried out, any calibration certificate will be endorsed with a statement making it clear that the meter may not comply with all the requirements of the standard and that it was a snapshot of the instruments performance at the time of the part 3 tests.

The price of a sound level meter can range from a few tens of pounds to many thousands. The price may differ due to features within the instrument or because of the many expensive tests to confirm its ability to accurately measure noise have not been carried out.

This article reports on a project that looked at a range of low-cost meters that claimed compliance to BS EN IEC 61672 class 2 standard in their sales literature. Six meters were purchased, from five different manufacturers, and submitted for UKAS accredited periodic testing at Campbell Associates and Cirrus Research calibration facilities to see how they performed to the restricted range of tests at reference conditions. Testing was against the Edition of IEC 61672-3 with which each meter claimed conformance. Meters selected were priced between £75 to £375.

Results were mixed, with most failing to provide sufficient information to perform periodic test and all failing at least one test.

First impressions

First impressions of all instruments selected were good, each meter was well packed and built. Only two of the six had the required information within the user manuals to enable periodic testing to be performed. The other four manufacturers were approached for this missing information and none were able to provide this data. The information on the corrections, test points and reference data are mandated by the standards and hence if not available the meter immediately does not comply with the standard and testing should not be performed. However, for the purposes of this paper, it was decided that each of the test laboratories would make their own estimates on the required information based on previous experience so that testing could continue. For this exercise, each laboratory performed testing as best they could, one laboratory performed electrical and sound pressure testing, whilst another also performed free-field tests. This resulted in greater variance in results between the two calibration facilities than would be expected if all relevant information was available.

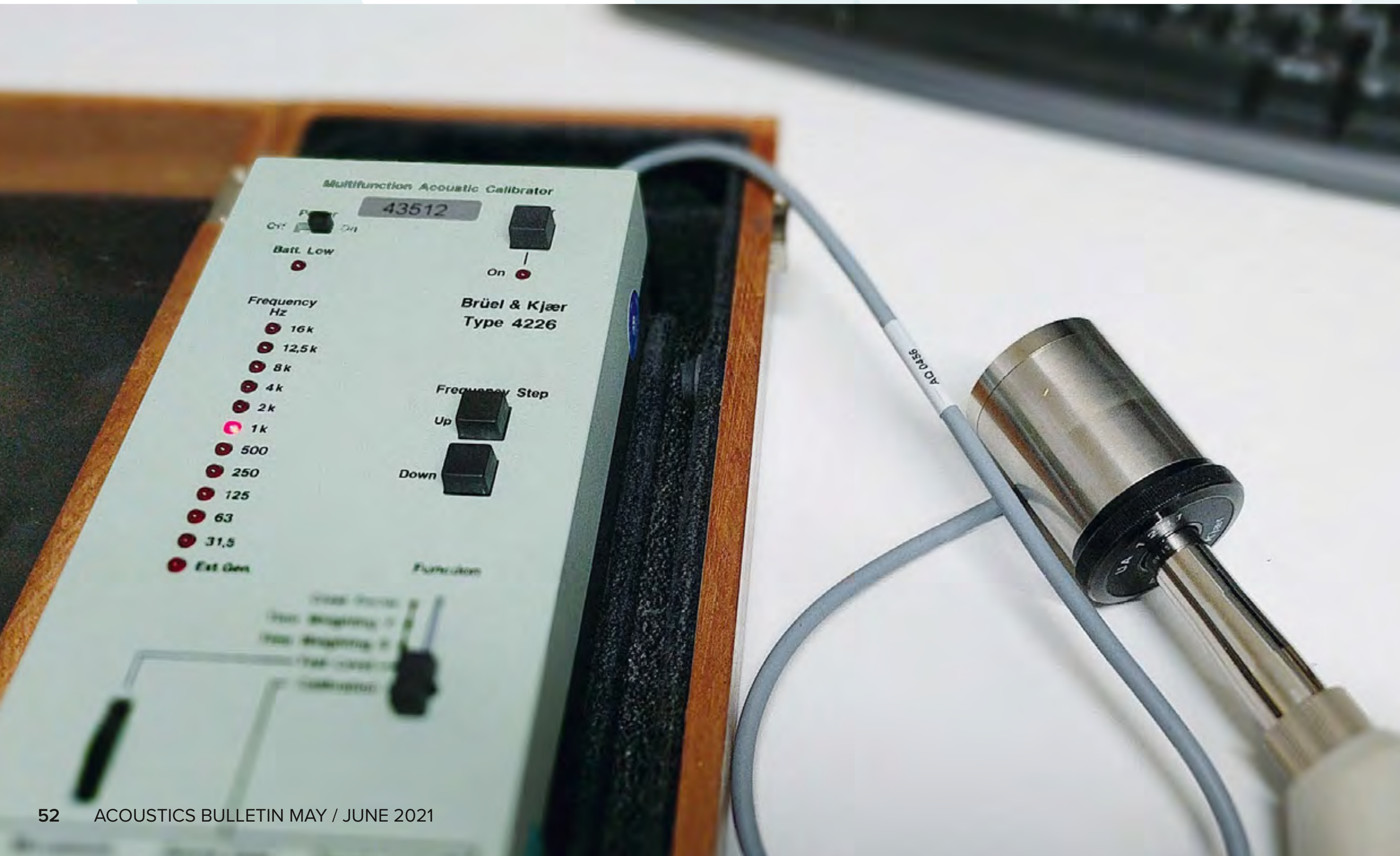
Method of testing

A number of the periodic tests are based on an electrical signal being applied to simulate an acoustic response. This is typically applied by removing the microphone and fitting an adaptor to the preamplifier. Some of the meters had fixed microphones, and, as no test point was provided, the electrical signals were directly input into the meter as appropriate. IEC 61672 requires a sound level meter to have a removable microphone so any meter that does not have this capability immediately fails to conform to the standard.

Other tests performed include sound pressure testing using a multi-frequency acoustic calibrator, measurement of the microphone self-noise and free-field testing in an anechoic chamber.

Test results

The following tables provide a summary of the results for each instrument at both test facilities. Instruments have been labelled A to F. P54



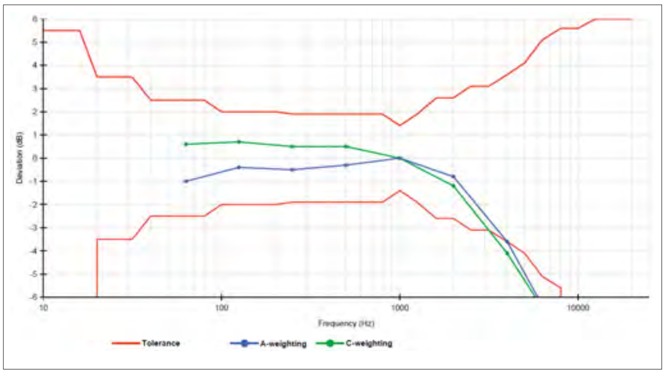
Below: Acoustic pressure testing using a B&K 4226 multifunction calibrator

Test per IEC 61672-3 (2006) Edition 1	Instrument A	Instrument D	Instrument E	Instrument F
Self-generated noise – clause10.2**	Failed (1)	Passed (1) Passed (2)	Passed (1) Passed (2)	Failed (1) Passed (2)
Acoustic frequency weightings – clause 11	Passed (1)	Passed (1)	Passed (1)	Passed (1)
Electrical frequency weightings – clause 12	Passed (1)	Failed (1) Failed (2)	Passed (1) Passed (2)	Passed (1) Passed (2)
Weighting at 1 kHz – clause 13	Failed (1) Failed (2)	Failed (1) Passed (2)	Passed (1) Passed (2)	Failed (1) Failed (2)
Linearity – clause 14	Passed (1)	Passed (1) Passed (2)	Passed (1) Passed (2)	Failed (1) Failed (2)
Linearity (all ranges) – clause 15	Passed (1)	Passed (1) Passed (2)	Passed (1) Passed (2)	Passed (1) Passed (2)
Tone burst response – clause 16	Failed (1)	Failed (1) Failed (2)	Failed (1) Failed (2)	Failed (1) Failed (2)
Overload indication – clause 18*	Passed (1)	Passed (1) Passed (2)	Failed (1) Failed (2)	Passed (1) Passed (2)

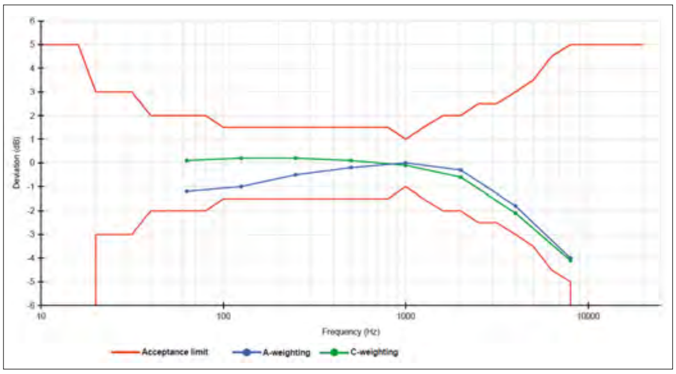
KEY:
*Overload is optional for non-integrating instruments
**Self-generated noise test is for indication and does not on its own, mean a meter does not comply, but may affect linearity
(1) Tests performed at Calibration facility 1
(2)Tests performed at Calibration facility 2

Typical results measured for frequency weighting are shown below. Typical failures recorded for units were failures above 2kHz and below 200Hz. Results are shown for electrical and free-field testing. Electrical testing should include manufacturers' correction data to correct to free-field which was typically not provided, whilst correction data is not required for free-field testing. P56

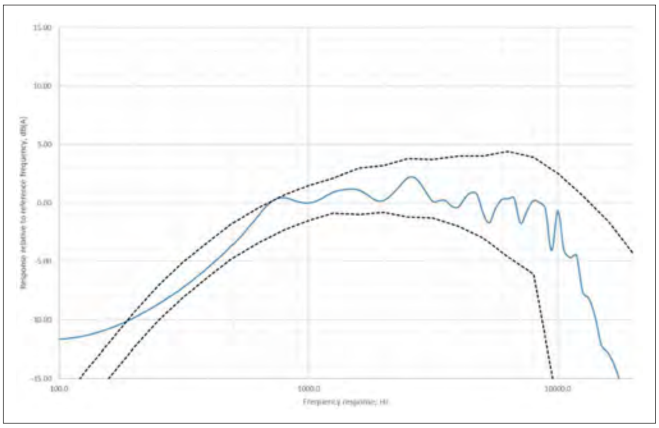
Test per IEC 61672-3 (2013) Edition 2	Instrument B	Instrument C
Self-generated noise – clause 11**	Passed (1)	Passed (1)
Acoustic frequency weightings – clause 12	Passed (1)	Passed (1)
Electrical frequency weightings – clause 13	Passed (1) Passed (2)	Passed (1) Failed (2)
Weighting at 1 kHz – clause 14	Passed (1)	Passed (1)
Long-term stability – clause 15	Passed (1)	Passed (1)
Linearity – clause 16	Failed (1)	Passed (1)
Tone burst response – clause 18	Failed (1)	Passed (1)
C-weighted peak – clause 19	Failed (1)	Passed (1)
Overload indication – clause 20*	Failed (1)	Passed (1)



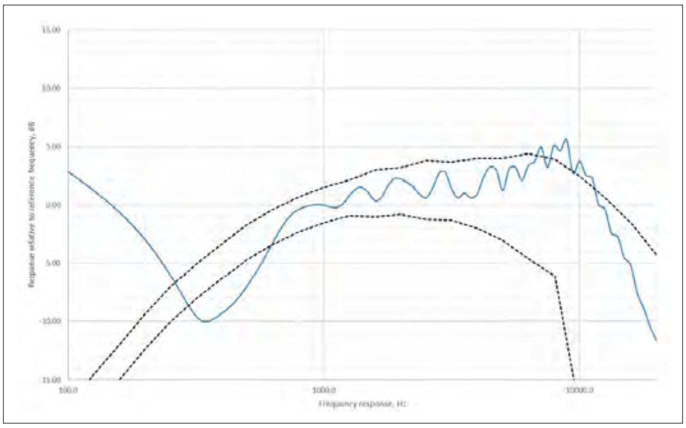
Electrical frequency A & C weighting for, instrument D – Fail
(no corrections provided)



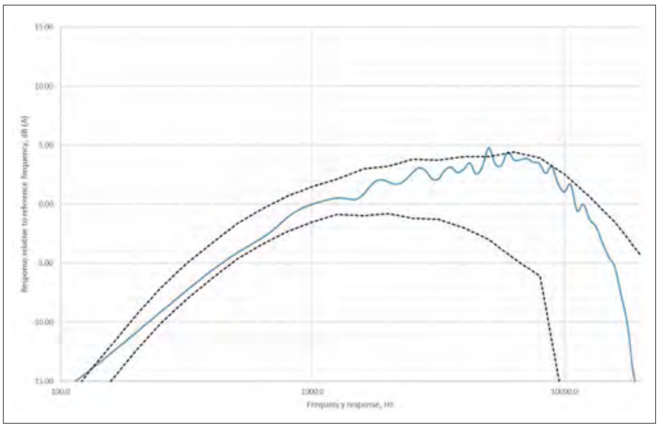
Electrical frequency A & C weighting, instrument A – Pass
(no corrections provided)



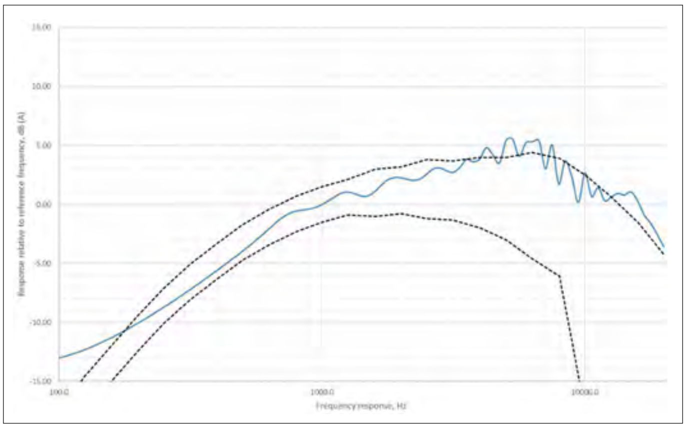
Free-field frequency A weighting, instrument D – Fail
(no corrections required for free-field testing)



Free-field frequency A weighting, instrument A – Fail
(no corrections required for free-field testing)



Free-field frequency A weighting, instrument E – Fail
(no corrections required for free-field testing)



Free-field frequency A weighting, instrument F – Fail
(no corrections required for free-field testing)

Of the six units, two failed linearity testing. Linearity tests are performed at the reference level range for meters with multiple ranges. The results shown are for the reference range if identified in the manual. A second test is then performed at each range but limited to a single value in each range. Typical linearity failures at the low end of a range are due to noise floor of the instrument, however instrument A had an interesting step change halfway through the range. P58

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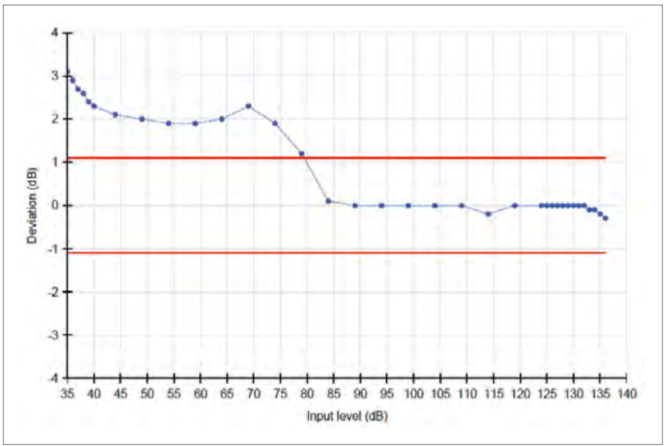
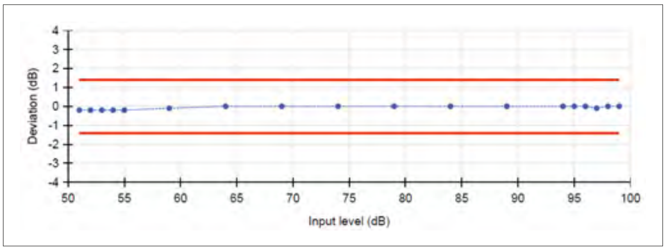
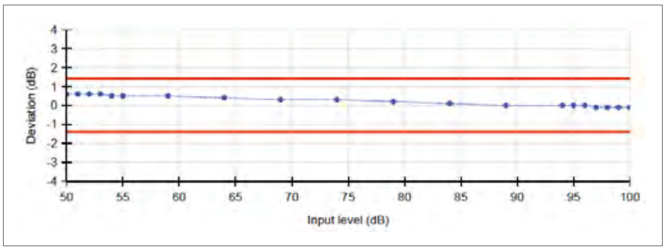
Most units failed tone burst tests, in many cases significantly. For example, a 2ms burst on meter D should have measured 79 dB, it measured 45.6 dB, giving a 33.4 dB error. Most tests performed by IEC 61672 are based on stable sinusoidal test signals, whilst tone burst consist of a short burst of 4kHz sinusoidal signals, this test ensures the instrument measures complex signals correctly for fast and slow time weightings. A failure of this test will typically result in a meter reading low in real world situations and is typically the result of an over filtered front end or insufficient sampling to detect noise bursts.



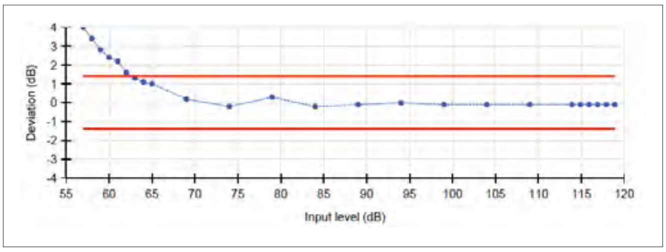
Electrical linearity – instrument A – Fail



Electrical linearity – instrument B – Pass



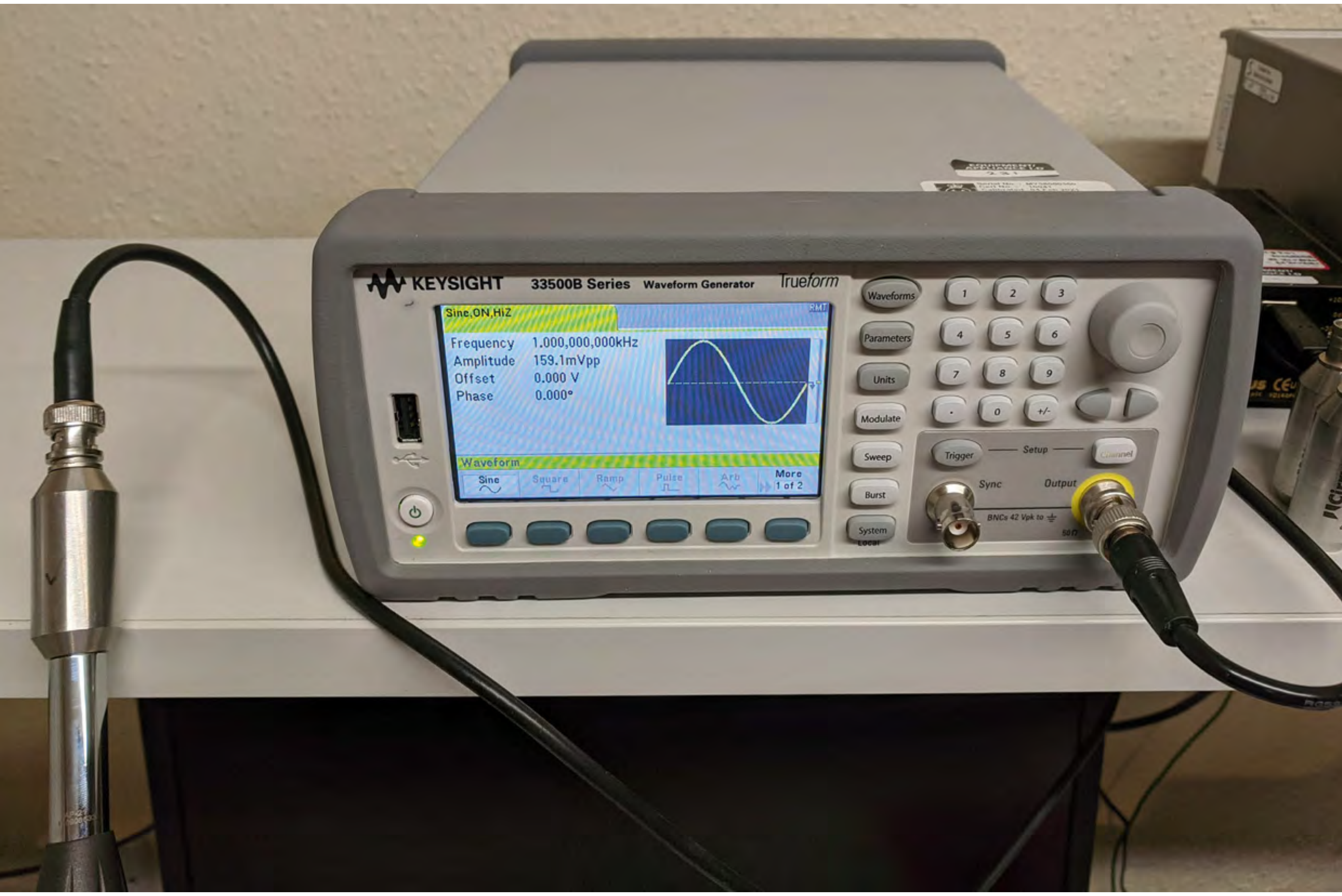
Electrical linearity – instrument E – Pass



Electrical linearity – instrument F – Fail

Burst Duration	Meter A			Meter B			Meter C			Tol (worst case)
	Exp	Act	Dev	Exp	Act	Dev	Exp	Act	Dev	
ms	dB	dB	dB	dB	dB	dB	dB	dB	dB	dB
200	96.0	91.7	-4.3	126.0	93.9	-32.1	116.0	116.0	0.0	+/-1.3
2	79.0	56.3	-22.7	109.0	58.8	-50.2	99.0	98.9	-0.1	+1.3/-2.8
0.25	50.0	45.4	-24.6	100.0	47.9	-52.1	90.0	89.8	-0.2	+1.8/-5.3

Burst Duration	Meter D			Meter E			Meter F			Tol (worst case)
	Exp	Act	Dev	Exp	Act	Dev	Exp	Act	Dev	
ms	dB	dB	dB	dB	dB	dB	dB	dB	dB	dB
200	96.0	96.8	0.8	96.0	88.0	-8.0	116.0	117.8	1.8	+/-1.3
2	79.0	45.6	-33.4	79.0	57.6	-21.4	99.0	80.0	-19.0	+1.3/-2.8
0.25	50.0	38.7	-31.3	50.0	41.1	-28.9	90.0	73.8	-16.2	+1.8/-5.3



Above: Electrical testing a meter by using an adaptor fitted to the preamplifier

Summary and conclusion

All meters failed at least one test. Whilst one meter was close to passing all tests; others failed several tests, including linearity, frequency weighting and especially tone burst, which five of the six failed.

Each meter was advertised as being compliant to IEC 61672, which would indicate it should meet the stringent requirements of this standard and should pass all the tests detailed of part 3. Meters were purchased new and immediately submitted to periodic testing per IEC 61672-3 at two test laboratories.

Four units failed to provide required information in the user manual to enable a calibration check to be properly performed. In each case the manufacturer was contacted to request this information, and none were able to provide the correct information, with one acknowledging the requirement and changing their marketing information to remove any claims to IEC 61672. According to the standard, as this information was not available, testing should not normally be performed, but for this exercise tests were made and failure of the manufacturer to provide this information will mean some of the tests performed will not be accurate as additional uncertainties will have been introduced, as shown by some variance between individual calibration facilities. However, it is unlikely the lack of this data would have resulted in failed tests becoming passes.

The results show that a low-cost meter is (as might be expected) capable of providing a noise level indication, but also that a number of instruments that claim IEC 61672 compliance are not compliant. If an instrument is required for accurate noise measurements it is recommended that any claims of compliance are confirmed. This can be established by asking for evidence of type approval, typically in the form of a certificate from a national metrology institute, and not by just relying on the marking on the sound level meter.

2021 Conference programme

Understandably, the 2021/22 conference programme is likely to be affected by the COVID-19 virus.

2021

ACOUSTICS 2021
11-12 October 2021
Crowne Plaza Hotel, Chester

REPRODUCED SOUND 2021
16-18 November 2021
The Bristol Hotel, Bristol
Organised by the Electroacoustics Group

2022

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

ICUA 2022
20-24 June 2022
Grand Harbour Hotel, Southampton
Organised by the Underwater Acoustics Group

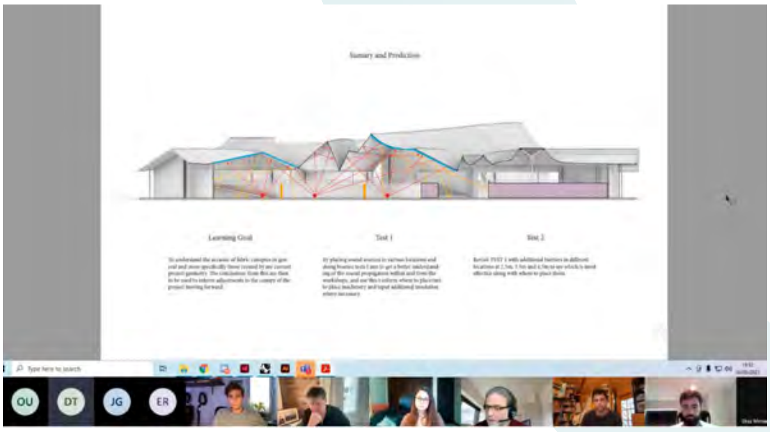
INTER–NOISE 2022
20-24 August 2022
SECC, Glasgow

Novel online conference held to promote mutual discipline awareness between acoustics and architecture students

On 4 March 2021 an online conference was held between London South Bank University (LSBU) Acoustics Group and the world-famous Architectural Association (AA) School of Architecture. 45 students and academic staff from both institutions attended the afternoon event.

By Dr Luis Gomez-Agustina, Director for IOA courses at LSBU

EST 1892 LSBU



Left: The LSBU and AA online conference, 'Acoustics in Architecture, Architecture in Acoustics'

The theme of the conference was 'Acoustics in Architecture, Architecture in Acoustics' and its aim was to improve the understanding of each other's disciplines, enhance communication and promote collaborative work between acousticians and architects.

The idea of this novel conference was formulated and developed by Dr Luis Gomez-Agustina in response to the impossibility this year to hold the face-to-face educational exchange events and site visits that both universities normally have in March.

Exchange of knowledge

The conference started with an introduction to the event in the main virtual room, to set the scene and create a participatory and relaxed atmosphere. Then attendees, calling in from locations around UK, Europe and the Americas, were distributed in three breakout rooms with a balanced, mixed audience. Students from both institutions delivered a total of 17 presentations in the three parallel sessions moderated by academic staff. Question and discussion time after each presentation was keenly utilised by the audience and provided the exchange of knowledge, ideas and insights sought by the organisers.

In the concluding part of the conference there was time for further debate and final remarks from everyone gathered back together in the main room. The attendees were asked to vote online in real time for the best presentation of their break out room session. The winners have received a certificate of achievement and an Amazon voucher as a prize. The conference was closed by showing a short, entertaining video which illustrated the effects of reverberation in music and speech.

Networking and feedback

The conference was followed by a virtual audio visual tour of the LSBU acoustic laboratory facilities where the concept of reverberation and absorption were aurally demonstrated. After the tour, a friendly and virtual networking event was held for attendees to meet and greet.

28 attendees completed an online evaluation questionnaire designed to provide feedback on the event. 93% of those felt satisfied or very satisfied with the conference. 57.1% of the respondents believed that reciprocal appreciation and understanding of the two disciplines in the architectural design is very important while 42.9% believed that it is important. Almost three quarters (74%) felt that the conference had increased their understanding and awareness of the other discipline.

My thanks go to AA School of Architecture teaching staff and former LSBU MSc acoustics student, Laura de Azcarate, as well as LSBU Acoustics PhD student, Douglas Shearer, for assisting with the organisation and facilitation.

It is hoped that this successful event will be repeated and even expanded in the near future with the participation of other national and/or international universities.

For more information

For an overview of the IOA Diploma in Acoustics and Noise Control at LSBU visit **www.lsbu.ac.uk/courses/course-finder/acoustics-diploma**

Complex decision-making processes

In this article, Dani Fiumicelli looks at two cases where noise impacts were considered when deciding on development proposals nearby.

The first case is a planning appeal regarding the extension and conversion of a listed building in the centre of Wallingford, Oxfordshire, from a bank to eight flats. The local planning authority had refused permission because the scheme did not adequately protect the future residents against noise from the adjoining theatre/cinema. The appeal was denied by a planning inspector, who was concerned that the future operation of an adjacent community theatre and cinema would be jeopardised by noise complaints leading to enforcement action.

The inspector expressed concern that future occupants would be affected by noise transmitted through a flanking wall and shared foundations, and doubted whether this noise could be realistically mitigated by amendment of the scheme before her. The source noise levels, and frequency of occurrence were debated extensively by the acoustic expert witnesses.

Below: Dani Fiumicelli

The council and the theatre considered that the higher crescendo system levels represented typical operating conditions, whereas the appellant argued that these were exceptional operating conditions, with the lower in-house cinema system levels being representative. The appropriate source noise levels required to trigger an assessment and/or design mitigation is a common area of disagreement in these cases.

However, broad agreement was reached that disturbance was most likely from noise in the lower frequency octave bands. For example, it was agreed that internal design criteria for music noise levels in the proposed flats were 40 dB LZeq, one minute in the 63Hz octave band and 30 dB LZeq, one minute in the 125Hz octave band, with a relaxation of 5 dB for non-habitable rooms e.g., toilets, kitchens and circulation spaces etc.

The developer was prepared to accept a Grampian-style condition prohibiting development until further exploratory works and suitable noise mitigation had been secured. But the inspector rejected this approach, observing that if the foundations were shared; a substantially revised scheme would probably need to be resubmitted. This would mean a fundamentally different design might have to be submitted and this would require an entirely new application as this would not match the description of the scheme in the submitted planning application.

Case law means that conditions cannot be used to change the description of a permitted scheme, so it would be unlawful to leave these issues for 'approval' under a reserved matters condition i.e. 'submit a scheme for approval etc'.

Having regard to the agent of change principle of the PPG and adopting a precautionary approach to noise effects, the inspector concluded the development would not provide satisfactory living conditions and statutory nuisance complaints could compromise the future of the community entertainment venue. This would conflict with the local plan policy and NPPF paragraphs 180 and 182 concerning noise mitigation in development.

This case is Appeal A Ref: APP/Q3115/W/20/3249052, 4 Market Place, Wallingford, OX10 0EH.

Council's "confused thinking"

The second case is a High Court Judgment involving the clash of interests between a licensed premises and an adjacent housing development.

In May 2000, the council granted permission for a change of use of the licensed premises from retail to the sale of food and drink on the ground floor. To protect the conservation area and the amenity of neighbouring properties, the premises was required to close at midnight and not to play amplified music audible from the public highway.

The venue applied to vary the existing planning conditions under section 73 of the Town and Country Planning act 1973. This empowers local authorities to amend or remove conditions, but they are not entitled to amend any other part of the original permission. The application was granted with new conditions, amongst other things, allowing the venue to stay open until 2am from Thursday to Saturday and on New Year's Eve and Christmas Eve.

The council granted the permission despite objections from the developer of flats next door to the venue, who were concerned about the impact of noise from the venue on residents.

Furthermore, the EHO had advised that the under the previous permission the venue had operated at internal levels around 70 dBA, but in this case the 'level of sound transmission here is of a different order of magnitude where sound levels at source are approaching 100dB(A) with powerful bass tones ... It is debateable whether any reasonable noise mitigation between the properties would be totally effective in protecting new dwellings from intrusive noise from music levels found in a nightclub. ... The protection of residents from excessive noise intrusion through the party wall is dependent on the adjacent property reverting to its lawful planning use and significantly reducing sound levels generated within to a level more typically expected within a pub/restaurant environment.'

The developer alleged that varying the original conditions 'would intensify the noise impact'. They also argued that it was 'unlikely that any level of mitigation could be provided to safeguard the amenity of residential units.'

Whilst noise was a primary driver in overturning the council's decision, the High Court judge said the case "illustrates once again the difficulties caused when a local planning authority purports to grant a permission under section 73 without sufficient care as to its relationship with the parent permission". The conditions attached to the section 73 permission were appropriate for a 'drinking establishment', rather than a bar and restaurant, and were therefore 'inconsistent with the use specified in the description of development in the original permission.'

The judge upheld the developer's argument that the revised conditions 'derogated from the operative words' of the 2000 permission and that the description of the development in the 2000 permission could not be amended under section 73, which 'only permits the variation of conditions.' And the judge accepted that "if a party wishes to vary the description of the development, then it must apply for a new planning permission."

Although the section 73 permission did not purport to change the original operative description of the development, it "sought to create the same effect by imposing conditions inconsient with it", the judge added. On the face of it, the permission authorised the venue's mixed use as a restaurant and drinking establishment, but the conditions attached to it purported to limit its use to that of a drinking establishment only. That inconsistency, said the judge, illustrated the council's "confused thinking." Adding: "This has resulted in a permission which has had conditions imposed that are inconsistent with the original permission, purported to grant permission for something other than originally permitted and other conditions that were not consistent with an attempt to limit the new permission."

A requirement to fit a limiter to sound equipment was not included as a formal condition to the section 73 permission and the judge said it was "perverse" not to have in place some means of enforcing compliance. The council should have refused, or deferred granting, permission until such compliance was secured.

There also appeared to be substance in Parkview Homes' complaints that it was irrational of the council to grant the permission without first performing noise tests, as recommended by its own environmental health department.

Quashing the permission, the judge concluded: "This is a case of multiple errors in the decision-making process, including in the consultation process and in the substance of the permission issued."

Chichester District Council did not contest Parkview Homes' judicial review challenge to the section 73 permission and played no part in the hearing of the case. Sussex Inns Limited, however, defended the permission as an interested party.

Case Citation:

Parkview Homes Ltd, R (On the Application Of) v Chichester District Council [2021] EWHC 59 (Admin) (15 January 2021) – can be viewed at **https://www.bailii.org/**

BRANCH NEWS

Midlands Branch

By C J Biggs

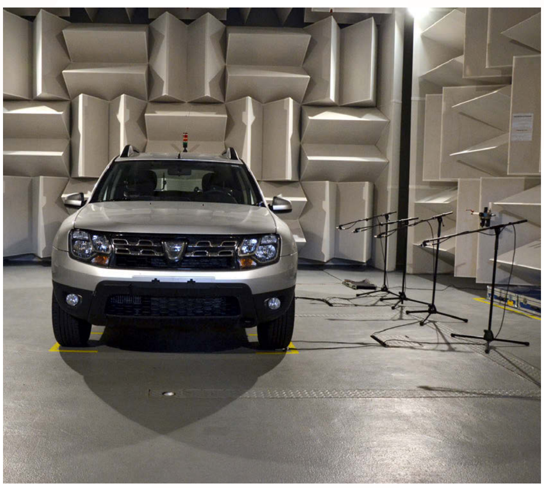
An introduction to automotive NVH trim materials – AVA Consulting.
In a well-attended presentation on 11 March 2021, Richard Crompton, Director at AVA Consulting, gave an interesting talk on an area of automotive acoustics that focused on the trim materials used in vehicles to control noise, vibration and harshness. Unfortunately, Richard's business partner Roanan Ellis was unable to attended.

Richard's presentation gave a fascinating walkthrough of the process that is involved in getting the correct trim package. It started by looking at the sources of noise and transmission paths they will take for both internal and external noise, whilst comparing the difference in frequency between traditional internal combustion engines, hybrid and electric vehicles.

The presentation then progressed to the selection of the trim package and focused on airborne sound transmission paths due to time constraints. Richard discussed the methods of testing these materials, including absorption, transmission loss, damping, and the parameters of selection such as cost, weight and effectiveness.

The final part of the presentation covered how electric and autonomous vehicles will change the type of trim selected in the future, especially as driverless cars may need to reduce the focus of external noise and make the interior more comfortable.

The Midlands Branch would like to thank Richard Crompton for a very well received and informative presentation.



Southern Branch

By Jack Richardson

On Wednesday, 24th March, IOA Southern Branch members met on Zoom for a presentation on the acoustic vehicle alerting system (AVAS) for London's (TFL) emerging electric bus fleet.

The presentation; *'A soundscape approach to creating the urban bus sound',* was jointly presented by Anderson Acoustics' Grant Waters and Ed Manzano, who set the scene by introducing TFL's brief and vision for their new electric bus sound, and providing a concise technical overview of the current regulation governing sounds from electric vehicles at low speeds (< 20 kph): UN ECE Regulation 138. In short, their brief was to develop a balanced AVAS sound that was pleasant, safe and could improve urban soundscapes.

Grant and Ed took attendees through the step-by-step evolution of the AVAS sound they created alongside their client and major stakeholders. They then described the early stages of their creative process, which involved a series of moodboarding workshops to generate a variety of potential sounds, and which eventually saw these whittled down to just 10 finalists. They described how they refined the characteristics of the sounds to ensure they remained pleasant to their collective ears, but also easily identifiable and localisable by vulnerable road users and pedestrians – it was particularly interesting to learn how the requirements of the latter necessitated the addition of a comparatively impulsive 'beacon' sound, that would help people localise the source once the vehicle had begun to move.

Following numerous computer simulations conducted in their SonicRoom and some final tweaks, they described how they were eventually ready to install the prototype onto a real bus and carry out in-situ tests. Grant and Ed finished by informing us of the success of the prototype testing and successful approval of the system for trial on TFL's Route 100.

The presentation generated a lot of interest, with Zoom's live chat becoming awash with questions and comments throughout the hour-long presentation. The level of engagement was a clear indication that this area of acoustics is still very much in its nascent form and the future will undoubtedly need to see synergy between the acoustics and automotive industries. The event was a great success, with 64 people in attendance. We hope to welcome Grant and Ed back following completion of phase two.

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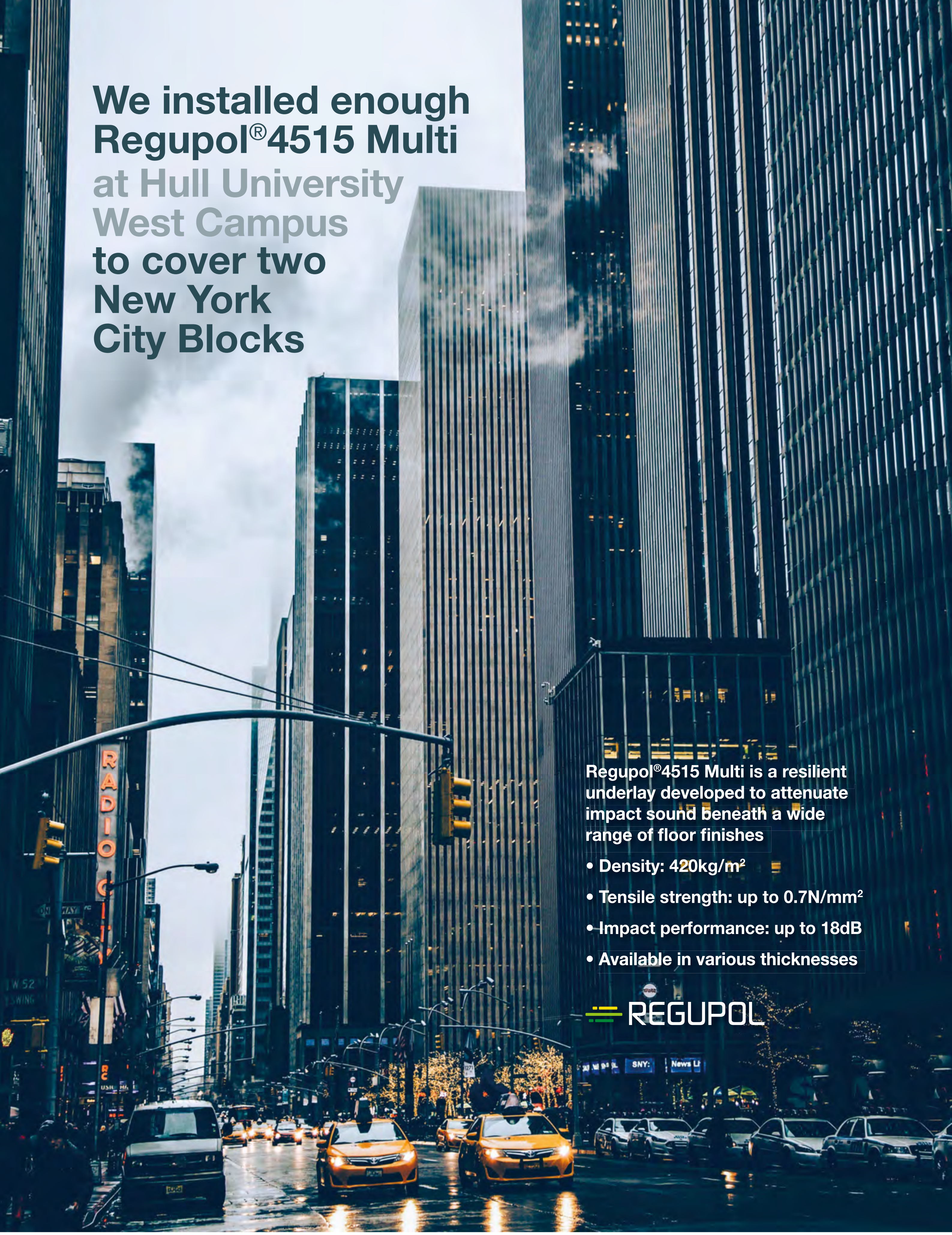


Scottish Branch

By Anne Budd

The Scottish Branch has had a busy start to 2021. Our postponed 2020 AGM was held 18 February when some long-standing members of the Branch decided it was time to step down and a new group of volunteers came forward to take on their roles. Many thanks to Alistair Somerville (IOA President Elect) for his many years as Chair of Scottish Branch and to Craig Simpson (Sandy Brown) for his time on the committee as Membership Secretary.

Our new committee members are Lindsay McIntyre (KSG Acoustics), Chris Steel (HSE), Ashley Leiper (Envirocentre) and Mark Robertson (North Lanarkshire Council). Laurent Galbrun (Heriot Watt University), Nicola Symington (RMP), Martin Butterfield (Arup) and Lilianne Lauder (Mid Lothian Council) will continue in their roles on the committee. Anne Budd (New Acoustics) has taken on the role of Chair. We are also delighted to welcome Zanyar Abdalrahman (Sandy Brown) who has volunteered to be co-opted to the Scottish Branch Committee as Early Careers Group Representative.

The new committee has an excellent mix of representatives from both commercial and public sectors and coverage from east and west of the country. We hope in future to encourage those members located further to the north and south of Scotland to join us, which is all much easier in these days of virtual meetings.

Noise control of drones

The AGM was followed by an excellent presentation by Dick Bowdler (Dick Bowdler Acoustics) on the topic of 'Noise from drones – are they the next environmental noise problem?' Dick started his presentation by taking us through what is classed as a drone, which essentially are unmanned aerial vehicle or transportation systems. He then went on to tell us about the many types of drones which are already in use, including applications in photography and film, and those used for crop spraying. He outlined other potential uses, which are at various stages of design and development, even including examples of air taxi services. Dick noted that the main emerging use of drones is for delivery and gave examples of them in use and in trials across the world, including one in Scotland for delivery of medical supplies across from the mainland to islands off the west coast. He then took us through some of the research on noise from drones and the features which affect it, such as the aerofoil trailing edge and noise from motors, as well as technical methods of mitigation.

Dick described some of the factors relating to noise control of drones including the ethics of operational noise, parameters which could be used to best represent the noise and some existing and emerging regulation of drone noise. Finally, he suggested that there are opportunities for consultants and researchers to get more involved as this novel area and the policy surrounding it develops.

The presentation was well received and prompted a lengthy discussion and debate on many of the topics covered. The Scottish Branch, headed by Dick Bowdler and Anne Budd, has now taken on the role of coordinating an initial IOA Briefing Note on the topic.

Edinburgh Science Careers Hive Event

As well as our AGM the Scottish Branch have been busy preparing for the upcoming Edinburgh Science Careers Hive Event sponsored by the IOA. Normally a live event, as so many things have had to, this year the event will be entirely virtual on the Gather Town Platform. Students are invited to take part in a series of interactive events and workshops, allowing them to hear from inspirational early-career STEM professionals, speak directly with a variety of people working in the STEM industries and explore their own skills and strengths. IOA volunteers will man the virtual sound exhibition stand to talk about acoustics and careers with secondary school (S1-S3) students from across Scotland prior to them choosing the National Grade subjects. In addition, we are excited to see the IOA sponsored science experiment 'Ella's Wobble' being sent out to primary schools in Scotland as part of the Edinburgh Science, Generation Science initiative, which despite having to be scaled back due to COVID constraints, is still going to be supporting the 200 most deprived primary schools in Scotland this year.

Branch plans and developments

Our Scottish Branch programme of events for the year is taking shape and we hope to expand on what we have been offering in recent years by taking on the lunchtime slot. To that end we are hoping to hear from Scottish Branch members about interesting projects they have been working on and on which they would be willing to present to the group, in a friendly lunchtime CPD session format. We are also planning to send out a short questionnaire to all Scottish Branch members on what more the IOA Scottish Branch can be doing in Scotland; for our members, but also to play a full role in the development of relevant legislation and national guidance, as well as inspiring our young people to take up careers in the field of acoustics and influencing education and other areas of society.

If have any questions do not hesitate to contact Anne Budd, Scottish Branch Chair, to discuss at **anne@newacoustics.co.uk**

IOA Noise and Vibration Engineering Group

By Malcolm Smith and Matt Torjussen

The second talk in the series of seminars being organised by the NVEG committee takes place on 11th May at 13:00, on the topic of 'Aerodynamic noise from planes, trains...and buildings'. To register please use the Eventbrite link at https://www.ioa.org.uk/civicrm/event/info?reset=1&id=618

The seminar will review the mechanisms of broadband and tonal flow noise: vortex shedding from car roof racks and train pantographs, the difficulties of reducing noise from the landing gears and wings of aircraft at landing approach to an airport, and why railings on bridges or balconies sometimes whistle or hum in the wind. There will inevitably be a few equations, but the aim is to provide an accessible introduction to how these and other flow induced noise problems are investigated and controlled. The talk should be of interest to a general audience from the IOA, as well as from the wider community of mechanical, aeronautical and building design engineers.

The following seminar, planned for August, will be on the topic of noise generated by the electromagnetic forces in the motors and equipment of electric vehicles. Thereafter, there will be talks on applications of active noise control and noise and vibration control for power tools to meet Health and Safety regulations.

Suggestions and offers for other topics are welcome.

Survey of noise problems from domestic heat pumps

There is anecdotal evidence that domestic heat pumps being installed to minimise carbon emissions are resulting in noise complaints. To see if there is a case for researching ways to reduce the noise from heat pumps at source, the NVEG has put together an online survey to collect IOA members' experience of complaints. To fill out the survey, scan the QR code using your iOS or Android device or follow this link to see a desktop version: **https://forms.office.com/r/jnxvAFsnh4**

NEWS

Stolen equipment

A RION sound level meter was stolen in Inverness at the beginning of March.
Make/Model: RION NL52
Serial No: 00620898
If you have come across this item please contact Robin Mackenzie Partnership at
Tel: **0345 062 0000**
Email: **rmp@napier.ac.uk**

FIS launches technical note on specifying acoustic absorbers

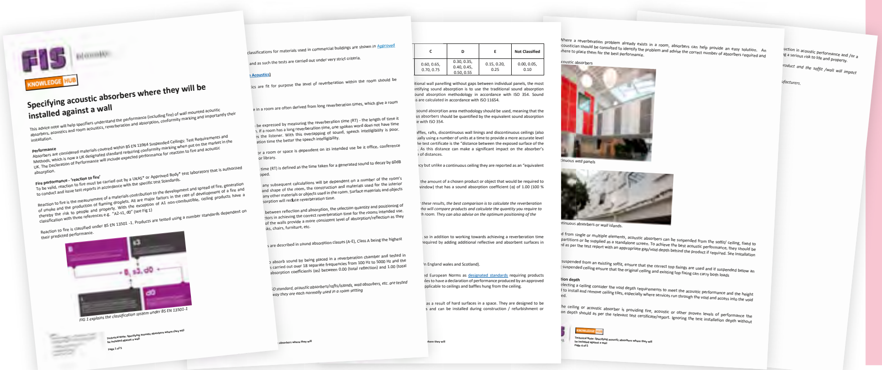
To help specifiers understand the performance of wall mounted acoustic absorbers, FIS (the representative body for the finishes and interiors sector in the UK) has published a new technical note, 'Specifying Acoustic Absorbers where they will be installed against a wall'.


Rockfon Eclipse wall panel

The guidance will help specifiers understand the acoustic and fire performance of wall mounted acoustic absorbers, acoustics and room acoustics, reverberation and absorption, conformity marking and importantly, their installation.

Iain McIlwee, Chief Executive of FIS, said: "The positioning and installation of the absorbers can all have a big impact on the effect the absorbers will have, so it is important for specifiers to have all the information during the crucial specification stage."

The technical note is available to download at **www.thefis.org/knowledge-hub/technical/fis-technical-notes-industry-alerts**



The Aural Diversity Network

The Aural Diversity project was started in 2018 by Andrew Hugill to explore the differences in hearing between individuals and their artistic and scientific consequences.

2021 sees a further evolution of the project, as the Arts & Humanities Research Council (AHRC) has funded a two-year research network, beginning in July.

The term 'auraldiversity' echoes 'neurodiversity' as a way of distinguishing between 'normal' hearing, defined by BS ISO 226:2003 as that of a healthy 18-25 year-old, and atypical hearing (Drever 2018). This affects everybody to some degree. We have all experienced temporary changes in hearing, such as when having a cold and everybody goes through age-related hearing loss at varying rates.

More specific aural divergences are the result of many hearing differences or impairments, including noise-related, genetic, ototoxic, traumatic, and disorder-based hearing loss, some of which may cause full or partial deafness. However, "loss" is not the only form of impairment: auditory perceptual disorders such as tinnitus, hyperacusis and misophonia involve an increased sensitivity to sound.

The Aural Diversity project explores the consequences of these differences. The list of disciplines that are affected by this includes music and performance, soundscape and sound studies, hearing sciences and acoustics, hearing care and hearing technologies, audio engineering and design, creative computing and AI, and indeed any field that has hearing or listening as a major component.

Join the network here **https://auraldiversity.org/contact.html** and see the list of workshops planned for the next two years at **https://auraldiversity.org/workshops.html**

Predictor-LimA users

Softnoise has taken over support and sales of Predictor-LimA products from EMS-B&K/Envirosuite. This means that all Predictor-LimA users can now contact Softnoise directly for support and sales at **https://softnoise.com/**

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Committee meetings 2021

DAY	DATE	TIME	MEETING
Wednesday	**9 June**	**10.30**	**Council**
Tuesday	15 June	10.30	Engineering
Wednesday	16 June	10.30	Engineering
Tuesday	22 June	10.30	ASBA (Edinburgh)
Wednesday	7 July	10.30	CCWNRA Examiners
Wednesday	7 July	13.30	CCWNRA Committee
Thursday	8 July	10.30	Meetings
Tuesday	13 July	10.30	Diploma Tutors and Examiners
Tuesday	13 July	13.30	Education
Wednesday	14 July	09.30	CCBAM
Wednesday	14 July	10.30	CCENM Examiners
Wednesday	14 July	13.30	CCENM Committee
Thursday	5 August	10.30	Diploma Moderators Meeting
Thursday	12 August	10.30	Membership
Thursday	26 August	11:00	Publications
Wednesday	8 September	10.30	Executive
Wednesday	**22 September**	**10.30**	**Council**
Tuesday	5 October	10.30	Engineering
Wednesday	6 October	10.30	Engineering
Thursday	7 October	10.30	Meetings
Thursday	14 October	11.00	Publications
Thursday	28 October	10.30	Membership

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