Vol 39 No 5 September/October 2014

ACOUSTICS BULLETIN

in this issue… **Digital emulation of the acoustics violin response: a tool for electric violin players**

Institute of Acoustics

1974 - 2014

plus… **40th Anniversary Special**

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Front cover photograph:
Electric violin players have a new tool at their disposal

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, electroacoustics, engineering dynamics, noise and vibration, hearing, speech, physical acoustics, underwater acoustics, together with a variety of environmental aspects. The Institute is a Registered Charity no. 267026.

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17-19 September 2014
Organised by the
Underwater Acoustics Group
Third international conference on synthetic aperture sonar and synthetic aperture radar
Lerici, Italy

14-15 October 2014
Organised by the
Electro-Acoustics Group
Reproduced Sound 2014
Birmingham

15-16 October 2014
Institute 40th Anniversary Conference
Birmingham

7-9 September 2015
Organised by the
Underwater Acoustics Group
Seabed and sediment acoustics: measurements and modelling
Bath

29-31 October 2015
Organised with support from the
French Acoustical Society (SFA)
Auditorium acoustics
Paris

Please refer to
www.ioa.org.uk
for up-to-date information.

Dear Members

It is an honour to be writing my first President's letter to you all.

Since becoming the President Elect more than two years ago, the Institute has quietly evolved under the stewardship of Trevor Cox and Bridget Shield. We have been able to have more comprehensible finances and have generated surpluses. These surpluses and our financial stability have underpinned our strategic plan that has progressed with the membership to safeguard our future and to promote acoustics. None of this could be achieved without you, the members, volunteering your expertise and goodwill for the benefit of the Institute and acoustics in general.

Shortly and looming fast, we will have our 40th anniversary. We have much to be proud of and this is a perfect opportunity for us to present our work and history. It is planned to include reports from each of the eight specialist groups in this and the following issue of the Bulletin about what's been happening in each area over the last 40 years and looking ahead to future developments. Most groups have submitted articles and we hope to have all eight to ensure we have a true representation of the Institute.

On a personal note I changed companies last year, taking my knowledge into a new domain of underwater acoustics. I mention this, as throughout my life in acoustics, just like going to school, it is a continued learning process. The Institute's wealth of material, courses, seminars and professionals enable one to continue to maintain and broaden one's knowledge and skills. These are not just for young members; I personally have had two mentors in acoustics, with more than 40 and 50 years' experience respectively, who took the time and had the patience to enthuse me with the love of the discipline – demonstrating that we learn something new each day. The Institute's Continued Professional Development Scheme supports and encourages continual learning, as part of one of our core strategies, so please review the events, both locally and internationally, for the great opportunities they provide and remember that these events are open to non-members, so bring along a colleague.

As part of our promotion of acoustics, we have been liaising with IIAV (International Institute of Acoustics and Vibration) to bid to host ICSV2017 (International Congress on Sound and Vibration) in London in 2017. The bid was presented at ICSV21 in Beijing in July. I am pleased to announce that we have been successful. Thank you to all involved for the hard work required in gaining this triumph.

As I commence my term as President, I wish to welcome Jo Webb as President Elect and thank in advance the support of the Executive and Council, as well as dedicated members. It's going to be an exciting two years and I look forward to continuing the good work of my predecessors.

As a final note, I hope you enjoy this issue of the Bulletin and I encourage you to submit ideas for stories and to provide feedback on the content.

William Egan, President

Committed to spreading the word

William Egan, the Institute's new President, has made the promotion of acoustics one of his main goals.

Speaking as he took over the reins from Bridget Shield, he said: "It may be something of a cliché among members to say that acoustics is in everything we touch and hear, but this is still something that very few people outside the sector, most pertinently those in Government, appreciate.

"That's why I'm determined during my two-year term to do all I can to raise its profile – and that of the Institute – as much as possible. As a profession we have so much to be proud about. We must now spread this message and, with us celebrating our 40th anniversary this year, this is the perfect opportunity to start to do so.

"I really enjoy the discipline of acoustics, it's such a fascinating and diverse subject, and it's one that I never tire of talking about to people whenever I have the chance. Having got so much enjoyment out of the subject and the Institute, I'm now determined to bring this to a wider audience during my presidency."

Like Bridget, who made Institute history by becoming the first female President, William's election also marks new ground, for, unlike his predecessors, he comes very much from a business background without a traditional academic grounding in acoustics.

Although having a science foundation, he went on to study business and finance. He then worked for a series of high-tech companies, expanding his technical knowledge in such roles as technical purchasing, technical sales and business development before spending three-and-a-half years as a business consultant.

A six-year spell followed as General Manager with Parmley Graham before he moved to sound and vibration measurement specialist Brüel & Kjaer, first as UK Managing Director, subsequently Northern Europe Managing Director and then as Global Services and Solutions Director. At the end of 2013 he moved again – to underwater acoustic solutions specialist Teledyne RESON as Vice President–Global Sales.

Like his previous job, his current role involves a huge amount of time spent flying to meet customers across the globe and he estimates that since the beginning of 2012 he has been around the world the equivalent of at least 10 times.

"My first full-scale involvement with acoustics came when I joined Brüel & Kjær. This eventually led to me joining the Measurement and Instrumentation Group committee and, as a result, I applied to join the Institute. Now that I am with Teledyne RESON my focus is fully on the underwater side of acoustics, which I am finding absolutely absorbing."

While the promotion of the acoustics and the Institute to the wider world is a key goal so, too, is ensuring the Institute meets its strategic targets.

William Egan

Factfile

Born: London, February 1963
Lives: Bicester, Oxfordshire
Personal: Married with three grown-up children
Likes: Family, socialising with friends and walking his two Labradors

"We've already come a long way since our strategy workshop in St Albans early last year when we agreed 11 priorities for action. For example, a huge amount for has been done on upgrading our IT systems and website and this will continue over the next year or two as it's crucial to our future and meeting our goals.

"It's also vital that we continue to put our finances on a firmer footing so we can weather any storms that lie ahead. This will allow us to use our reserves so that we derive best value from them to drive forward our vision.

"I am wholly conscious that we have a dedicated volunteer base without which the Institute could not function, so another major goal is to continue to utilise this; to harness this huge pool of expertise and goodwill at our disposal, complementing it with additional services.

"I believe that because of my diverse background I am able to see the Institute in a slightly different way, through a different set of eyes, and I hope that this ability will help take us through to the next stage in the Institute's development. It's going to be a very exciting two years and I can't wait to get going."

Formation of Institute AM working group

The IOA has formed an amplitude modulation (AM) working group as a sub-group of the wind turbine noise working party.

Gavin Irvine, of Ion Acoustics, is the chairman. Other members will include acousticians working for developers, local authorities and objector groups.

It aims to review methods to quantify and assess AM in wind turbine noise. This review will include: the AM work funded by R–UK; the "Den Brook" condition and other historic and emerging research. A further aim is to progress a preferred metric from those considered and a preferred methodology for assessing AM.

As a first step, the group will produce an options paper for consultation. A workshop is also planned in November to allow members and interested parties to participate in the process.

The first four Supplementary Guidance Notes (SGNs) to the wind turbine noise Good Practice Guide have been published. They can be downloaded from **www.ioa.org.uk/publications/good-practice-guide**. The remaining two will be published in mid September.

All will require Government endorsement, and the President will write to the Government seeking this.

Bridget Shield presented with scroll in recognition of her contribution

Outgoing Institute President Bridget Shield was presented with a scroll at the Institute's AGM in London in recognition of her "leadership, commitment and wise counsel" during her two-year term. The presentation was made by new President William Egan.

And in her final act as President Bridget presented Trevor Cox, who was stepping down from his role as Immediate Past President, with an Honorary Fellowship in recognition of his contribution to the Institute.

Bridget Shield with her scroll

Casting light on sound

By Richard Cowell and Peter Phillipson

Initiated in, and supported by, the Sustainable Design Task Force, this partnership between Young Members Group (YMG) and the Society of Light and Lighting (SLL), affiliated to CIBSE, explored a ground breaking collaboration between acousticians and lighting designers, who too often design quite separately. Focus was on health, learning, artistic collaborations and better outcomes through sound and lighting design.

First Dr Elliot Freeman, a neuroscientist from City University, London, demonstrated the interactive perception of sound and light by our brains and the McGurk effect (the illusory sound perceived when one sound is paired with the visual component of another sound). The impact of audio on perception of visual movement was demonstrated. A video illustrated "a flow of an array of dots spreading out quickly" which can, in some subjects, induce perception of a "whoosh" sound, when there is none.

Some asychronicity between audio and vision can be accepted for accurate speech perception. Each of us has our own value of asynchronicity. In the late 18th century, the Astronomer Royal, John Flamstead, noticed significant, but consistent, variations in aural and visual observations. A "personal equation" offered correction to achieve higher accuracy. Speech reading can be helped, by improving timings of signals. A retired pilot with brain lesions causing doubly asynchronous senses has received therapy to recover adequately synchronous perception.

Different parts of the brain influence McGurk, reading of graphemes and phonemes, and the perception of speech in noise. For some, an auditory lag of 80-120 milliseconds is beneficial. Hearing is better at processing time than vision. In tests with Morse code, auditory sequencing proved easy, visual sequencing less so. Auditory recoding in the brain during visual testing improved results.

Brain activity is diverse and tasks are achieved through re-normalisation processes which optimise the timing between sight and hearing and can improve personal performances in sports, driving, VR and language learning.

Andrew Parkin (acoustician) and Andrew Bissell (lighting) of Cundall use collaborative design centred on human senses, understanding each other's disciplines as sound and light share many similar characteristics.

Projects were shown in detail. First, poor examples of projects were demonstrated (not by Cundall, of course) – the ubiquitous office ceiling (BCO approved) offering little light outside the working surfaces, or sound absorbent "trays" blocking daylight and leaving a high level "mess". Cundall design at Bourneville Place had more daylight and balanced the acoustics in a three-storey atrium. Birmingham SA Water House, Adelaide used vertical acoustic baffles integrated with task lighting and thermal mass and Google used a domestic "home from home" approach with ordinary lampshades illustrated. In Cundall's own Birmingham offices, originally "boring" with a flat ceiling, an integrated acoustic and lighting scheme added life.

For BSF, daylighting and "where light is going" are considered, with modelling of real sky, and careful control of glare. With careful integration, windows can be smaller (helping energy conservation). Cundall is exploring cylindrical illuminance – in the cone of light received by the eye. Visual lip reading cues are crucial for people with special auditory needs.

For health projects, we like daylight to control our Circadian rhythms, for our mood. Schemes for this involve considering the colour of light e.g. backlit beds. Low reverberation times and aural privacy are also keys to healing.

Luca Dellatorre (acoustician), Paula Longato (lighting) and Giulio Antonutto (associate) of Arup, sharing out-of-hours interest in sound/light relationships, presented *The Sound of Light*.

What is light? With colour change, what is the quality change and what do we see? Photography cannot accurately capture a particular quality. Studying the spectral quality of candlelight, daylight and fluorescents, a parallel interest in sound quality and spectrum developed. Can we correlate the light quality (e.g. more reds, more blues) with sound spectra? Is this best with frequency, timing and/or amplitude? Quality was considered in subjective terms. Max 6 software was used for sound to modify light and vice versa.

In small alcoves in Frankfurt Architecture Museum, six different light samples from colour controlled tubes, and MIDI sound were used to move from "warm" to "cold". Visitors could vary light and sound. To improve sound, purity of spectral comparisons between light and sound was compromised.

The authors consider themselves "at the start of something valuable".

Simon Jackson (Arup) and Chris Lowe (BDP) introduced the Subluminal Design Collective.

Chris described the Dark Art of Philip Rafael, the cultural P8

◂P7 role of sunlight and a word survey by Claudia Dutson (RCA) encouraging design using more contrast. Simon embraced powerful low frequency sound and reviewed its influence from our time in the womb.

In John Rylands Library, Manchester, bellowing voices in the entrance combine with up lighting and side lit statues. In the library were inspirational lighting quotes, speaking statues and the ceiling lit in saturated red. A synthetic aural heartbeat fed up a narrowing spiral staircase leading to the aurally and visually womb-like basement, containing a giant "woofer" producing > 100dB at < 150Hz + standing waves, lighting designed to create sensory deprivation + intermittent strobe and UV lighting (ref. thedarkart.org and www.subliminal.eu).

Separately, soundscapes were noted as valuable for navigation without sight, but can become irritating. A new ISO standard aims for more consistent soundscape terminology.

Peter Phillipson (left) leads a discussion

Bernard Berry (Berry Environmental) described noise and health work over decades, starting with noise assessments (during Bingo!) at the Farnborough Air Show, the Wilson Report, and many scales and criteria for aircraft noise e.g. PNdB and NNI, before Leq.

Disturbance to activities, stress, biological impacts and cardiovascular diseases affect health. Coping, a key factor, has its limits. Quality of evidence has been explored and more is needed. The EEA Technical Report 11/2010 indicates exposure reaction differences pre-1990 and post-1990, important for future predictions. Corrections are made for illness occuring without noise. Babisch looks at odds ratio (likelihood of Acute Myocardial Infarction) against traffic noise (UBA Report 2008). Odds ratio has also been plotted against aircraft noise. The WHO Report *Methodological guidance for estimating the burden of disease from environmental noise* 2012 gives recommendations for planning. These, and developing noise weighting curves, are being used in considering expansion at London airports. Monetising the adverse health effects of noise produces shocking findings, the numbers dwarfing NHS budgets.

Chris Driver-Williams (Security WSP), previously in Special Forces/ bomb disposal, emphasised the importance of observation. A "whodunit" video demonstrated our lack of observation. Examples of Police flagship 'Secured by Design' were shown.

Light is used in heavy security situations, for openness, searches, and CCTV (getting smarter at detecting unusual behaviour). OODA (Observe, Orientate, Decide, Act) and drive-through searches using millimeter wave and terahertz technology were explained. We risk mistakes (e.g. Jean Charles De Menezes at Stockwell Tube Station, farming at night in Afghanistan being mistaken for IED preparations). The role of smoke obscuration was noted.

White noise and loud music contribute to interrogation. Long range, high power sound sources are directed at protest groups. Stun grenades use both high sound levels and small bright particles. Sound and light are crucial in communications. Hearing damage is common amongst bomb disposal personnel who listen for the high frequency "crack" at detonation, to check that disarmament is complete.

Daniel Connolly, Senior Lecturer at Southampton Solent University, summarised change since Victorian classrooms. NSF has generated variety, including learning pods, more attention to open planning, including toilet areas (to fight bullying), noisy window controls, and rain noise. Impacts on short term and working memory have been studied by Philip Beaman (Reading University). Reading may not be disturbed by raised noise levels, but trials involving New York railway noise demonstrated adverse outcomes.

RANCH (Road Traffic and Aircraft Noise Exposure and Children's Cognition and Health) at Heathrow uncovered annoyance, poorer reading and increased blood pressure. Learning environments and teaching methods vary widely. As Dockrell and Shield introduced "babble" as background sound, pupils with special needs were worst affected by deviation from standards. In secondary schools, assessing 2,588 pupils with 93 questions, maximum noise disturbance occurs during reading and exams, mostly noise from outside classrooms. The Lombard effect leads to strain on teachers' voices. Pupil sensitivity varies. Those with multiple learning needs are most affected. Unsurprisingly, their reading and memory are poorer in loud conditions.

Matt Clark described the work of United Visual Artists, an award winning multi-disciplinary arts practice exploring our relationship with technology and creating phenomena that transcend the physical.

For Monolith, a brightly lit figure in a V&A doorway screamed increasingly loudly at approaching visitors, who stayed close and moved little – this proved noisy! For Volume, a platform containing a grid of monoliths emitting sound (by Massive Attack) and light allowed visitors to enter and modify output. Bravery to enter varied widely between cultures e.g. French were eager, Koreans more cautious.

Chorus used eight tall black pendula (emitting both a soundtrack written by Maria Calix and light), swinging back and forth. In Durham Cathedral, this seemed religious, but in Wapping, industrial. Momentum was presented in the Barbican's Curve Gallery using unnatural arcs of 12 Foucault's pendula, narrow beam lights and unusually light loudspeakers (designed by John Clarke) feeding disturbing sound – aimed at "messing with people's reactions". Visitor bravery varied. Design to construction took only four months. Discussion included how to choose collaborators and 'What Next?'

See **http://uva.co.uk/work**.

Discussion

Both the interactive effects of sound and light and acoustic/lighting designer collaboration were considered important. Ideas for influencing behaviour (e.g. power cables indicating energy use; lighting that induces people movement) were suggested. We are seeing poor uses of cheap LEDs. Joint research, combined acoustic/lighting labs and common efforts to attack grey restrictive regulation, were discussed.

Thanks were expressed to the SLL, to contributors, delegates and the Young Members, organisers and venue hosts for a day from which important messages will be spread.

The organisers: (l-r) Inessa Demidova (SLL), Peter Phillipson (SLL) Richard Cowell (IOA) and Ellen Harrison(IOA)

Initiative to provide professional practice guidance on planning and noise

Professional practice guidance on planning and noise (ProPG) is being prepared in response to recent changes in the planning system and requests from practitioners for additional technical guidance on the management of noise within the planning system.

The initiative is being overseen by a steering group comprising representatives of the IOA, the Association of Noise Consultants and the Chartered Institute of Environmental Health.

The guidance will be subject to peer review and wide consultation among members of the relevant professional bodies. It is anticipated that it will be published in its final form early in 2015.

Its preparation responds to recent developments in the field, such as the National Planning Policy Framework, Government Planning Practice Guidance and Noise Policy Statement for England. The drafting is being undertaken by Colin Grimwood.

The aims of ProPG are to give good practice advice to local planning authorities in England and to developers' professional advisers on the application of the land-use planning process to encourage good acoustic design.

The initial focus will be on new noise sensitive development, in particular housing. However, similar advice on noise generating development may follow in due course.

The steering group is appealing to members to provide information that will ensure that ProPG reflects current practice, in particular:

- Examples of Supplementary Planning Documents (SPDs) on noise that have been produced under the new post PPG24 planning regime
- Examples of good acoustic design in new residential developments, including both individual building and larger scale measures
- Examples of decisions by planning inspectors relating to the consideration of noise in new residential developments that have been made under the new planning regime.

For full details of the initiative, including where to send examples, go to **http://goo.gl/ewKcZc**

New technology for engineering noise control

By Malcolm Smith and Russell Tipping

Nathan Thomas presenting his paper

In July the Noise and Vibration Group held a one day meeting entitled *New technology for engineering noise control* at the Royal Society, London. The meeting was specifically focused on noise control used within large process and petrochemical plants, and the speakers reflected the diversity seen within this particular speciality, ranging from the Environmental Agency and plant designers to manufacturers of noise control equipment.

As with previous NVEG meetings, the delegate turnout was high, filling the Mercer Suite. As with the speakers, the delegates all came from a range of backgrounds, all eager to listen and participate in the final session, an open discussion.

The opening presentation was given by Tony Clayton and Jon Tofts (Environmental Agency) and entitled *The Environmental Agency's approach and expectations to noise control*. The talk was divided into two main sections; the first giving a brief overview of permits and regulations, and the second describing a range of case studies. One of the main talking points was the Environmental Agency's move away from specific noise limits, and instead requiring the use of Best Available Technology (BAT) and Appropriate Measures (AM). The talk went on to discuss in more detail the concepts and application of BAT and AM, before finishing with some examples of past agency cases, these reflecting the wide ranging scope of the agency.

The next presentation was given by Nathan Thomas (Xodus), who gave a short talk on Xodus' *Approach to noise control prioritisation*. The talk began with a summary of the drivers behind the choice of noise mitigation options for an industrial site. This was followed by a case study, considering a scenario where an existing plant was to be expanded. This highlighted the need to consider not just the mitigation options applied to the new plant but also the possible gains in retro-fitting mitigation to the existing plant. The talk concluded with an insight into the importance of cost benefit analysis.

After a short coffee break, Malcolm Smith (ISVR) gave a presentation on *Control of aerodynamic noise sources in fans, jets and valves*. He started with a summary of all noise generation mechanisms associated with fans and turbines. He then went on to outline current research by his co-author Professor Phil Joseph (ISVR) on the application of serrated trailing edges and leading edges to reduce broadband noise from the fan blades and guide vanes of aero engines. Malcolm closed by suggesting that although the noise mechanisms and concepts are well understood by aero-acousticians, this knowledge may not be as widely understood within the industrial acoustics world.

The final presentation before lunch was given by Simon Stephenson (Xodus) and documented his personal experience in *Noise control techniques for electrical substations*. He opened with an overview of the issues associated with substations, with particular attention paid to the dangers involved when working close to high voltage equipment. Simon went on to discuss the noise generation mechanisms associated with the transformer itself, which in part can be attributed to magneto-restrictive forces with in the transformer core. Following this, he detailed the issues with buildings, enclosures and some examples of specific structure-borne sound problems. The presentation concluded by discussing the resonance issues found in Gas Insulated Systems (GIS), a system which allows high voltage cables to be laid in close proximity.

The first session after lunch saw Malcolm Smith (ISVR) return for a second presentation, which took the form of a case study entitled *Transmission of exhaust noise from a marine gas turbine*. The presentation began with a review of the transmission P12

◀P10 paths by which the noise is radiated outside the duct and how these can be modelled: mass law transmission driven by the acoustic field inside the duct, and resonant mode transmission forced by the turbulence in the flow. The presentation outlined a programme of scale model tests, analytical modelling, aero-acoustic scaling, Finite Element and Boundary Element modelling that had been performed to understand the differences in noise breakout between a test bed exhaust collector and a production duct.

The final presentation was given by Paul Williams (AAF) and discussed his recent work in *Improving predictions of gas turbine exhaust silencer performance*. The presentation covered an initial summary of the types of dissipative silencers available, the test methods used to test the transmission loss and the effects of the high temperature exhaust on the absorption material. Paul concluded with a summary of results and a design process method that can be implemented to ensure the correct and most cost effective silencer is installed.

Following the presentations, the final session of the day was an open discussion, initiated by the question: "Are there any new technologies out there?" This question was answered by a free flowing debate, covering topics such as:

- sonic crystals and their use as noise barriers
- the possible use of recycled materials for barriers and its impact on the sustainability of projects
- elastomeric foams as an alternative to mineral wool for pipe insulation and its ability to prevent under-insulation corrosion
- possibilities and use of active noise control within an industrial setting.

The day's speakers assemble for the final session

In general the day was very successful, reflected in the good delegate turnout, the lively discussion during breaks, the open discussion and the positive comments given in the feedback forms. The meeting organisers (Malcolm Smith, Simon Stephenson and Russell Tipping) would like to thank all of the speakers and other contributors for volunteering their time and experience.

The acoustics of organs and the buildings in which they are housed

By Mike Wright

In July the second Musical Acoustics Group (MAG) one day meeting of 2014 was held at the Duke's Hall, London, which is the main concert hall for the Royal Academy of Music. This was the first meeting to be held by the Institute at the academy since 1994 soon after the building underwent a major refurbishment. That meeting focused on acoustic work undertaken by Bickerdike Allen. However, the installation of an organ by J.L. van den Heuvel, in the style of those by the famous French builder Cavaillé-Coll, was undertaken at that time. This had replaced the original Norman and Beard organ of 1912 when the hall was built. The replacement organ of 1993 appears to have been less than successful and a new organ built by Orgelbau Kuhn of Switzerland was completed last year. It was generously funded by former Junior Exhibitioner Sir Elton John and Ray Cooper, also a past student of the RAM.

This meeting was attended by 21 delegates and following an introduction by the MAG Chairman, Michael Wright, seven presentations were given. The aim of the meeting was to "drill deeper" into how architects, acousticians, organ builders and consultants can successfully match a fine pipe organ to its acoustic space in the course of fitting out new performance buildings and refurbishing existing ones.

Delegates tune in to a presentation

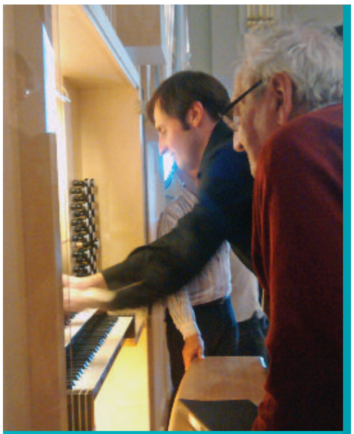
Organ consultant and past Chairman of the British Institute of Organ Studies John Norman considered the musical requirements, factors external to the instrument and the "tools" that are available to organ designers. He described a number of problematic installations. Saint Alban's, Holborn has a Compton organ that is widely regarded as the loudest church instrument in London. The 1996 Marcussen organ in Bridgewater Hall has proved to be too quiet, and the Palace of Westminster Grant Degens & Bradbeer organ of 1972 has had problems of treble and bass balance. He described the various musical requirements that can range from small house organs through to large church and concert hall instruments. He went on to explain problems that can result from the placement of the instrument, distance separations, reverberation times, the balance of acoustic absorption, the layout of the pipes and tuning temperament, including the sharp thirds of equal temperament.

Nicholas Edwards, Principal Consultant at Idibri, described the problem of organs housed in concert halls. These buildings are not usually acoustically ideal for pipe organs. He described the work involved to achieve an excellent environment in the Royal Opera House, Muscat and the features that enable an organist to exploit this unusual acoustic. He drew comparisons with other halls including the Meyerson Center, Dallas, the Concert Hall at Kazan, Tartarsan and Symphony Hall, Birmingham.

Alan Woolley then presented a review of pipe organ related research carried out with Murray Campbell at the University of Edinburgh over the last 12 years. This included a three year project looking at the importance of rhythm and timing as a means of achieving expression. This included methods of quantifying airflow through pallet opening and the effect on transients, the effect of 'pluck' on various speeds of key movements and whether the finger is in contact with the key. Studies comparing a model clarinet with a clarinet reed organ pipe showed distinct ▶

differences which may help to determine an optimum process for tuning reed pipes.

David Howard, University of York, described and demonstrated a new approach to designing a "Vox Humana" stop actually based upon human voice production. This stop is one of the oldest reeds commonly used in organs to varying effect, sometimes in a rather unconvincing way and not based upon anything that looks like a human vocal tract! David's approach was based upon building working models from actual human vocal tracts. This required the use of a CT scanner to obtain the model data and a 3D printer to produce the model out of a flexible material. Although the model was driven by an acoustic transducer and not by wind upon reeds, the results demonstrated drew considerable interest by delegates.


Christopher Stanbury demonstrates the new organ at the Duke's Hall to Dr Edgar Brown

After lunch, the session concentrated on the Duke's Hall and its organ. Architect Paul Wiseman and acoustician John Miller of Bickerdike Allen described the work they undertook on the building which is grade 2 listed. This included much that was previously described at the IOA meeting 20 years previously. Works were substantial and involved major changes to the floor, the barrel vaulted ceiling and gallery.The refurbishment works improved the sound clarity in the stalls by reducing the focusing of the barrel vault by achieving greater acoustic diffusion. New secondary glazing had reduced the traffic noise with the new ventilation system making it unnecessary to open doors and windows. The raised auditorium floor with vibration isolation bearings reduced vibration from underground trains which were also helped by contemporary work on track improvements. The introduction of the new organ by Orgelbau Kuhn required further work in very tight spaces. This included relocating the organ blower, some modifications to the backstage lobby and structural works to support the much heavier organ than the instrument it replaced.

The MAG AGM was held during the break and elected Christopher Stanbury (previously co-opted to the committee) and Sam Wise to augment the existing committee who remain.

The meeting concluded with Christopher Stanbury who explored the design of the new organ by briefly describing his impressions as an organist and acoustician. He highlighted its features that facilitate performance of a wide range of organ works, and evaluated the success of the builders in designing an instrument that can truly cope with all styles of organ music. He then demonstrated this in a live performance of a 21st century organ work, 'Homage to Fats' celebrating the jazz musician Eddie Harvey (1925-2012). This was given its first performance at the Duke's Hall on 10 November 2013.


Mike Wright

Moves to halt slump in workplace noise course numbers

By Keith Attenborough, Education Manager

In the 2014 spring/summer examinations for the Certificate of Competence in Environmental Noise Measurements there were 106 passes from 117 candidates at 10 accredited centres. This is fewer than for the presentation last autumn but, nevertheless, the demand for the course remains buoyant.

The low number of 17 passes out of 19 candidates for the Certificate of Competence in Workplace Noise and Risk Assessment confirms the continuing low demand for this course. Discussions are continuing to explore possible collaboration with IOSH who run a similar course.

The 13 passes out of 17 candidates on the Certificate of Competence in Building Acoustics Measurements confirm the fact that the demand may be sufficiently sustained to warrant delivery by another centre in addition to Southampton Solent University in the near future.

In 2014 15 of the 16 candidates for the Certificate Course in the Management of Occupational Exposure to Hand Arm Vibration have passed although, since it is offered only once a year at present, five of the 15 who passed took advantage of an opportunity to resubmit their case study reports within six weeks of the original examination.

The Certificate of Proficiency programme in Anti-Social Behaviour (Noise) which is offered in Scotland was not run by Strathclyde University this spring. However, Strathclyde has recently confirmed its interest in running the ASBA and Environmental Noise Certificates subject to sufficient numbers of candidates.

Building Acoustics Measurements

Southampton Solent University
Ainsworth M
Akers B E
Ashe J W M
Brown D C
Fuzellier M
McGurk R
Murphy L E
Potter C
Rayner B
Read D J
Speed M A
Tilbury E M J
Willcocks J F

Environmental Noise Measurement

Bel Educational Noise Courses
Bolderson S
Bowditch R J
Brunton M
Harper I
Kearns L
Lindop G E
McKenzie K E M
Redmond S J
Riddick C D
Sawers B
Smith D
Wardrope K
Will L

University of the West of England
Blackman J P
Butterwick J D
Buxton O S
Carpenter S N L
Erskine N
Hicks W A
James I J C
Keen E
Livock R D
Macadam F
Mullett M
Park C
Smallwood C J
Wilson R

Colchester Institute
Balding C
Bond D
Burge R A
Burns L
Carpenter C S
Cundall E
Faill J
Forsdyke N S
Glasscock N
Grace E R
Grey T L A
Ibrahim D
Ndarake E
Olose O
Strang W
Thirunavukarasu A

University of Derby
Bacon D A
Crowe T P
Duffy N J
Fitton S J
Hickman D
Lynam K
Reed L
Sammons A G
Schofield M R
Sullivan D
Wain S A

Leeds Metropolitan University
Ashe J W M
Clark A D
Gallimore S
Himsworth C
Imevbore S
Peeke M

Liverpool University
Ashburner J P
Ball C D
Dornan H E
Hadzhisotirou M I
Heath K
Keable D J
Taylor E
Wakeling D M

London South Bank University
Baker T
Callan C
Cox-Rogers J
Goodhand A
NESCOT
Jobs R
Keegan J
Kennedy S E M
Shaw B M

Shorcontrol Safety Ltd
Boyle J
Bradley P E
Coates J K
Conroy C J
Daly M
Farrell C
Fitzpgerald B G
Galbraith l
Hamilton H
Irvine Y E
Kirkpatrick T
McCullough J G T
McKenna C
McLaughlin M
O'Brien J
O'Grady P M G
O'Grady D
O'Hora E
Patton R
Rodham L

Southampton Solent University
Akers B E
Beer K J
Bouvet C
Burgess T J
Coulter T D
Dearman H V
Hale S D
Hima B
Pereira P S J
Tuora M J

Workplace noise risk assessment

University of Derby
Bowers P
Brown C
Dolan J
Elsey J
Howett M
May A P
Parry J
Ratcliffe P J
Smedley A J

EEF Sheffield
Baldock R K
Myers-John Q
Somers J

Shorcontrol Safety Ltd
Davidson A
McManus R
O'Connor B
Spencer J L

Management of Occupational Exposure to Hand Arm Vibration

Institute of Naval Medicine
Barron R S
Caulfield A
Chapman A L
Clayson C
Culley P
Gaze J P
Hensellek S
Hornby P I Hughes M D
Nolan A P
Tamcken M J
Thomas H
Wallace A J
Webster I M
Westlake S M

Nearly 80 more membership applications approved by Council

Seventy-eight applications were approved by Council in June following the recommendations of the Membership Committee.

Of the total, 55 applications were for new or re-instated membership. The remainder were for upgrades.

FIOA
Mike Lower
Rick Methold
David Sharp

MIOA
Peter Beke
Franco Bertellino
Stephen Byrne
Craig Cloy
John Edhouse
Edward Elbourne
Stephen Fairfield
Rebecca Fallon
Dan Fitzgerald
Robin Honey
Gareth Hooper
David Hughes
Pyoung Jik Lee
Stuart Lyness
Helen Makewell
Sandy Marshall
Andrew Milton
Fraser Poxon
Christopher Rush
Martin Stevenson
Mark Underhill
David Wilson
Robin Woodward

AMIOA
Guillermo Alfaro Martinez
John Allen
Stephan Booi
Cesar Bou
Daniel Bradley
Peadar Carley
Paul Daly
Max Foster
Benjamin Gaten
Federico Gottardo
Brian Heffernan
Cameron Heggie
Michael Hills
Ye Ji
Perttu Laukkanen
Rowina Long
Josebaitor Luzarraga
Gregory Minns
Luis Morgan
Phill Moxley
Gerry O'Brien
Mark O'Donovan
Peter Richardson
Andrew Ridley
Jonathan Roberts
Colin Roche
Diana Sanchez
Adam Scott
Ashley Shepherd
Russell Smith
Christopher Smout
Konstantinos Sotirakopoulos
Louise Stewart
Shane Sugrue
Emily Tilbury
Anthony Trup
William Wigfield
Richard Wilson
Alex Woodfield

Technician
Simon Beanland
Shelly Cameron
Liam Elliott
Michael Flannagan
Ria Monckton
James Pearson
Steven Reynolds
Alexander West

Affiliate
Martyn Parker
James Spencer

Student
Cesar Bustos
Joshua Dunham
Graeme Littleford

Some thoughts on noise and planning in the new era

By Tony Higgins

At a time when the debate over measurement or prediction affects many aspects of assessment for future noise impacts, the Measurement & Instrumentation Group reviews the best approaches to finding appropriate solutions. One area that has become less clear in recent times is planning applications, and in this article, these difficulties are highlighted and some guidance offered.

Obtaining planning permission in light of the recent changes to planning policy has arguably become easier for developers, particularly with the planning policy favouring sustainable development. The same cannot unfortunately be said for those consultants and local authority officers attempting to quantify, qualify and mitigate the acoustic issues surrounding some new developments and demonstrate the sustainable credentials of applications.

The loss of PPG24 Planning and Noise (PPG24) as a planning tool (and the recent consultation on proposed changes to the ubiquitous BS4142 standard) appear to have left something of a vacuum with no definitive standards, and variance in how remaining guidance is to be applied. The result is an acoustic no man's land into which we all trespass in an effort to seek a reasoned way forward. It might help therefore to review what there is to assist both consultants and local authorities to help properly evidence the impacts of/on new development.

The planning process

It is perhaps firstly incumbent upon us to recognise what the planning process actually is. Planning consent is sought to enable land owners to formally change land use, or develop within an existing use for profit (be it economic, social, or environmental). Such consents therefore are measured by Local Planning Authorities (LPAs) in light of local needs to ensure that they are consistent with local need and will not adversely impact on the public arena.

Each administrative planning area has to have regard to the National Planning Policy Framework 2012 (NPPF) which is national guidance, and is required to have its own Local Plan, and then, dependent on local need, may have subordinate documentation with increasing levels of detail for specific types or styles of development, e.g. Development Plan Documents (DPDs) which inherently provide more details on either preferred locations for development or action plans, and Supplementary Planning Documents (SPDs) that normally provide specific advice on thematic or site specific topics (such as expected noise controls, or design criteria within conservation areas etc. (see Fig 1. Planning Policy Schematic).

The overall aim of the planning documents is to encourage and support appropriate development in areas of need, and protect against/discourage unacceptable development that is likely to cause concerns. In both cases it is essential that (where necessary) planning applications are supported with robust data to support the application so that planning decision makers have an appropriate level of comfort to ensure that the decisions made are consistent, and based on evidence. This brings us neatly back to appropriate standards and demonstrating that level of comfort.

P16 ▸

◀ P15

Assurance and noise standards for planning

Notwithstanding that individual LPAs will have differing policies and requirements, the loss of the national guidance PPG24 has meant that there is a lack of detail as to how to assess the impacts of noise caused by or on a development. In most cases it is appropriate to contact the LPA and ask what methodology they require (typically this means talking to the local EHO), and then carrying out the assessment on that basis. However, such impact assessments still need to be grounded in good science, law or adopted planning policy.

In most cases the agreed assessment methodology will be determined by the potential noise impacts. For the consultant the job is to demonstrate the overall noise impacts are in line with the agreed policies, referencing (where possible) local and national standards as appropriate. As the local authority the job is to verify and validate that the submitted data provides the level of assurance necessary so that local decision makers can approve applications with comfort and for reasons that are defensible in the face of local criticism! Remember that local decision makers will rarely have technical knowledge of acoustics and as such this should influence how submitted data is produced.

It is sometimes the case that any planning application requiring the services of acoustic consultants will be controversial. On that basis it should be clear that most decision makers will want the greatest levels of assurance possible to deal with public perceptions and expectations see Fig.2. (cf. PPC/EPR relates to regulatory controls for some industrial premises involved in environmental permitting which is often relevant for waste sites, scrapyards etc.).

Which brings us to the question of how that level of assurance is provided. The answer is that the principle that, for new development, no one should be expected to live on the cusp of nuisance, and that, where possible, the precautionary principle should apply. In order to demonstrate both of these things, acousticians use the (hopefully agreed) standards.

Helpfully, the standards available are those that are already well understood by acousticians:

- Regulatory Guidance – Control of Pollution Act 1974 codes of practice e.g. Noise from Ice Cream Van Chimes (recently revised). Environmental Permitting legislation etc.
- National approved standards – e.g. BS4142:1997 (in review), BS8233:2013, BS5228:2009 etc.
- Codes of practice e.g. ETSU-R-97 (and the recent clarification documents issued by the IOA available from **http://www.ioa.org.uk**)

Unfortunately this isn't the entire story. Whilst the NPPF directly (paragraph 123) references the Noise Policy Statement for England (NPSE, Defra 2010) which in turn introduced the concepts of NOAEL (no observed adverse effect level), LOAEL (lowest observed adverse effect level) and SOAEL (significant observed adverse effect level) levels derived from World Health Organisation Guidance; it did not specifically reference any of the above standards. It also recognised that the SOAEL is likely to be different for different noise sources, for different receptors and at different times. This leads directly to the principle aims of the NPSE:

The first aim: Avoid significant adverse impacts on health and quality of life from environmental, neighbour and neighbourhood noise within the context of Government policy on sustainable development.

The second aim: Mitigate and minimise adverse impacts on health and quality of life from environmental, neighbour and neighbourhood noise within the context of Government policy on sustainable development.

Conclusion

It is suggested that, in practice, the two aims noted in the NPSE are substantively equivalent to the two levels outlined in Fig.2. Those levels are themselves able to be demonstrated by use of the standards noted above. It should be remembered that for planning purposes the key is demonstrating compliance to provide the right level of assurance to decision makers, as a consequence the following advice might be applicable:

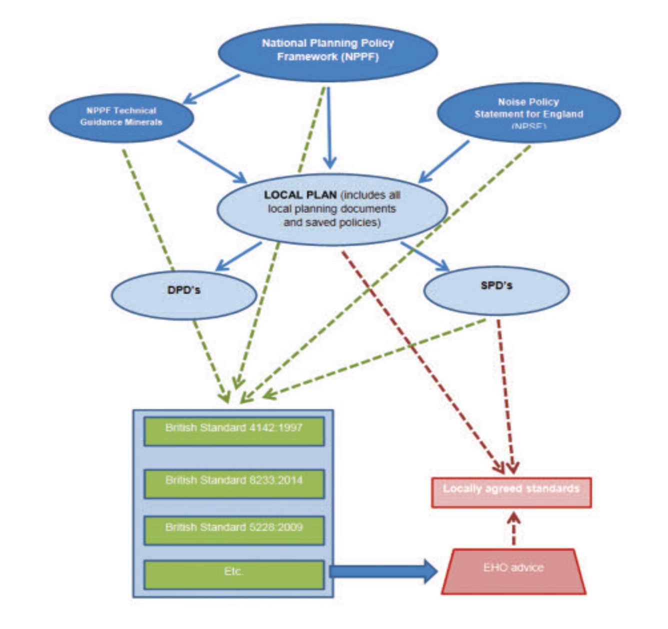


Fig.1. Planning Policy Schematic

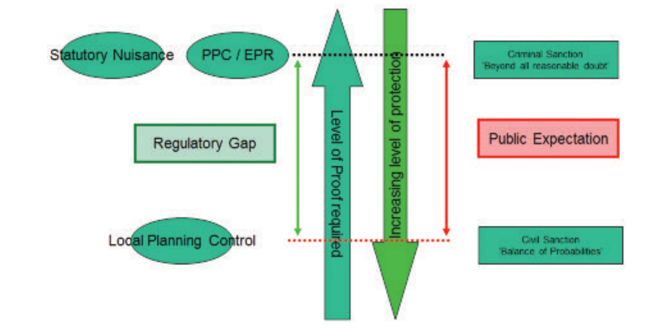


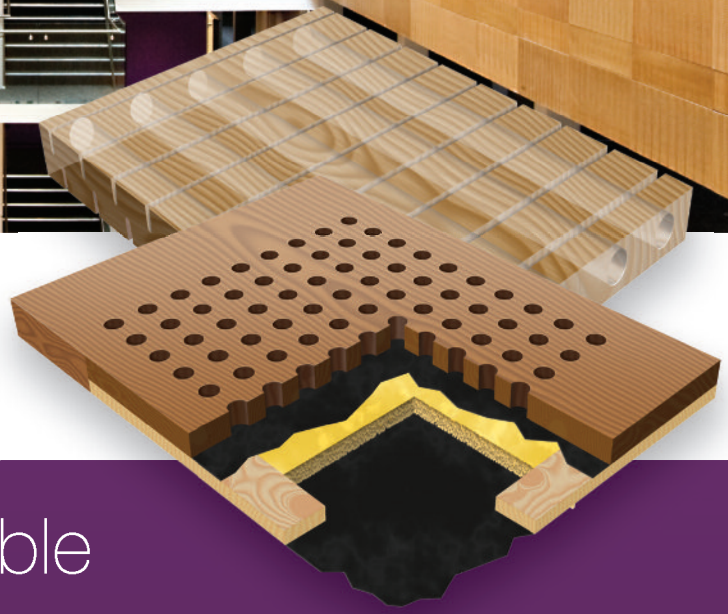
Fig.2. Planning practice and level of assurance

- Ensure that the means of demonstrating the environmental impact is agreed between consultant and LPA (or EHO as necessary)
- Ensure that the noise environment is properly characterised in terms of level, frequency (of operations), duration, etc. so that it can in turn be properly modelled for its impact.
- Ensure that appropriate standards are used, ideally defaulting to specific standards if they are available.
- Produce results in a manner that is clear and concise, with a summary that is capable of being easily understood by non acoustics professionals or laymen.

It should also be remembered that the NPPF paragraph 123 recognises that businesses should not be unduly affected by proposed new noise sensitive development and that the policy recognises that areas of tranquillity should be preserved.

In general LPAs should approve planning applications that can prove they are sustainable, and do so without delay. Acousticians and planning officers therefore have to decide on how sustainability can be best demonstrated.

Tony Higgins has more than 20 years' experience dealing with environmental noise and planning applications both as a regulator and as a consultant, including providing evidence at courts and planning inquiries. The observations made are his opinions on the increasingly complex relationship between noise and planning and practical advice on how to minimise the potential for friction between applicants and planning authorities in securing planning permissions.



Excellence in acoustics showcased at annual ANC awards

The second ANC (Association of Noise Consultants) Awards were held in June at Crowne Plaza Hotel in Birmingham. The awards promote and recognise excellence among UK acoustic consultants and are intended raise the profile of the acoustics industry.

The four awards were: environmental acoustics (sponsored by Brüel & Kjaer); architectural acoustics (sponsored by Ecophon); transportation noise control, (sponsored by IAC); and sound insulation (sponsored by Robust Details).

They were presented by Sarah Cruddas, former BBC science correspondent now reporting for Sky News and ITV.

Environmental acoustics

Winner
HS2 – sound demonstrations
Arup Acoustics
HS2 is a nationally-significant project, high in the public's awareness. The UK has very little existing high speed rail, and very little railway with noise mitigation. Hence the public has almost no experience of what the project will sound like. This understandably increases public concern about potential noise impact. This is the first time state-of-the-art 3D auralisation has been used on such a large infrastructure project to engage with stakeholders, inform design, and aid decision-makers. This enables people to decide for themselves what the impact of the proposals might be.

The demonstrations have been played to leaders of community groups, MPs and central government officials. Most importantly, an estimated 25,000 people have heard what HS2 will sound like in their community, and are now better informed about the character, level and impact of high speed rail.

The judges were impressed by the practical and extremely useful nature of this project which provided a means to demonstrate noise in a way the general public would understand. It was an approach that others should adopt and the engagement with those affected was a good example to follow on similar projects.


HS2

Highly commended
Wind turbine amplitude modulation: research to improve understanding as to its cause and effect
Hoare Lea Acoustics

Commended
Calculations of noise levels from road and rail sources for END round 2 mapping
Hepworth Acoustics

Architectural acoustics

Winner
Winsford E-ACT Academy
WSP Acoustics
This 12,500m2 new build school for 1,700 pupils had to be delivered to a budget of £18.1million with a contractual requirement to achieve all relevant legislative and regulatory requirements, Building Bulletins as well as a BREEAM rating of "very good". The acoustician played a proactive role in achieving the acoustic contractual requirements stipulated on this project, without compromising quality, performance or budget.

The judges noted that a range of acoustic solutions had been employed and they were very effective in difficult spaces with a limited budget. It was most encouraging to see the integration of acoustics with the design from the earliest stage which had resulted in a successful acoustic environment being created. Talking to the architect at an early stage was an innovative element of this project and an approach which should be adopted wherever possible.

Highly commended
Fundacion Calouste Gulbenkian, Lisbon
Arup Acoustics

Commended
Radegund Hall, Coleridge Community College, Cambridge
Max Fordham

Transportation noise control

Winner
Ground-borne sound and vibration from trains
Arup
HS2 project is the largest implementation of a ground-borne sound and vibration prediction model in the UK. It is also the first time a project has implemented a method to predict ground vibration from trains in revenue service at speeds of up to 360km/h. Consideration of these speeds has led to a better understanding of the parameters that are most important to vibration generation and hence how HS2 can be designed so that it minimises the impact of ground-borne sound and vibration. P20


The Winsford E-ACT Academy


Predicting ground-borne sound from trains

◀P18 This project has for the first time developed an accurate prediction method for ground-borne noise and vibration which is able to extrapolate to train speeds greater than 300km/h by ensuring that the mechanisms that generate ground-borne vibration, such as wheel and rail roughness, are appropriate for the required speed range and by maximising the goodness of fit of the model with the available data at lower speeds.

The judges noted this work was pioneering as a model to predict ground-borne noise and vibration from trains in excess of 360kmh did not exist and were encouraged to see that input had been sought from an expert group throughout the model's development. The development of the model is a significant step forward in ground-borne sound and vibration modelling possibly discovering something that was unknown previously and so receives the transportation noise control award.

Highly commended
British Airways' east and west base ground running pens
Clarke Saunders Associates

Commended
Park House, London
Hann Tucker Associates

Sound insulation

Winner
Racecourse Estate, Sunderland
Apex Acoustics
The Racecourse Estate in Houghton-le-Spring is the largest residential Passivhaus scheme in the UK, built as part of a sustainable legacy. This was a pioneering development for the UK in terms of design and scale, delivering Passivhaus with a more traditional UK design aesthetic as well as a new approach to customer education and engagement.

The acoustic design is special for two distinct reasons: first, the performance achieved is of the highest quality – these may be the first dwellings to be measured in the UK to achieve the Class A categories for both sound insulation and ambient noise according to the acoustic classification scheme proposed under COST Action TU0901, now to be adopted as an ISO Standard. Secondly, the method used to assess the sound insulation design is highly innovative, original and offers powerful insight into the performance parameters; this method is transferrable to other design and testing assessments.

The Racecourse Estate, Sunderland

The judges noted that this project combined high performance thermal design with good sound insulation which offered a good way forward for sustainable development. They were pleased to see a post-occupancy assessment was undertaken and that ambient noise and noise from the ventilation system was considered. Using the latest information from the COST programme was an illustration of innovative and original thinking which helped this project to be declared the winner.

Highly commended
One Hyde Park, London
Clarke Saunders Associates

Commended
Saw Swee Hock Student Centre, London School of Economics
Arup

Engineers recreate the 'classic' sound of Formula 1 in London

Formula 1 fans still pining for last season's engine noise can now imagine the "old school" sound of a racing car driving down The Mall towards Buckingham Palace.

Acoustic engineers from 24 Acoustics have created a fantasy "blast from the past", producing an animated noise map of a Formula 1 car from 2013 driving through central London.

Until this season Formula 1 cars used 2.4 litre engines, but rules changes this year saw, to the consternation of many fans, the introduction of much quieter 1.6 litre engines.

Using data from one of last year's engines, 24 Acoustics' animated map takes a car for a drive towards Buckingham Palace before turning into the royal gardens for a royal cup of tea.

Formula 1 cars in 2013 produced noise levels in excess of 120 decibels in close proximity. The animation from 24 Acoustics is made up from a series of noise maps, each incorporating a unique speed, location and source noise level from the car.

The team at 24 Acoustics created more than 1,200 high resolution noise maps, comprising a total of 221 million data points, to produce the animation.

Steve Gosling, Principal Consultant, said: "For those reminiscing about the remarkable noise produced by previous years' cars, this animation will be a welcome demonstration of just how loud those engines were.

"The video shows real-time propagation from a very fast and loud source, showing how noise spreads in an urban environment and across open spaces."

To listen to what the Queen might hear go to **http://youtu.be/1yrmSQYlBOs**

A shot from noise map

Launch of Tunisian acoustics association

Tunisia has become the latest country to form an organisation for acousticians. The Tunisian Society of Industrial Acoustics and Vibration (ATAVI) aims to bring together engineers, professionals, researchers and PhD students working or interested in these topics.

Its targets are to:

- promote communication and collaboration between international and local communities involved in the fields of activities of the association
- organise meeting forums for the benefit of researchers, doctors, scientists, engineers and students to share and enrich their ideas and experiences in the field of interest
- organise conferences and seminars to promote science-based research and encourage meetings between professionals and researchers in the field of interest
- co-operate with other similar national and international organisations taking profit from their services to promote exchanges in research fields and serve the community in general
- promote education and research activities oriented to experiments in the fields of engineering, technology and science.

It is now planning its first conference, on industrial acoustics and vibration, in 2016.

For more details go to **www.atavi.org/en**

Safety chiefs in major crackdown on construction site noise risks

A national targeted inspection focussing on health risks for construction workers saw enforcement action taken at one in six of hundreds of sites visited.

During a concentrated two-week period of proactive inspections, the Health and Safety Executive (HSE) demanded improvements, and in some cases put an immediate stop to work activities, where they fell short of expected standards.

Inspectors focussed on significant health risk issues, such as respiratory risks from dusts containing silica materials, exposure to other hazardous substances such as cement and lead paint, manual handling, noise and vibration.

Final figures have yet to be confirmed, but conditions were so poor in some situations that the work had to be stopped on at least 13 occasions.

A total of 560 sites were visited and enforcement notices were served at 85 of them. Thirteen Prohibition Notices were served (where certain work or practices must be stopped until improvements are made), and 107 Improvement Notices. A total of 239 health-related Notices of Contravention were served at 201 of the sites.

And as the result of another crackdown on poor workplace safety standards, a Ramsgate company has been fined £20,000 and ordered to pay £49,149 in costs after one of its employees was left with a severe long-term disability following prolonged working with a range of vibrating machine tools and a further four employees of were also diagnosed with symptoms consistent with early stage Hand Arm Vibration Syndrome (HAVS).

Cummins Power Generation Ltd admitted at Canterbury Magistrates' Court a breach of Section 2(1) of the Health and Safety at Work etc Act 1974.

Workers must be protected from noise

40 years on – the past, the present and the future

As the IOA prepares to celebrate its 40th anniversary with a major conference at the NEC, Birmingham in October, its specialist groups have been looking back at key developments in their sectors over the past four decades and looking ahead as to what the future might hold. In this first series of reviews, we look at the work within Measurement and Instrumentation, Musical Acoustics and Noise and Vibration Engineering.

Measurement and instrumentation

Where have all the knobs gone? I think I can put my finger on it

By Ian Campbell

A safe and agreeable acoustic environment is now taken as a basic right by most people; and it is accepted that it is something that has to be designed; it can't just be left to chance. As a result we have a wide range of Standards and Regulations that control noise generation and transmission and all of these rely on relationships between subjective reactions to the acoustic environment and our ability to quantify that acoustic environment in meaningful terms. It follows that since the start of serious attempts to quantify acoustic parameters the understanding of the relationship between the subjective reactions to a given sound has advanced hand in hand with the ability to measure it.

The first serious attempts at standardising follow on from the Wilson Report in 1963. We saw measurements specified in dB(A), and first attempts at quantifying noise nuisance, motor vehicle noise limits, aircraft noise impact, etc. introduced. In turn this focused attention towards standardisation of the measuring instrumentation with the first sound level meter standard published in 1960 (IEC 123) followed in 1965 with the first precision sound level meter standard (IEC 179) which established the now accepted general purpose and precision measurement standards. The conical shape of the instrument to give the correct acoustic response was the innovation in these early days and it has been with us ever since. The key elements in the rest of the instrument are the microphone, active electronics and the user interface. Unlike the shape of the case these elements however have seen some significant changes over the years and this is also set to continue.

The very early sound level meters used either moving coil or piezo ceramic microphones, which were often selected devices from batches of mass produced capsules in order to obtain ones with the required frequency response. Their plus was low price but they suffered from stability problems and hence designers moved towards the air condenser (capacitive) design. This design was originally proposed in 1916 by Wente, and Brüel and Kjær started using a Danish design from Ortofon which had a 36 mm diameter. This design was optimised by Gunnar Rasmussen for measurement applications and by the late 1950s he had mastered the production process and Brüel & Kjær had its own 25 mm diameter microphone that had the aluminium diaphragm replaced by nickel to minimise corrosion and a new method of securing the diaphragm which offered further advantages. To extend the frequency range 12.5 mm models were introduced by several manufacturers and with improvements in materials and production techniques the sensitivity of the half inch units improved to match the old 25 mm design and this is now the "standard" microphone fitted to modern sound level meters. The only significant change was the advent of the electret or self-polarised microphone; this removed the need for the highly stable polarisation voltage to be generated in the instrument, hence saving cost, but originally at the expense of reduced low frequency response and long term stability. The standard measurement microphone protection cap has almost become the visual icon for a sound level meter. Acoustic professionals now have a wide choice of suppliers of these devices, and as a result prices have started to come down. In addition, there is also competition coming on the technology front with the introduction of micro electrical mechanical systems (MEMS) to microphone production. In these devices the active diaphragm is grown from silicon, still a capacitive device but the matching electronics can also be grown on the silicon substrate to give a low impedance output hence simplifying the preamplifier. These MEMS produced microphones are widely used in mobile phones and other high volume communications systems where stability and dynamic range are not so important; but development work is progressing and there are prospects for measurement devices in the future. MEMS is however very reliant on volume production and the start-up costs may be hard to justify for the quantities needed for measurement applications.

In terms of the active electronics in sound level meters the changes have been significant. In 1960 the big innovation was the availability of transistors to replace thermionic valves. As they were much smaller, required less power and were more robust they made hand-held instruments a possibility. However, even then it was necessary to use a thermionic valve to provide the impedance matching between the microphone and the rest of the circuits in the instrument; it was also necessary to select individual transistors from a batch to get the performance standards required. Towards the end of the 1960s the advent of field effect transistors allowed the thermionic valve to be replaced, but the chunky Brüel and Kjær connector between the preamplifier and the main sound level meter body stayed with us for several more decades. The early sound level meters would use between 10 and 20 transistors, with each instrument individually hand assembled and all they did was to measure sound level using either fast or slow time weighting. Operational amplifiers allowed the component count, and hence assembly cost, to come down. Some more dedicated integrated circuits allowed linear displays of dB levels and for dynamic range to increase from the original 10 dB to 30 and then to 60 dB using cascaded display scales, but it was still all analogue with a moving coil meter as the display. Digitisation first made an appearance with just the display replacing the moving coil pointer. First, there were the seven segment filaments, then the liquid crystal version which offered still lower power consumption, but to this day we still have the fast and slow time weightings that were originally developed to compensate for the limitations of the human eye and a moving coil pointer! All the time digital technology was improving and the Analogue to Digital (AD) converter moved in front of the RMS detector offering still further improvement in dynamic range up to 120 dB in a single span and hence the demise of the range control. Driven on by the volume audio markets digital audio chips became available to allow the raw microphone signal to be digitised with all the amplification, filtering etc. to be done in the digital domain. Once the signals are digital the wide range of post processed indices required can be performed in the instrument in real time making the transfer of data to secondary processors a thing of the past with the PC now being just an archiving and reporting tool for adding headers and courtesy information to a measurement report. There is, of course, a downside to all this progress, digital electronics often needs more power than its analogue equivalent, and as it can do more so we ask for more; and this places further loads on the battery. Even with the improvements in battery technology we are still having to put bigger batteries into the current generations of instruments to meet the power demands. For longer term measuring, getting to the equipment on site to recover data has also been supplanted: originally by the GSM modem that allowed you to recover the data over a mobile phone network, where the meter would even call you up if anything of note had occurred. Now we are linking to the Internet, even via the "cloud", so data is streamed to remote locations in real time. Continuing development of integrated circuits and silicon based MEMS microphones offers the prospect of building a sound level meter on a chip that could be very low cost. Digital communications and daisy chain technology would allow data to be collected automatically so we could be approaching the days of just sowing the SLM chips around a site and leaving them to report the numbers. As the location and orientation of the measurement microphone is important we would need to deal with the power supply and location problems; batteries are bulky and still only offer days and not months of autonomous operation.

The user interface used to be a series of knobs, switches and a moving coil display, but we have seen the display replaced from the seven segment devices to custom matrix LCDs that gave more information. Full digital displays followed that allowed dynamic real time displays of frequency spectra, electronic level recorder traces, and as much other information that could be squeezed onto the display which was limited in size by the need to have a hand-held device. Buttons replaced knobs and switches to select all of the functions that can now be produced, and the option of lots of buttons or complex nested menus have been tried by competing manufacturers. The next development was the use of colour in the displays to differentiate the different data sets being displayed and now we have moved into the area of the touch screen instrument and all the knobs and buttons have disappeared and you just poke the bit of information on the screen that interests you at the time. Implementing this technology has thrown up different options, a small target area on the screen with a need to use a stylus to select it or finger sized targets on larger displays. Some manufacturers have taken the view that a combinations of buttons and touch screens avoids excessive nesting of functions and allows quicker routes to the required data. The future of the human interface is harder to track as developments in respect of data transfer over the web are moving on a pace and are being accepted very quickly by the acoustic community. For sure we will see more interconnectivity but the need to see the data on site and make quick measurements means that local display and control will remain essential but backed up by remote control as and when required; but this does not rule out a tablet PC or similar with a communication link of some sort providing the readout and set up media. The conventional sound level meter shape established 50 years ago has stood the test of time and is widely accepted by the profession; it is just the overall dimensions that have shrunk a bit. In the heyday of the laptop the virtual instrument made a brief excursion into acoustics, but it soon became evident that it was not suited to field measurements and some of the manufacturers of these devices have morphed into conventional sound level meter suppliers. It would appear that the traditional sound level meter will be with us for some time to come.

The number one accessory for the sound level meter has always been the sound calibrator. In the early days these were electro-mechanical devices, the most amusing of which was the "falling ball" calibrator. In these a cascade of small ball bearings was dropped onto a diaphragm to produce a broad band sound level. These devices were manufactured and then measured to see what level they produced; but they were reasonably stable in a controlled environment. The electro-mechanical pistonphone on the other hand produced a good stable sine wave the sound pressure of which could be related directly back to first P24

◄P23 principles. The dimensions and stroke of the pistons along with the volume of the calibration cavity could be closely controlled and hence the level confirmed with a high degree of accuracy. They were, however, expensive and very dependent on the environmental conditions, but remained the primary field calibration reference for over 30 years. The cost element was addressed by the development of electro-acoustic sound calibrators, although these added the uncertainty of the sound generation (the loudspeaker etc.) to the environmental uncertainties of the pistonphone For the past 15 years, thanks to modern electronics, we have had a new generation of "smart calibrators" that can correct for volume loading, environmental conditions and the stability of the acoustic source giving performance that rivals, or exceeds, that of a pistonphone. But you need to "check the spec" as externally they all look much the same! A hangover from the old pistonphone days comes from their limited high frequency response; above 250 Hz. the pistons would tend to bounce and cause distortion, so we still have 250 Hz as the reference for microphone sensitivity even though 1k Hz is the standard reference for the weighting networks and most modern sound calibrators.

Where do we go from here?

The current situation is really of measurement overload as we can do so much, but the cost axes have changed significantly in two respects from the early days. First, the instruments were very expensive but the technicians were cheap, with a precision sound level meter costing around a technician year, whereas now a similar meter costs around a technician month. Now it is all about getting the labour out of the investigation, so real time report ready outputs are now what is in demand. Second, the most expensive part of a sound level meter for a manufacturer is the recovery of the development cost. In the early days a sound level meter design project would employ one engineer and one technician for just a few months but today it is many engineer years. Modern digital electronics hardware is fairly straightforward and is supported by large volume design projects in the computer industry which spins off many design tools and techniques that can be used to speed up the process. The key is then the software and the growing complexity of the measurement and post processing tasks that have to be included in the instruments. It is not uncommon for instruments to now include web servers, modems, GPS systems and cameras as standard equipment. Software has extended the range of applications to include building acoustics, sound power measurement, vibration measurements, etc, so the development teams are now dominated by the software engineers who, of course, have to be briefed by market-orientated engineers who really understand what it is that the clients need to do. It must not be forgotten that sound level meters are instruments primarily used for legal metrology; most people commission noise measurements because they have to, not because they want to. The attitude of caveat emptor (let the buyer be aware) that developed in the early days, where no one checked manufacturers' claims of performance, allowed some kit to be accepted in the market that was not really as good as it should have been. Claims that the meter was designed with the requirements of the standard in mind does not mean it complies with the Standards, or that having the A weighting as per the standard means that the rest of the instrument meets the requirements. The current procedures where manufacturers should obtain a pattern evaluation from a National Laboratory and have the instrument periodically verified by an approved laboratory to obtain a certificate of Calibration and Conformance are now addressing these problems. These arrangements are voluntary in most countries at the moment so there are still options for low cost market entry and acoustics professionals who use these devices to take advantage of capital cost savings should include the unverified claims of the manufacturers into their uncertainty budgets.

The arrival of mobile phone apps that make a wide variety of claims for measuring sound (and vibration) is unlikely to yield any precision measurements as things stand, although with a remote transducer, even this may render the separate instrument redundant. With communications links set to continue increasing in capability and complexity, and power sources increasing operating lifetimes, there is really no limit to the amount of data that could be measured and stored. Whether anyone will have the time available to analyse all this data is another question that will need consideration. There are still measurement challenges that need solutions, but in the last 40 years the change that measuring instrumentation has undergone is enormous. It took 20 years before the Institute of Acoustics set up its Measurement and Instrumentation Group, and since then the group has always tried to keep members of the Institute abreast of developments, and whatever changes do lie ahead, it will continue to try and bring to members' attention the latest information and developments in quantifying sounds of every variety. ■

Figure 1. Contrasting sound level Meters of the 1960s.
At the top the B&K 2203 the first meter to the International Standard and below Acos SLM 3 with limited functionality but to the same standard and cost only 10% of the B&K unit. Today B&K still exist and Acos do not.

Figure 2. How the equipment has shrunk.
On the left a typical time history analysis kit to obtain the L_{eq} and L_n values from a B&K 2203 in the 1970s. On the right one of the many modern sound level meter that will do the same and more!

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Advances in musical acoustics over the last 40 years

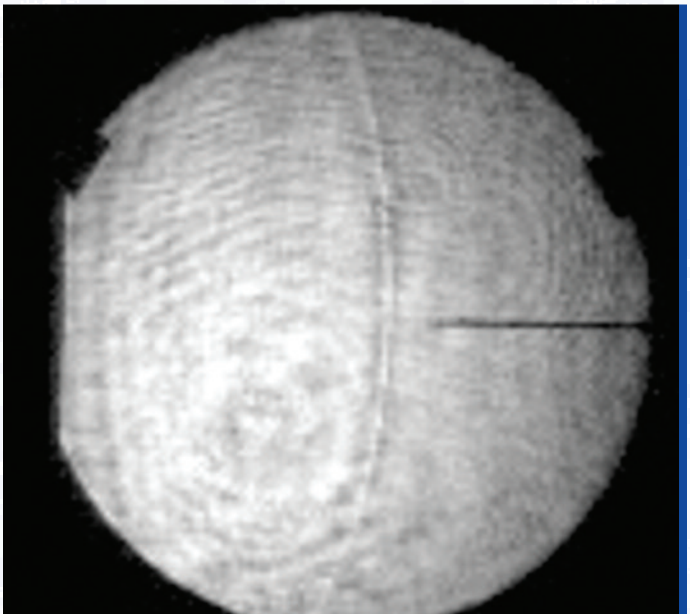
By Murray Campbell

Introduction

Musical acoustics could probably claim to be one of the oldest sciences, with experimental studies on the behaviour of musical instruments reported by followers of Pythagoras in the fifth century BCE. In the 20th century there were two periods of notably accelerated development in musical acoustics research, both fuelled by advances in instrumentation technology. In the decades immediately following the Second World War, analogue electronic equipment became readily available for non-military applications, and experimenters in acoustics were able to record and analyse the properties of vibrating systems using portable tape recorders, signal generators, oscilloscopes and chart recorders. A second revolution in instrumentation – the development of digital signal processing and computer modelling technologies – was starting to have a major impact on our subject at about the time that the Institute of Acoustics was founded in 1974. Over the last 40 years every branch of musical acoustics has benefited greatly from the increased accuracy and reliability of digital measurement techniques. Even more important has been the ability to develop models of specific musical instruments, including many of the subtle second-order processes which turn out to be vital for musical realism, and to derive from these models predictions of behaviour which can be tested against experimental studies. In what follows we look at a few examples of how this approach has illuminated our understanding of brass, woodwind and stringed instruments.

Brass instruments

Although trumpets, trombones and horns fall into the musical family of brass instruments, from the acoustical standpoint their important unifying feature is not the material of construction but the method of excitation. These instruments have a cup or funnel shaped mouthpiece at the entrance, on to which the player's lips are pressed. An excess pressure from the player's lungs causes air to flow between the lips; if the facial muscles controlling the lips are properly adjusted they perform a self-sustained oscillation, modulating the air flow into the mouthpiece at the lip vibration frequency.

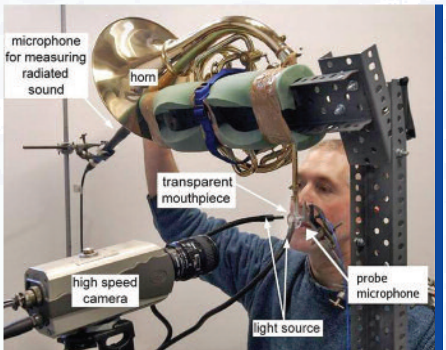


Schlieren image of a shock wave radiated from the bell of a trumpet

The development of accurate methods for measuring the input impedance of musical wind instruments in the 1970s led to a good understanding of the passive linear acoustics of brass instrument bores [1, 2], but the importance of nonlinear processes in determining the playing properties of brass instruments was gradually clarified over the next two decades. A seminal paper by Steve Elliott and John Bowsher [3] developed a model of the feedback loop governing the coupling between the mechanical vibration of the lips and the acoustical resonances of the air column in the instrument bore, providing a partial explanation of the way in which the timbre of a note played on a brass instrument becomes brighter as the loudness of the note increases. The nonlinear dynamics of the interaction between lip valve and air column was further investigated in a series of experiments using artificial lips [4].

In 1996 a remarkable paper by Avraham Hirschberg and colleagues, entitled *Shock waves in trombones*, appeared in the *Journal of the Acoustical Society of America* [5]. The authors pointed out that the amplitude of the acoustic pressure in a trombone mouthpiece can exceed 10kPa in fortissimo playing, and at this level linear acoustics can no longer adequately describe sound propagation in the instrument. As a sound wave travels from the mouthpiece towards the bell the wavefront steepens, and for a very loud note a shock wave develops inside the bore. The resulting almost instantaneous pressure rise corresponds to a timbre dominated by high harmonics. Although this timbre is described by musicians as "brassy", its strident brilliance is due not to vibrations radiated from the brass walls of the instrument but to nonlinear wave propagation in the air column. Subsequent work has shown that nonlinear distortion also plays a significant role in brass instrument timbres at sound levels well below the threshold for shock wave generation [6].

Whether the wall material of a brass instrument significantly affects its sound remains a matter of controversy. Richard Smith carried out a series of carefully designed experiments in the 1980s which showed that changes in the wall thickness of an artificially blown trombone caused measurable changes in the radiated sound, but he also found that professional players could not distinguish between otherwise identical instruments of different wall thickness or material composition when visual and tactile cues were suppressed [7]. In the last few years the research teams led by David Sharp at the Open University has further investigated the effects of wall material in artificially blown brass instruments [8], and researchers in Vienna and Florida have measured significant changes in radiation from trumpets and horns when wall vibrations are damped by sand [9]. The perceptual importance of these effects in musical performance is not yet clear.



Studying the lip vibrations of a horn player at the University of Edinburgh

Woodwind instruments

Flutes, clarinets, oboes, saxophones and bassoons are all members of the musical woodwind family. As with brass instruments, the common musical family name is misleading, since many of its members are not normally made from wood; however, unlike the brass family, the woodwinds do not share a common excitation method. In the flute, an air jet issuing from the lips of the player travels across an embouchure hole in the side of the pipe and impinges on a relatively sharp edge at the far side. The instability of the air flow results in an oscillation of the jet, diverting air alternately out of and into the embouchure hole. In the clarinet and saxophone, a slot in the side of the instrument mouthpiece is covered by a single reed – a thin strip of cane – which is bound to the external wall of the mouthpiece on the downstream side of the slot and otherwise free to vibrate. When the mouthpiece is inserted in the mouth of the player and the static air pressure in the mouth is increased, the reed is driven into self-sustained oscillation, modulating the air flow into the instrument. Double reed instruments like the oboe and bassoon operate in an analogous way, except that the excitation system consists of two thin cane reeds bound to a short metal tube which is inserted at the input of the instrument; in playing, the double reed is inserted into the player's mouth and air is blown through a small gap between the reed blades.

The essential physics of the sound excitation systems in woodwind instruments was understood by the mid 1970s, but many musically important features of the operation of these instruments are still the objects of active research. A complete model of the behaviour of a clarinet would involve the solution of the Navier-Stokes equation throughout the instrument, including the fluid-structure coupling to the vibrating reed and the radiation through multiple open side holes. This is still a formidable task even for a modern computer, although calculations of this type have recently been reported for flute-like instruments [10,11]. A more tractable approach, and one which has offered valuable insights into the underlying physical principles, has been to consider the instrument as made up of an acoustical lumped element (the excitation system) and an acoustical waveguide (the resonating tube). In an important paper published in 1983, Michael McIntyre, Robert Schumacher and Jim Woodhouse introduced a method for generating time-domain simulations of a wide range of instruments, including the flute and the clarinet [12]. This paper triggered the development of time domain physical models, in which simplified versions of the governing physical equations are solved to yield an output signal representing the radiated sound pressure. Some 10 years later Yamaha introduced the first commercial physical modelling synthesiser, based on the digital waveguide techniques pioneered by Julius Smith [13]. Although physical modelling synthesisers have not yet made a major impact in the music industry, the time domain modelling approach has been invaluable in scientific investigations of wind instrument behaviour [14].

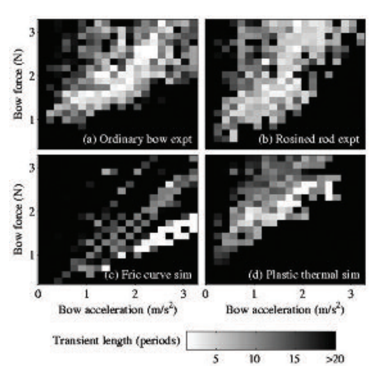

Mode of vibration of a guitar soundboard visualised using holographic interferometry

Stringed instruments

By the 1970s many studies had already been carried out on the modal frequencies and nodal patterns of violins and guitar bodies. The development of lasers led to the application of holographic interferometry to stringed instruments including the violin [15] and guitar [16], complementing improved modal analysis techniques and finite element modelling of body shells. P28

◀P27 TV speckle interferometry proved a useful tool for the study of stringed instrument resonances [17]. Complete models were developed for the guitar, including coupling of the strings to the body and radiation of sound [18].

Modelling of the violin proved a much more challenging task. A plucked guitar can be considered as a linear system to a reasonably good approximation. In contrast, a bowed string instrument like the violin contains a strongly nonlinear element in the sound generating mechanism, involving a slip-stick interaction between the bow hair and the string. A satisfactory model for the frictional processes in this interaction is still elusive, although considerable progress has been made. A crucial insight was the realisation that during the part of the cycle of vibration in which the string slips past the hair, the rosin with which the hair is coated to improve adhesion heats up sufficiently to soften and even melt, drastically changing its frictional properties. A friction model incorporating these thermal changes gives a much better match to measured bowing behaviour [19].



Guettler diagrams for a bowed cello string: (a) and (b) experiments with an artificial bowing machine; (c) simulation using conventional friction model; (d) simulation incorporating thermal effects

Another major advance in understanding the musically important aspects of violin performance was the recognition that aspects other than the quality of the radiated sound were of great importance to the player. This led to the introduction of the concept of "playability" [20], which includes the ease with which a note can be made to sound, the responsiveness of the instrument to subtle changes in bowing parameters, the tendency of some notes to develop the unstable sound described as a "wolf", and many other properties which affect the player's control of the instrument. Most of these features relate to the transient behaviour of the instrument, and therefore require to be modelled in the time domain. The late Knut Guettler, a virtuoso double bass player as well as an acoustician, made a valuable contribution to understanding the way in which the length of the starting transient in a bowed note relates to the force exerted by the bow hair on the string (perpendicular to the bowing direction) and the initial acceleration of the bow [21]. A plot of one of these parameters against the other is now known as a Guettler Diagram; only in certain regions of the diagram can notes be started cleanly.

Future challenges in musical acoustics

The science of musical acoustics is by its nature intimately bound up with the practice of music making, and progress in the subject relies on the constant exchange of ideas and information between acousticians and musicians. As computing power continues to grow, and techniques such as finite difference time domain modelling become increasingly sophisticated [22], we can look forward to real-time physical models of musical instruments which are sufficiently realistic to be of practical use to both performers and researchers. Such models could be used to test the perceptual significance of small changes in the design of an instrument, such as the thickness of a violin soundpost or the taper of a trombone mouthpiece backbore. They could provide sound sources for a virtual orchestra to test the acoustical parameters of a hypothetical concert hall design. In the hands of a gifted performer they could open new worlds of sonic possibilities through exploration of the parameter space.

Realistic physical models could also be tools in a process aimed at optimising the design of an instrument to meet predetermined targets for playability and timbre. The determination of such targets is in itself a major challenge for musical acoustics, since it is notoriously difficult to find robust correspondences between evaluation of instruments by musicians and objective measurements by scientists [23]. To break through this barrier will require not only more detailed experimental measurements and more powerful simulations, but also more careful psycho-acoustical studies under musically relevant conditions, aimed at a clearer understanding of the vocabulary, discriminating ability and musical priorities of performing musicians. ■

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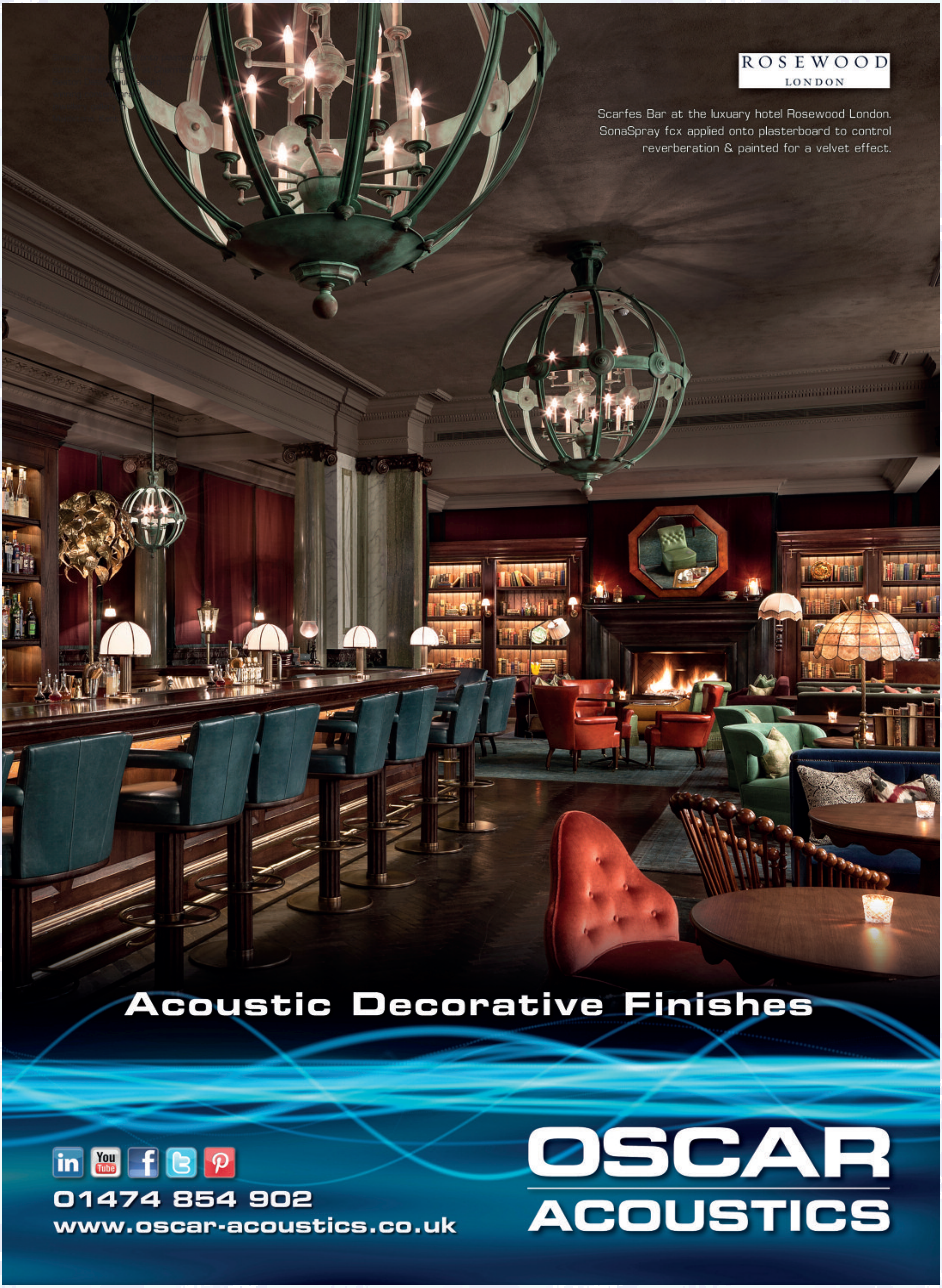
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ACOUSTICS

The changing world of noise and vibration engineering

By Bernard Challen, David Lewis and Malcolm Smith

Over the last 40 years, since the inception of the IOA, there have been many changes in the landscape for noise and vibration engineering. The driving forces for change have come from a mixture of legislation to protect amenity and health, commercial competition to improve the technology of products and, last but not least, the ever increasing expectations of consumers.

We travel in aircraft, trains, cars and ships; our factories are filled with the machines that produce consumer goods and industrial products; homes have vacuum cleaners, washing machines and fridges. We expect that the vehicles in which we travel and the equipment we use will be quiet and unobtrusive; we expect that the workers producing them will not suffer harm and we expect that their manufacture and use will not disturb our sleep or leisure.

To illustrate the changes to the world of noise and vibration engineering that have occurred over this period, we consider two specific areas of interest that typify the action of the legislative, commercial and consumer forces: workplace/industrial noise and automotive NVH.

Workplace noise

It had been known for more than 100 years that prolonged exposure to high levels of noise can cause noise induced deafness, but it was not until 40 years ago that there was specific guidance to alert employers to the risk associated with exposure to noise at work and the need to control it.

In 1970, W. Burns and D.W. Robinson published their report *Hearing and Noise in Industry*. This was a study of occupational hearing loss in approximately 1,000 workers and was one of the first studies to relate the risks on noise induced hearing loss to noise exposure. It led, in 1971 to the publication of ISO 1999 *Acoustics–Determination of Occupational Noise Exposure and Estimation of Noise-Induced Hearing Impairment* and subsequently the publication of the 1972 *Code of practice* for reducing the exposure of employed persons to noise. This code recommended reducing exposure to less than 90 dB(A) over an eight hour working day. However, it did not suggest that exposure below that level was safe hence implying further reductions should be sought.

In 1974, the same year that the IOA was formed, the Health and Safety at Work Act was published. For the first time a legislative framework was provided under which the recommendations of the 1972 Code could be enforced.

During the 1970s and early 1980s industry became more aware of the need to reduce noise in the workplace and to protect employees, but progress in reducing noise in existing workplaces was slow. In many industries equipment had been in place for many years and the design had not considered noise as a primary design criteria. Although some noise reduction could be achieved by implementing known "good practice" the primary control measure in many cases was personal hearing protection. What was needed was a way to estimate the noise levels in the workplace and define targets for noise control at the design stage of projects.

One of the first empirical models for predicting the effect of treating the walls and ceilings of industrial halls with acoustic materials was published by Friberg in 1975. Since then a range of approaches have been developed using diffuse/semi diffuse sound field theory (Kuttruff), imaging methods, (e.g. Jovicic,), method of images (Ondet and Barbry) and semi empirical/hybrid approaches (e.g. Hodgson). With these approaches it is possible to evaluate appropriate sound power specifications for machines, compare building geometry, finishes and layouts. However, such methods can only ever be approximate and, furthermore, even if the appropriate sound power specification for an industrial noise source is known that does not mean it can be easily achieved.

In the automotive industry, as discussed below, detailed analysis at the design stage of a new vehicle could be easily justified in view of the cost and production volume of the end product. However, in the manufacturing industries such investment was rarely justified and in the absence of specific legislation, machine suppliers were slow to reduce noise from their manufacturing equipment.

For workplace noise the legislative framework started to change in the mid-1980s with the publication of two specific EU Directives. The Council Directive 81/188/EEC of 12th May 1986 on the protection of workers from risk related to noise at work. This led to the implementation of The Noise at Work Regulations 1989 in January 1990 which was the first specific UK legislation designed to protect most employees from exposure to noise. This was followed by the Supply of Machinery (Safety) Regulations 1992 which implemented the requirements of the EU Machinery Directive 89/392/EEC. These regulations required manufacturers of machines to ensure their equipment was safe to use, to provide noise data and to reduce the risk associated with noise and vibration.

From the user's perspective, while measurement and diagnostic techniques improved during the 1990s, many machinery suppliers were still slow to adopt the principles of low noise design. With the pressure on costs, unless specifically requested by the purchaser, machine suppliers were reluctant to invest in specialist advice on how to reduce noise. It is suspected that this remains a problem to this day, hence the need for specific meetings (such as the NVEG "Buy Quiet" meeting) to raise awareness.

On a more positive note, the drive for increased machine efficiency, increased speed and automation has had beneficial effects on workplace noise. Automation and remote supervision of plant and processes enables the operator to work from a location at which noise levels can be controlled. To enable machines to operate more efficiently and at increased speed, machine motions can now be more accurately designed and controlled. Ensuring machine components and products accelerate and decelerate smoothly by removing discontinuities in motion profiles can have a significant impact on noise levels.

In the last 20 years there have been amendments to the machinery regulations but the basic requirements remain the same. The regulations relating to workplace noise were extended in April 2006 by The Control of Noise at Work regulations 2005 reducing the action values for daily personal noise exposure by 5dB to 80 and 85 dB(A). Exposure limit values were introduced and health surveillance is now a specific requirement where there is a risk to health. Hearing protection is specifically identified as a control measure of last resort, for use after technical or organisational methods of reducing noise exposure have been implemented as far as possible.

This legislative framework should provide the motivation to further reduce noise levels in the workplace. Innovations in measurement, analysis and noise control utilised in automotive and aerospace could be used to identify noise reduction opportunities in manufacturing equipment. However, machine suppliers need to be made aware of these opportunities and encouraged to utilise them by their customers.

Forty years of progress in automotive NVH

Whilst the basic principles of car and truck design remain the same now as they were 40 years ago, there have been major technological developments which mean that modern vehicles are far more sophisticated and refined than their counterparts of the early 1970s. P32

◀P30 The reasons for this are not too difficult to spot, just look at the price of fuel. In inflation-adjusted terms fuel costs today are some 10 times greater. The "great oil shock" of the mid 1970s is something that had a major effect on prices and the consumer view of "gas-guzzling" cars. Since that time the pressure of the world economy and usage on a finite fuel reserve continue, so prices rise in real terms. Overall, in the developed world our standard of living has increased over the period and one measure of this is that the demands of vehicle buyers ("market expectations") continue to increase, with quieter vehicles being high on the list of requirements. Although we tend to think mostly of the internal noise levels, the story of the past 40 years really starts with legislation.

In the early 1960s there had been concern over the noise levels experienced in cities, especially in London. A large-scale study was launched and reported in 1963 in the Wilson Report. This had a major effect on public thinking, indicating that the "noise night" had been dramatically shortened by the volume of traffic, late night and early morning, flowing through most areas of the capital. In remarkably short order, for Parliament, the first legislation requiring measured noise levels for vehicles on a standardised pass-by test were introduced in 1969. The UK standard was adopted as the basis for the ISO 362 drive-by test internationally. In the USA a modified SAE standard was later adopted, but the legislative control of the vehicle noise had been claimed.

Initially, the reactions to this legislation were focused on improved exhaust silencers and limiting engine speeds during the pass-by test. This developed into a specification battle over transmission ratios and the legislation. That process continues and the legislation continues to evolve, with tyre noise now the battleground, where noise levels of tyres must now be labelled. Engine designs have changed a little, with gross noise generators now avoided.

To put the vehicles of the 1970s in context, it was only just becoming common that heaters were a standard item rather than a luxury add-on, with the internal trim being a very basic specification. The evolution of internal noise has been a long and twisty road, driven almost entirely by the market expectations. The majority of mass-market passenger cars early in this period were mainly utilitarian, catering to a market where it was probably the first car that the purchaser had owned. The development of affluence and expectations has been accelerating at a rapid rate. One measure of this can be found in the growth in the kerb weight for the "simple" basic cars. An example might be taken in the VW Golf, which was introduced as a basic model for the mass market to replace the pre-war Beetle. The first version weighed in at around 860kg and was 3.70m long. (Even the first version was generously wide, a major selling point.) The latest version, introduced recently, weighs 1,220kg, unladen, and measures 4.35m long. Since it was selected as the world car of the year for 2013, it does represent the way things have developed, with the weight up 50%.

Acoustically, we have developed much more complex noise-reduction strategies for cars. The main structures are now studied in the early phases of design to optimise vibration modes and to minimise acoustic impact on the passengers. Both dynamic finite element analysis and statistical energy analysis are deployed to provide engineering design insight. Avoiding modes that "boom" at the engine and road speeds to be used, coupled with damping and absorption materials located in the most effective places have resulted in quiet and comfortable vehicles. In a similar way to crash modelling, the dynamics of the bodyshell can be studied in detail and optimised, depending on the powertrain mounting locations. There have been some developments in acoustic absorption and damping materials, but these are essentially minor refinements on older technologies.

Some of the changes in vehicle design have offered greater challenges to quiet and comfortable products. One of these that has taken decades to impact the UK is the adoption of diesel engines in passenger cars. The routes to the present solutions are partly in improved mounting isolation of the engine/transmission, together with good transmission loss design bulkheads, and partly through greatly improved diesel engine

Another challenge, that continues strongly today, is the downsizing of engines, often coupled with intensive pressure charging, in order to improve fuel economy. In the other direction we see a slow growth in the adoption of various forms of hybrid systems.

Technological advances have steadily reduced vehicle noise in recent decades

Although the use of electric motors is usually viewed as a noise reduction route, the results in many cases are a new set of challenges presented by the gear drives and other mechanisms that are required.

Most of the acoustics advances have been achieved through improvements in understanding that have led to better engineering designs. The tools that we use have changed dramatically, both in measurement and analysis. Some of these are reviewed here.

Microphones have changed in their distribution, especially for accurate measurement. At the beginning of this period the majority of these were of the polarised condenser type but the introduction of reliable electret technology that could survive getting wet and also reduced prices has changed things. One thing that has not changed is the need for repeated and reliable calibration, despite some people's optimism.

Perhaps the greatest change has been the introduction of digital technology, in both measurement and analysis systems. As others have observed, the whole modern usage of FFT mathematics is based on a series of coincidences. The initial work by Gauss was buried in Latin and partial publication in the early 1800s but later publication of their well-known methods by Cooley-Tukey in the 1960s coincided with the early spread of relatively low-cost digital computers such as the HP1000, which was customised to form the HP5451C FFT and modal analyser. The speed-up of frequency analyses was something like two orders of magnitude so that it became a temptation to do the analysis and think about it afterwards. Today FFT routines are embedded in many systems with the sampling rate and low-pass filtering precautions hidden from the operator, which works well most of the time.

Array processing is another digital activity that has found more civilian applications, including the critical engineering requirement for noise source location. This can almost replace the traditional lead-covering method, which could take weeks of testing. The acoustic imaging technology continues to improve.

Future power plants are tending to involve more complex designs with potentially multiple hybrid systems, offering challenges of understanding and analysis to the engineers responsible for the acoustic characteristics of the product.

That orphaned child, active noise control or "anti-noise", has also eventually come into serious commercial use, both as a tool in helping form better interior noise environments but also recently as an exhaust noise assistance, implemented by Eberspächer in Germany.

The future has to include a reverse of what we have been trying to achieve for many years – the generation of external vehicle noise. It will soon be a requirement that hybrid cars broadcast some kind of noise signal to allow those nearby to be aware that the vehicle is active and moving. The details remain to be decided!

The IOA Noise and Vibration Engineering Group

The members of the Noise and Vibration Engineering Group have a diverse range of interests which extends beyond the topics discussed above. This is reflected in both the composition of the NVEG committee and the topics of the meetings that have been organised in recent years. These include: workshops on the accuracy of different methods of sound power measurement; a meeting organised with HSE on the topic of "Buy Quiet – Design Quiet", which targeted machinery buyers to buy low noise machinery as a means of providing a commercial incentive for low noise design and most recently, a meeting on recent advances in the prediction and control of noise in industrial plant. NVH (Noise, vibration and harshness) sessions have been included at Acoustics 2011, Glasgow, Acoustics 2013, Nottingham, and at the forthcoming IOA 40th Anniversary Conference in Birmingham. It is through these meetings that the NVEG hope to promote the principles of good acoustic design leading, hopefully, to a quieter future at home, at work, when travelling and when we are at leisure.

Practical challenges with post completion measurements of the ETSU-R-97 simplified 35dB(A) planning condition for wind turbines

By Cameron Sutherland, Green Cat Renewables

Introduction

Experience to date is that application of the ETSU-R-97 guidelines' simplified 35dB(A) LA90,10min noise planning condition for wind turbines has proved difficult post-completion. This article seeks to evaluate some of the practical implications in the light of the IOA Good Practice Guide (IOA GPG), particularly the Supplementary Planning Note 5: Post Completion measurements (SPN5), based on recent experience of compliance measurements relating to this condition.

Background

The majority of wind turbine projects that Green Cat Renewables have provided consultancy services to over the last nine years have consisted of turbines in the size range 75m – 100m tip height, ranging from maximum power outputs of 500kW to 10MW. Enercon E48 or E70 machines have been a popular choice with developers for these projects.

In this context, it is no surprise that a large proportion have been consented with the simplified ETSU-R-97 noise condition. Variants of this condition are still widely used either for projects which can demonstrate that no sensitive receptors would be present within a 35dB(A) "noise contour", or as a "catch all" for properties not specified by background noise related planning conditions. Ironically, however, it is in the context of receptors being located comfortably far enough away in noise terms for the 35dB(A) fixed limit to apply that proving or disproving compliance with this noise condition becomes difficult.

This was particularly highlighted by a single turbine project which received a noise complaint from a receptor approximately 750m away for which the maximum ISO9613:2 prediction was 28.2dB(A) at 10m wind speeds of 8 – 10ms^{-1}. As is common in such cases, step one of the complaint investigation requested by the local Environmental Health Officer (EHO) was to demonstrate or refute that the 35dB(A) condition was being met, thus indicating whether or not actual noise levels were within the permissible range. Step two was then to investigate such other potential factors as difference between turbine and background noise levels, and levels of any amplitude modulation that may have been audible at the property.

For this receptor location, considering downwind directions only, the finally agreed maximum level of turbine noise derived from an extended measurement campaign was 33.8dB(A) at standardised 10m wind speed (v_{10}) of 8ms^{-1} with a similar value obtained for 9ms^{-1}. This was an unexpectedly high noise level with little apparent relationship to the ISO9613:2 downwind propagation prediction, despite using noise recording in this case to assist in filtering extraneous measurement data. Meanwhile, the complainant's noise diary pointed towards being annoyed at wind speeds below 8ms^{-1}, and it was clear from aural observation at the site that the complaint was most likely to relate to an amplitude modulation effect.

From this measurement, a number of limitations emerged about the potential to effectively use the 35dB(A) condition in practice and these are discussed below.

Variation of noise with wind speed

Figure 1 illustrates a typical site where the 35dB(A) condition has been assessed at a suitable, representative location within the property. The site in question was found to be a low wind shear site. In red is a third order best fit polynomial of turbine plus background noise level data, while the blue best fit line represents background noise only.

One consequence of low wind shear is that the noise data to wind speed gradient is steeper than for standard conditions. This can result in a higher spread of noise data within each wind speed bin resulting in a lower level of confidence in the trendline fitted through the data.

In the situation illustrated by figure 1, the signal to noise ratio (between the trendlines) remains less than 2dB

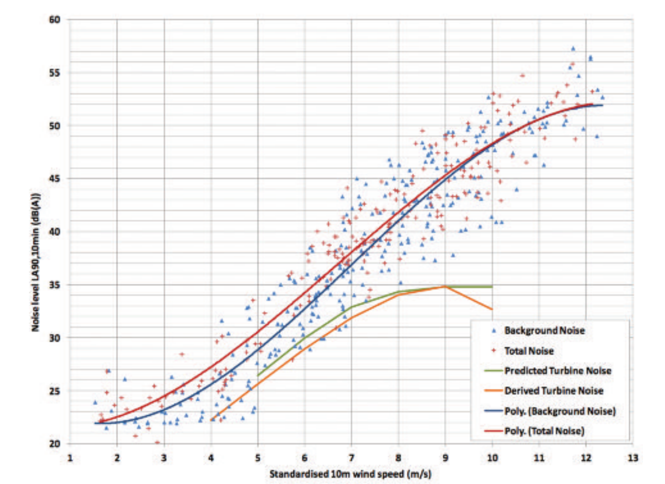

Figure 1 – Noise level variation with wind speed for a wind turbine site

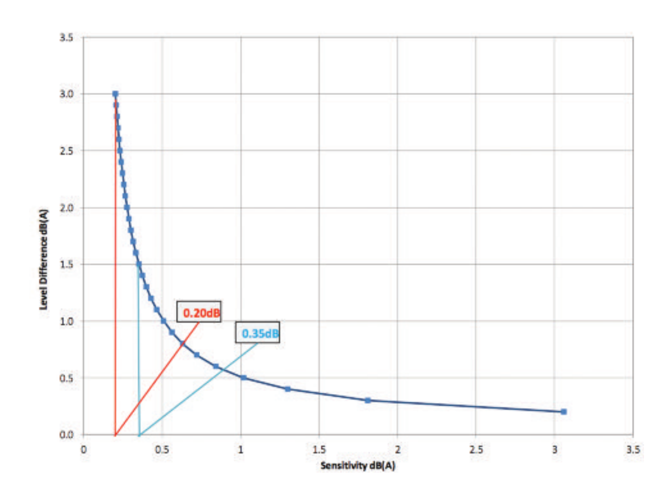

Figure 2 – Graph of level difference vs calculation sensitivity highlighting the effect of a 0.1db decrease in signal to noise ratio on derived turbine noise

throughout the wind speed range. In addition, background noise levels exceed predicted turbine levels throughout.

In fact, the IOA GPG anticipates the problem of proving turbine noise levels where background levels and level differences are low. SGN5 paragraph 2.4.8 states:

"…It should be noted, however, that where the shut-down noise approaches the operational noise, the level of shut-down noise has an increasing effect on the calculated turbine noise such than ***when the difference between the two is 3 dB or less****, it may no longer be appropriate to use this correction with any degree of accuracy and* ***some other method*** *of determining turbine noise in the presence of high levels of background noise may need to be agreed with the planning authority.* ***In the event that the typical background noise is greater than the turbine noise limit, and if the additional contribution of the turbine noise to the prevailing background is difficult to discern with confidence from the data, then it is likely that compliance with the ETSU-R-97 limits would be demonstrated.*** *In such cases where noise limits are less than ETSU-R-97 limits (e.g. apportionment of noise impacts due to cumulative impacts) compliance measurements may need to be undertaken in closer proximity to the wind farm to ensure background noise levels do not unduly influence the readings.* ***This may also be significant when determining compliance with planning limits such as the ETSU-R-97 simplified limit of 35 dB*** L_{A90} *since background noise is likely to be around this level or higher when the turbine reaches rated power, except under exceptional conditions."*

In the light of this, could we have any confidence at all in the turbine noise levels computed above?

Our experience is that derived turbine noise tends to follow prediction until background levels reach ~40dB(A) $L_{A90,10min}$, with results obtained at higher background noise levels tending to be far more variable. In the example given in figure 1, the developer "got lucky", because the results at wind speeds where the background was above 40dB(A) (8, 9 and 10ms^{-1}) ended up lower than 35dB(A) even though the signal to noise ratio between trendlines was <1dB(A). However, at lower wind speeds where the signal to noise ratio was at least 1dB and background noise levels were below 40dB(A), the derived turbine noise levels were fairly consistently around 1dB(A) below prediction.

Calculation sensitivity vs level difference

The above discussion requires more consideration of the appropriate signal to noise ratio liable to result in useful results. To evaluate a likely useful range of signal to noise ratios, it is instructive to look at what happens if the measured turbine plus background noise level is just 0.1dB(A) lower, reducing the level difference by 0.1dB(A). The effect is illustrated by figure 2.

The graph highlights that little confidence can be taken from measurement results where the signal to noise ratio is low – a signal to noise ratio reduction from 0.5 to 0.4dB(A) would result in a 1dB(A) greater estimate of turbine noise. If the background noise levels were 45dB(A) $L_{A90,10min}$ at standardised wind speed of 10ms^{-1} (a fairly typical value) the measurement of turbine plus background levels should only be a maximum of 45.4dB(A) for a turbine noise level of 35dB(A) – it is easy to see in that context how either measurement (both essentially measurements of background noise only) could reasonably be 0.1 or 0.2 dB(A) different from this. If the background was measured at 44.8dB(A) in practice and the background plus turbine noise was measured as 45.6dB(A), the calculated turbine noise would be 37.2dB(A) – an apparently significant breach of the planning condition.

A 3dB(A) signal to noise ratio, as desired by the SPN5 para 2.4.7, across the full wind speed range is unheard of from our own measurements. For a single Enercon E48 turbine, P36

P35 this typically requires a measurement to be around 240m away – the property in our original example was 750m from the turbine. So what is to be done?

Firstly, as figure 2 suggests, it may be pragmatic to accept signal to noise ratios of around 1.5dB(A) as these do not significantly increase the variation in the turbine noise levels derived. However, level differences of 1dB(A) or less would seem to be subject to much more significant error.

Secondly, as the 45dB(A) background noise level example suggested, is it really appropriate to "measure" the turbine level at all when the measured background noise reaches that level? At lower wind speeds, it is more likely to be able to estimate the "true" wind turbine noise levels and, in this scenario, it is surely more sensible to extrapolate these to the higher wind speeds using the relationship of noise to wind speed provided by the manufacturer?

Thirdly, if it is not satisfactory to apply the above logic, the only sensible alternative is to measure at a proxy location much closer to the turbine. This has the advantage that signal to noise ratios of greater than 3dB(A) are more likely. EHOs have, so far, been receptive to this approach.

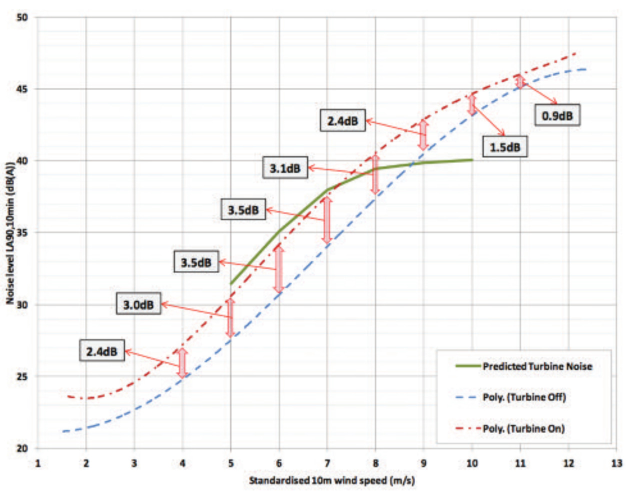

Figure 3 – Variation of noise with wind speed at an intermediate proxy location

Use of intermediate proxy locations

Figure 3 highlights the potential benefit of such an intermediate location.

The proxy location was chosen to lie on the 40dB(A) worst case prediction contour. As can be seen, a signal to noise ratio of 1.5dB(A) or greater was achieved at all wind speeds of interest. Meanwhile, at the mid range of wind speeds, background noise levels were largely below 40dB(A) and the level difference was sufficient to give a high level of confidence in the computed turbine noise levels overall.

However, proxy locations must be chosen with care. Moreover, if the measurement is a prelude to a complaint investigation, measurement should be carried out at the property from which the complaint originates. This leaves the only sensible solution to be to measure at a proxy location in parallel with a location at the property, adding to the cost of the measurement.

Consequences of not meeting the 35dB(A) condition

Figure 4 highlights the difference between wind speeds at which turbine audibility (and potential amplitude modulation effects) could be occurring, and those typically most critical for demonstrating planning compliance with a simplified 35dB(A) condition.

The foregoing discussion has already highlighted reasons why there is likely to be low confidence in the calculated turbine noise at the higher wind speeds. As a result, it is believed that projects are being asked to mitigate turbine noise levels where the turbine is apparently not meeting its 35dB(A) noise planning condition at wind speeds where the turbine isn't audible – this is unlikely to reduce any adverse noise effects at a receptor, will not satisfy any complainant and reduce financial viability of the project for the developer.

Practical concerns – standardised 10m wind speed derivation

A further practical difficulty for small commercial wind turbine projects with the 35dB(A) constraint is wind speed measurement. There are two aspects to this: firstly, obtaining a reliable v_{10} with and without the turbine operating that one can reasonably compare; and, secondly, dealing with turbines which reach rated power before $10ms^{-1}$ v_{10}.

The first part of the problem may not be entirely obvious since wind turbines have anemometry located at hub height. However, these wind speed readings are adversely affected by ▶

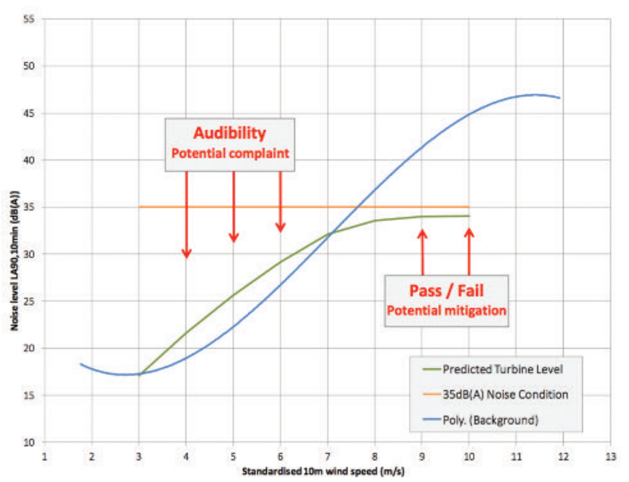

Figure 4 – Noise level v standardised 10m wind speed showing predicted turbine noise, the 35db(a) noise condition and a typical background noise profile

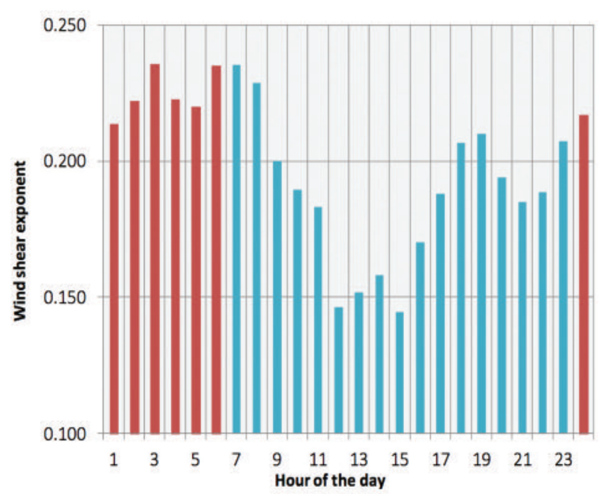

Figure 5 – Typical winter diurnal wind shear variation (with night-time highlighted in red)

the blades rotating in front of them. While wind turbine manufacturers make corrections for this, these corrections are in place when the blades are stationary, and so the wind speed readings when the turbine is switched off (as required during compliance measurements) are unlikely to be comparable with those made with the turbine switched on.

A more effective way of obtaining the hub height "wind speed" for the operating turbine below rated power is to look at the average power output. Any method that uses the power curve to derive the v10 with the turbine switched on is likely to suffer from the problem of power curve saturation prior to reaching 10ms^{-1}, particularly with the recent rash of 'de-rated' machines being used for feed-in-tariff purposes.

This still leaves the problem of obtaining equivalent data with the turbine switched off. While most large wind farm projects would have an onsite hub height anemometry mast installed from which a consistent hub height wind speed measurement could be obtained both with and without turbines operating, this is highly unlikely with the smaller projects subject to the simplified 35dB(A) planning condition. Moreover, small projects will often have much more limited scope for quickly installing a hub height wind speed measurement due to such factors as restricted land ownership and/or planning application boundaries, temporary planning permission being required for a mast and the costs associated with hiring wind masts, SoDAR or LiDAR equipment.

As a result of the above considerations and practical experience in the field, the following approach has been adopted to attempt to obtain credible and comparable v_{10}s:

- Install a control wind speed measurement ideally upwind of the turbine and property under investigation (a 10m mast can still be used effectively for this at low cost);
- Adopt the IEC61400-11 approach to deriving the relationship between power output and hub height wind speed with the turbine switched on. Temperature and pressure measurements are used, where available, to correct for air density.

With this approach, only a proportion of the power curve is used to avoid high scatter at cut-in wind speed or power curve saturation at rated power. For an Enercon E48 with 55m hub height, for example, the 'allowed range' translates to v_{10}s of 3.8ms^{-1} – 8.3ms^{-1}. For higher wind speeds, a correlation between the power curve derived wind speeds and the hub anemometer must be used.

- In contrast to the IEC61400-11 approach, the power curve derived wind speed data is correlated to the parallel set of 10m measured data. This then allows a 'true' hub height wind speed data set to be produced for the periods where the turbine is switched off. These can be consistency checked against the hub anemometer readings.

It is important to note that calculations are carried out for each wind direction (30° wide bins are commonly used) so that directional wind shear differences are accounted for.

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- These two sets of derived hub height wind speed data can now be "standardised" to 10m height using a roughness height of 0.05m.

The key point, in terms of compliance measurement, is that we now have two directly comparable wind speed data sets. This contrasts with the general method outlined by the IOA GPG and the IEC61400-11 method – in effect these approaches use different wind speed measurements for turbine on and off conditions.

Much time has been devoted in recent years to the treatment of wind shear in relation to noise assessment for wind turbines. It should be noted that the above method treats two of the three main areas of wind shear variation: wind direction and wind speed. Directional shear must be treated if a control wind speed measurement below hub height is used. Wind shear variation with wind speed is accounted for by the correlation of power curve derived wind speed and the control wind speed measurement.

The third main area of wind shear variation is time of day. In the context of the simplified 35dB(A) noise condition, it is important to recognise that wind shear is highest at night, as illustrated in figure 5, which shows a typical winter time diurnal wind shear profile.

A helpful suggestion of SPN5 (para 2.4.4) has been to direct 35dB(A) condition measurements to focus on 23:00 – 05:00 GMT, where wind shear tends to be highest and where the majority of extraneous noise sources are not present. 23:00 – 03:00 has used for summer periods because of the dawn chorus.

Conclusions

In conclusion then, experience to date with small-scale commercial wind turbine projects in Scotland is that establishing compliance or non-compliance with the simplified 35dB(A) planning condition is very challenging when noise levels are measured at the property itself, because of the distances and relatively low levels of turbine noise involved.

A potential solution to this problem is to increase the use and acceptability of intermediate proxy locations for noise monitoring. However, as mentioned, ensuring a robust proxy measurement can still prove problematic and may not eliminate the need to monitor at the property itself.

We have found the IOA GPG SPN5 para 2.4.7 has made little difference to the attitude of EHOs because they still require demonstration of compliance with the planning condition for all wind speeds even if signal to noise ratios do not justify any confidence in the results obtained, and even if the background noise levels measured far exceed 35dB(A).

Meanwhile, the IOA GPG's suggestion to monitor the 35dB(A) condition between 23:00 and 05:00 tends to maximise level differences and has generally been accepted by EHOs.

Generally, we have found the IOA GPG has helped to reduce the amount of time spent with EHOs discussing data exclusions and methods of establishing trendlines through data. It was also essential from a practical point of view that 10m masts could still be used for post-completion measurement, particularly in relation to cost and the need for measurement consistency when comparing turbines switched on and off.

Something that is not really touched on by the IOA GPG is the uncertainty treatment and how this could inform the EHO's view on compliance in marginal cases. In addition to consideration of typical measurement uncertainty factors, the key question would be: "*How confident can we be that the trendlines fitted to the measurement data are representative and equivalent?*" Even in cases where the turbine is being switched on and off on an hourly basis, there can be noticeable differences in the average background noise levels at very low wind speeds, where the turbine wouldn't be operating, for example.

It would be of great benefit if requests to vary background noise conditions from a fixed 35dB(A) to background + 5dB(A), or some other suitable background related condition were considered positively by EHOs simply because with such conditions it is less critical to correctly establish the actual noise level of the turbine.

Acknowledgements

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Digital emulation of the acoustics violin response: a tool for electric violin players

By Patrick Gaydecki of the School of Electrical and Electronic Engineering, University of Manchester

A highly integrated stand-alone system has been developed that processes the raw electrical output from an electric violin and produces an output signal which, when fed to an amplifier and loudspeaker, approximates closely the timbre of an acoustic instrument. The system comprises a very high-impedance preamplifier, a 24-bit sigma delta codec and a digital signal processor (DSP) operating at 590 million multiplications-accumulations per second (MMACs). The device holds in its memory up to fifty far-field impulse responses of wooden instruments, any one of which may be convolved in real-time with the input signal to synthesize the modified output signal. In addition, the device incorporates a suite of other functions to enhance the tonal quality of the final output. The user interface includes a set of navigator-style buttons and a simple display screen. Preliminary trials with a professional violinist have confirmed that the system improves significantly the tonal quality of the raw string force signal.

Introduction

Real-time signal processing based on both general purpose microprocessors and fast digital signal processors (DSPs) is a technique that emerged over twenty years ago, and is now widely considered one of the fastest growing application areas in the field of digital technology. Typically, the analogue waveform is first digitized by an analogue to digital converter (ADC), and the binary values are transmitted to a DSP device that performs a real-time convolution operation in discrete space using either a finite impulse response (FIR) or infinite impulse response (IIR) algorithm. The processed data are then sent to a digital to analogue converter (DAC) that outputs a filtered analogue signal.

Here is described a highly integrated stand-alone system, based on DSP technology, which has been developed to process the raw electrical output from an electric violin to produce an output signal which, when fed to an amplifier and loudspeaker, approximates closely the timbre of an acoustic instrument. The system comprises a very high impedance preamplifier, a 24-bit sigma delta codec and a digital signal processor (DSP) operating at 590 million multiplications-accumulations per second (MMACs). The device holds in its memory up to fifty far-field impulse responses of wooden instruments, any one of which may be convolved in real-time with the input signal to synthesize the modified output signal. This first stage convolution is realized as an FIR structure. In addition, the device incorporates a parametric equalizer, blender, mains filter unit and a gain adjustment function. The user interface includes a set of navigator-style buttons and a simple display screen. The device may be connected to a computer or tablet and controlled from a separate software package. Preliminary trials with a professional violinist have confirmed that the system improves significantly the tonal quality of the raw string force signal.

It is important to recognize, however, the limitations of this approach to electric violin enhancement. The sound radiation pattern emanating from a wooden body is spatially dependent: for example, the frequency response from the side of the instrument is quite distinct from the same measurement taken from the front or rear sound plates. The system described here only manipulates the far-field response. Perhaps most important, the hardware does not provide any form of feedback to the player from the string to bow.

Violin characterisation and perception

In all stringed instruments, the player directly controls only the motion of the strings. The vibrating strings exert forces on the instrument bridge, which cause the body to vibrate. The body vibration radiates sound, and in the process the string's waveform is modified by the pattern of body resonances. The musical qualities, and hence the value, of a particular instrument are determined by this pattern of resonances. This much is agreed by musicians, instrument-makers and scientists. However, much work is still required to establish, from a scientific perspective, the explicit relationships between these resonance characteristics and the perceptions of musical performers and listeners. This situation limits severely the interpretability of acoustical data by scientists, musicians and instrument-makers, who are forced to fall back on anecdotal understanding of musical sound production by, and perception of, stringed instruments. Data are needed concerning the degree to which different physical characteristics of stringed instrument sounds are operational in the perceptions of performers and listeners, so that we can begin to understand the perceptual mechanisms that mediate sound production, and to predict the perceptual effect of changes in features of instrument construction and design. Without it the ability to evaluate the basis for judgements about the musical acceptability of different instruments remains strictly hypothetical and pre-scientific. In some regard, the device described here offers a potential route forward, not only in relation to improvement in sound quality of body-less violins, but also in the area of psychoacoustics.

Enough is known about stringed-instrument body vibration response to ensure that adequate physical models can be developed; furthermore, recently-developed DSP techniques provide the means for resonant characteristics to be simulated and changed in real time. Such tools can facilitate comprehensive empirical investigations of the relationships between physical and perceptual dimensions of musical sound. These investigations could illuminate the cognitive and perceptual mechanisms that underlie the capacity to identify and discriminate between musical sounds, and would clarify for musicians and instrument-makers the musical-perceptual significance of a wide range of physical instrument parameters.

The violin as a linear system

The body of a violin is, to a very close level of approximation, a linear system. Although its properties do alter over time (as the wood, varnish and adhesives age), these changes only become significant over years. Within any reasonable time frame, the body manifests the property of temporal invariance. Hence if the body is tapped at a particular position using an instrumented hammer, the sound that it produces will always retain the same spectral characteristics (although the amplitude may vary, depending on the strength of the strike). Non-linearities are often introduced during performance, but these are player-dependent and confined to manner in which the bow moves over the string, not the body. Although the near-field impulse response is spatially variable, in the far-field these variations are less significant; it the far-field which is of interest in this case.

The characterization of a violin body as a linear system is pivotal since it allows the vibration behaviour to be characterized by the standard methods of linear acoustics, as has been explored by many researchers [1, 2, 3]. The most extensive attempts to date to use the linear model to explore the P40

P39 resonance characteristics of real stringed instruments have been conducted by Jansson and Dünnwald [4, 5, 6]. Dünnwald measured resonance characteristics of about 700 violins and found that certain resonance features (such as the presence of strong resonances in the region 190-650 Hz and 1300-4200 Hz relative to resonances in the regions 650-1300 Hz and 4200-6500 Hz) were characteristic of 'Old Italian' instruments; it was concluded that these features were significant in determining the acceptability of violin sounds, but no empirical research was conducted to explore or support the perceptual validity of this claim.

When performing on stage, violinists often use a microphone to amplify the sound from the violin; this has its disadvantages. The voice of the instrument is often not reproduced with fidelity since the microphone is in the near-field radiation zone of the transfer function. Additionally, interference is often introduced. From a pragmatic perspective, acoustic instruments are often very expensive – a typical Stradivarius will cost upwards of $5M.

An approximate violin bridge/body impulse response can be obtained by tapping the bridge with a small instrumented hammer and using a microphone and an ADC to record the signal. This impulse response is then processed with an FFT algorithm to obtain the frequency response. A typical violin body frequency response is shown in Figure 1a. The force signal from just a string may be obtained using miniature accelerometers mounted on the bridge; a typical signal is shown in Figure 1b. This is then processed digitally with the bridge/body filter to synthesize a convincing violin sound; the resulting waveform [7] appears in Figure 1c. An accurate measurement of the impulse response is technically challenging, and many publications have discussed this subject [8, 9].

Basic DSP filter theory

The real-time filtering system employs a combination of both finite impulse response (FIR) and infinite impulse response (IIR) filters to affect the processing of the input force signal. Specifically, an FIR algorithm convolves the incoming signal with the body impulse response, and an IIR structure is used for both the parametric equalizer and the reverberation stage. In general, the convolution integral in continuous space is expressed as:

$$y(t) = \int_{-\infty}^{\infty} h(\tau)x(t-\tau)d\tau \qquad (1)$$

where *y(t)* is the output (filtered) signal, *x(t)* is the incoming signal, *t* is the time-shift operator and *h(t)* is the impulse response of the filter. In discrete space, this equation may be implemented using either an FIR or IIR solution. In the former case, the infinite response is truncated, which yields an expression of the form:

$$y[n] = \sum_{k=0}^{M} h[k]x[n-k] \qquad (2)$$

with the z-transform of the impulse response, i.e. the transfer function *H(z)*, being given by:

$$H(z) = \frac{Y(z)}{X(z)} = \sum_{n=0}^{\infty} h[n]z^{-n} \qquad (3)$$

In contrast, IIR filters rely on recurrence formulae, where the output signal is given by:

$$y[n] = \sum_{k=0}^{N} a[k]x[n-k] - \sum_{k=1}^{M} b[k]y[n-k] \qquad (4)$$

and the transfer function is given by:

$$H(z) = \frac{a[0]+a[1]z^{-1}+\ldots+a[m]z^{-m}}{1+b[1]z^{-1}+\ldots+b[n]z^{-n}} = \frac{\sum_{m=0}^{M} a[m]z^{-m}}{1+\sum_{n=1}^{N} b[n]z^{-n}} \qquad (5)$$

There are important consequences associated with these two approaches to filtering; one of the most important criteria in assessing the performance of a filter is its stability. As Equations (2) and (3) show, FIR filters are unconditionally stable since there is no feedback in the convolution process. In contrast, IIR filters always feedback a fraction of the output signal, which necessitates careful attention to design if stability is to be ensured. This may be viewed another way: Equation (5) shows that the transfer function is the ratio of two polynomials in ascending negative powers of *z*. Thus high-order polynomials are associated with very small denominator terms and

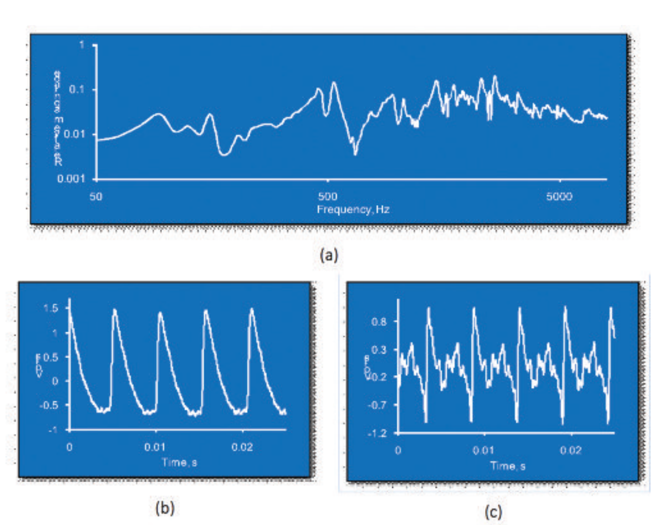

Figure 1. (a) Typical violin body frequency response; (b) force signal on bridge of violin; (c) force signal on bridge of violin mediated by body frequency response.

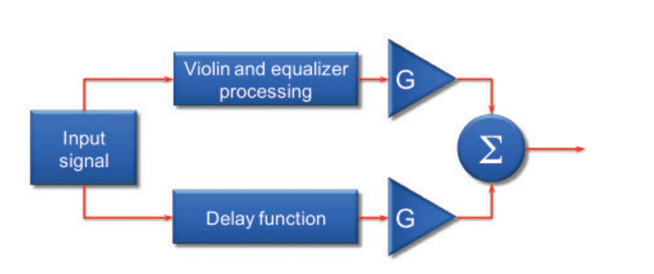

Figure 2. Blender architecture, comprising delay compensation and independent gain controls on each signal stream.

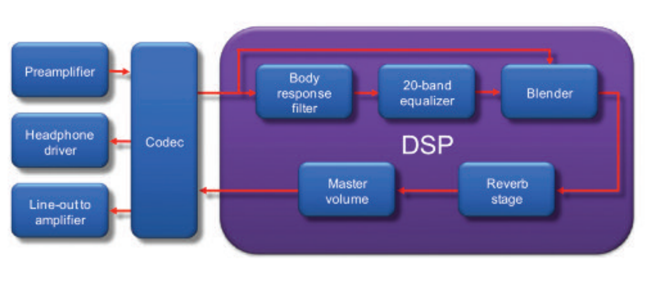

Figure 3. Main system components and signal processing chain

hence the risk of an ill-conditioned division. It is for this reason that IIR filters are sensitive to the word-length of the DSP device. In general, the higher the order of the filter, the greater the risk of instability, so high-order IIR filters are often designed by cascading together several low-order sections.

Parametric equalization

The parametric equalizer, which is controlled by the interactive user software, allows the user to shape the frequency response according to any arbitrary frequency shape. It is realized using the frequency sampling method, which proceeds as follows:

- The frequency response of the filter is specified in the Fourier-domain. For a linear phase filter, the frequency response is determined by setting the real terms to their intended values, and leaving the imaginary terms as zero.
- The inverse Fourier transform is taken of the designated frequency response, which generates a time-domain function.
- The ends of the impulse response are now tapered to zero using a suitable window function, such as a Hanning type. Application of the window minimizes ripples in the pass and stop bands but it also increases the width of the transition zone.

For a simple linear phase pass-band filter, the frequency sampling method is encapsulated by the expression

$$h[n] = f_w[n]F^{-1}\{H[k]\} \quad \begin{cases} H_r[k] = 1, & f_l < k < f_h \\ H_r[k] = 0, & \text{elsewhere} \\ H_i[k] = 0 & \end{cases} \qquad (6)$$

where $f_w[n]$ denotes the window function. Of course, the user does not need to be concerned with the mathematics or algorithm associated with the parametric equalizer; the software tool allows its configuration merely by adjusting the frequency response curve via the interactive graphical display.

Blender stage

A blender stage is included in the processing stream. This enables the player to mix the original (dry) signal with the processed (wet) signal, in any proportion, using the navigator keys on the top panel of the unit. Blending is easily implemented in software, although it is essential to incorporate a delay function in the dry signal path to compensate for the delay resulting from the various processing stages. This is illustrated in Figure 2.

Figure 4. Complete device showing display screen and navigator buttons

Mains filter

The mains filter, which is optionally selected from the hardware unit's navigator buttons, is realized as an 8th order IIR filter. It is designed to suppress 50 Hz and 60 Hz mains hum. This source of noise can be problematic when using pickups with very high input impedance, typically above 5 MW.

Hardware system and signal processing chain

A hardware system has been designed to perform the operations described above in real time. The output from the string pickup (normally a piezo-electric transducer) is fed to a high-impedance (5 MW) gain-switchable preamplifier and then to the analogue-to-digital converter section of a 24-bit codec sampling at 50 kHz. The output from the codec is then fed to the DSP device with a processing power of 590 MMACs, which performs all of the main-stage processing, i.e. body impulse response convolution, parametric equalization, blending (dry/wet mixing), reverberation and final volume control. The processing chain is depicted in Figure 3.

After processing, the output signal is fed back to the digital-to-analogue section of the codec and from there to appropriate buffers to drive both high power audio amplifiers and headphones. Other sub-systems include a display, keypad and interface to allow the unit to be connected to and programmed by a computer. The final device is shown in Figure 4. Convolution of signal with a long-duration impulse response is a compute-intensive operation. In the case of signals sampled within the audio band, it places a severe constraint on the specifications of the DSP device which is selected to perform the task. In this case, for example, the impulse response comprises 4096 coefficients. With a sample rate of 50 kHz, this alone represents a processing burden of 204.8 MMACs. P42

◀P41 In addition, the processing core must also accommodate the twenty IIR filters in the equalizer, the seven comb / low-pass filters and phase scrambler of the reverb unit, a master gain and the blender function. Modern DSP devices achieve the speeds required with the use of Harvard architecture, hardware multipliers and enhanced filter coprocessors, which are optimized to perform seamless multiplication and accumulation. Typically, such systems perform convolution at close to or equal 100% efficiency (i.e. two MMACs per clock cycle when using both the DSP core and the coprocessor).

Conclusion

A prototype system has been described that is intended to approximate, in real-time, the far-field impulse response of an acoustic (wooden) violin. It comprises a high-speed DSP core and codec in combination with software that convolves the incoming signal with a measured far-field radiative response. Other features include a software selectable preamplifier, user-controlled parametric equalizer, blender unit and mains filter and gain control. Preliminary tests suggest that the device may enhance significantly the voice of an electric instrument; additionally, it represents an ideal research tool due to its flexibility and the ease with which the entire convolution operation may be reconfigured.

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What's in a name as Acoustics Dimensions becomes Idibri

Acoustics Dimensions has changed its name to Idibri.

Nick Edwards, Principal Consultant, said: "Over time, we found Acoustics Dimensions was simply too small to express all we do. As a result, we've become Idibri, the place where bright ideas live."

The company, founded in 1991, will continue to provide design services for acoustics, theatre consulting and technology design from its offices in Coventry, Dallas and San Diego.

Its major projects in recent years have included the Royal Opera House in Muscat, the Royal Shakespeare Theatre in Stratford-upon-Avon, Circuit of the Americas in Austin, Texas and faith-based projects such as Watermark Church and First Baptist Church - both of Dallas.

More information is available at **www.idibri.com**

Nick Edwards (front centre) with members of the Idibri team

Southdowns bites bullet as it undertakes firing range study

Southdowns Environmental has been appointed to undertake a noise and vibration monitoring study of a military firing range in the Thames Estuary.

QinetiQ, which operates the range at Shoeburyness in Essex on behalf of the Ministry of Defence (MOD) has, at the request of the MOD, commissioned an independent study to determine the possible effects of noise and vibration which may result from the test, evaluation and training support activities which are carried out on the range.

The decision follows concerns by nearby communities that noise and vibration from the firing, which includes missiles, rockets and tanks, could be damaging their properties.

The study will monitor noise and vibration at multiple locations of interest in the vicinity of the range. Following a desk top study and site suitability surveys, several locations on the Essex and Kent coastlines have been identified to host a monitoring system.

The monitoring will be conducted over a six-month period, starting in spring of 2015.

Party time as Lord Tebbit hosts Robust Details' 10th anniversary celebrations

Former Cabinet Minister Lord Tebbit led Robust Details' 10th anniversary celebrations by hosting an event at the House of Lords.

In doing so, he called on the Government to be "as open minded and radical" as its founders and praised the company's scheme for sound insulation standards in new homes, which he described as being, "an inspired example on all sides of how the business of Government in regulating could be made user-friendly".

Robust Details CEO Dave Baker said: "We are very grateful to Lord Tebbit for hosting our event. It was a real pleasure to have someone of his vast experience speaking so highly about us."

The Milton Keynes-based company was formed in December 2003 in response to the housebuilding industry's request for an alternative to pre-completion sound testing (PCT) as a means of satisfying Part E (sound insulation requirements) of Part E of the building regulations (in England and Wales).

For more information visit **www.robustdetails.com** or contact John Thompson on **0870 240 8210** or via **jthompson@robustdetails.com**

Lord Tebbit (front centre) with members of Robust Details' management team

3D scanning laser vibration measurement centre is a UK first

The UK's first commercial robotised 3D scanning laser vibration measurement and modal analysis centre has opened in Leicestershire.

The £2.5million Advanced Structural Dynamics Evaluation Centre (ASDEC) has been developed by the University of Leicester and funded by grants from the Government's Regional Growth Fund and the European Regional Development Fund.

Located at the MIRA Technology Park near Hinckley, it offers a full structural dynamics service covering vibration testing, modal analysis processing and CAE correlation.

Professor Sarah Hainsworth, joint project leader, said: "The project delivers a key research capability to industry to allow customers to use state-of-the-art technology to deliver innovative engineering solutions to problems of vibration and noise."

The fully robotised 3D scanning laser Doppler vibrometer allows for high speed and high density vibration measurements without any loss of accuracy or precision. The non-contact measurement technique removes all observer effects increasing the accuracy of the measurement. The precise robot control and laser triangulation gives highly repeatable measurements ensuring the greatest precision.

Terry Spall, Commercial Director at MIRA Technology Park, said: "As well as creating new jobs in the area, the centre will complement our growing transport sector technology cluster here and help support the industry in vital research and development for future materials and solutions."

For more information about ASDEC contact Tim Stubbs at **asdec@le.ac.uk** or call **02476 358780**.

The centre in action

Improved noise monitoring at Manchester Airport

Manchester Airport has expanded its noise management capabilities with a new airport noise and operations monitoring system (ANOMS 9) from Brüel & Kjær.

ANOMS 9 enables Manchester Airport Group to monitor and report on noise and operations at multiple airports, including London Stansted, Bournemouth, East Midlands and Manchester, with a single system. The four airports serve around 43 million passengers every year and are an important part of the local economy.

The airports will also receive WebTrak and WebTrak MyNeighbourhood; part of a suite of web-based applications that assist airports in building good community relationships. WebTrak enables local residents to self-investigate recent noise and flight tracks, whilst WebTrak MyNeighbourhood illustrates typical operating scenarios. The WebTrak sites enables users to find answers to frequently asked questions, such as: "How loud and low was that plane?" or "How many flights pass over my house in a single day?"

Additional noise monitoring terminals (NMTs) will be deployed at Stansted, Manchester, East Midlands and Bournemouth. NMTs continuously monitor the environment for noise events, which are defined as noise that remains above a certain level for a prescribed period of time. These noise events are correlated with flight information and enable the airport to demonstrate compliance with regulations, respond to community enquiries, address noise issues with airlines, adjust operating procedures to limit noise impact and carry out measurements to improve their noise maps.

More information is available at **http://www.bksv.com/airports**

Monitored better: noise at Manchester Airport
Photo courtesy of Manchester Airport

Chris clutches at straws to cut music festival din

Noise consultant Chris Selkirk clutched at straws – quite literally – in order to mitigate the effects of noise at a music festival.

After mapping the noise hotspots at the Ravenstonedale Festival in Cumbria he bought 50 bales of densely-packed straw from a local farmer and built several 6m wide by 3m high walls around the worst offending sound systems.

Noise protector: some of the straw barriers

Once they were in place he re-took his measurements, on a Cirrus Optimus Green, and discovered a 42dBA reduction in the noise levels, only 12 meters from the dance-floor, behind the straw bales. This took the site to well within the legal limits of 45dBA from nearby noise sensitive properties after 11pm.

"The straw bale wall barriers were enabling 10-15dBA increase in volumes for the sound systems compared with the previous year, which was beyond our expectations," said Chris.

"It was a great solution because the bales didn't look out of place in this rural festival setting and at the end of the weekend we simply sold them back to the farmer so it was very cost effective and environmentally-friendly."

Xodus wins $1 million Middle East vibration engineering contract

International energy consultancy Xodus Group has been awarded a contract in Qatar with Qatargas to provide vibration engineering services at onshore and offshore facilities.

Working in partnership with Chiyoda Almana Engineering, Xodus will look to develop a long-term piping integrity management programme to assess, reduce or eliminate vibration in all of the Qatargas facilities, both onshore and offshore.

The $1million one-year contract is for a technical services vibration programme at four Qatargas liquid nitrogen gas facilties, Ras Laffan refinery and associated offshore assets, with the option of an extension for a further two years.

Xodus launched its Dubai office in 2012 and has grown to over 100 people in the Middle East. In that time it has secured more than $20 million of contracts from the region.

The company, which is based in the UK, has recently opened new offices in Abu Dhabi, UAE and Erbil, Kurdistan, and is in the process of setting up an operation in Qatar, which will launch later this year.

Colin Manson, CEO of Xodus Group, said: "Eliminating vibration supports integrity management plans and can deliver significant asset cost savings."

Care home residents on 'cloud nine' as hearing issues eased

Residents and staff at a Cheltenham care home can hear each other much better – thanks to the installation by The Woolly Shepherd of acoustic "clouds" and wall panels in the reception room and the dining room.

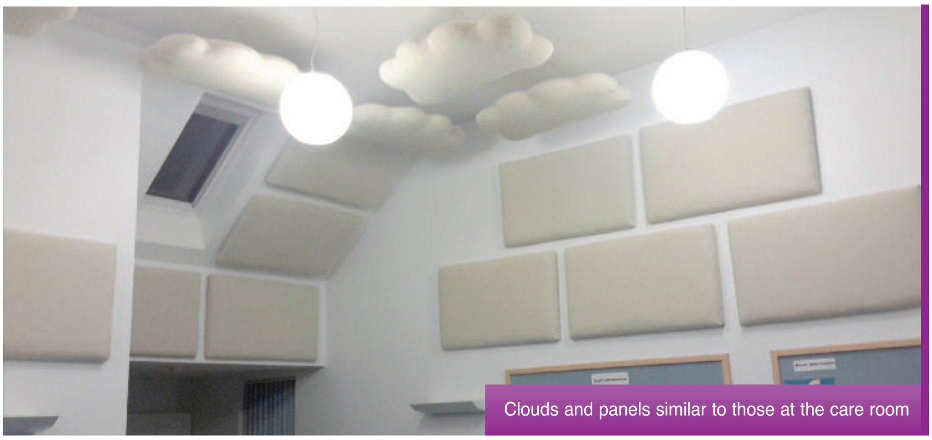
The company was called in by the manager who had complained of struggling to hear clearly on the phone, doorbells ringing and residents calling for help.

A survey revealed that her problems were exacerbated by hard floors and high ceilings causing echo and sound distortion which, when coupled with distorted and loud background noise, made hearing speech difficult.

Tim Simmons from The Woolly Shepherd said the survey had been carried out "as we could see that it was going to be crucial that we not only established accurate acoustic measurements, but also determined appropriate placement of acoustic treatment".

Three sets of RT60 readings were taken at randomly chosen points within each room, to ensure that the influence of positioning was minimised and a Tmf established for each room.

For more information contact Tim Simmons on **info@woollyshepherd.co.uk** or call **01823 400321**.


Clouds and panels similar to those at the care room

Hospital celebrates opening of new children's audiology facility

A new children's audiology facility at James Paget Hospital in Gorleston, Great Yarmouth has been officially opened by Gary Nethercott, Regional Director of the National Deaf Children's Society.

This facility, designed and built by Allaway Acoustics, allows the audiology department to carry out hearing tests using state-of-the-art equipment in a facility which meets the latest British, European and ISO standards for paediatric testing.

The free-field VRA room, sited in the former bank, includes a one-way vision panel to the adjoining observation room, with inter-connecting patch panels for audiometer and PC-controlled test equipment and a discrete Intercom system which allows direct unnoticed communication to the staff in the test room.

The room is fully air conditioned and digitally controlled light dimming has been installed along with high quality finishes throughout to provide the best possible environment to put patients at ease and allow confident accurate testing.

Allaway also refurbished the existing three adult test rooms in the department which had been in existence for some 30 years and were no longer fit for purpose, having failed a quality audit.

The firm has also recently installed new VRA and adult test facilities at many hospitals across the UK, including Bath, Bristol, Bury St Edmunds, Dundee, Glasgow, London and Melrose, and has completed refurbishment projects on existing facilities in Edinburgh and Telford and other locations in the UK.

For more details contact **01992 550825** or email **Info@allawayacoustics.co.uk**


The new children's VRA test room

Agency funding will help 'revolutionise acoustic barriers market'

Sonobex, a newly formed spin-out from Loughborough University, has announced the award of funding from the UK's innovation agency, the Technology Strategy Board, to develop next generation acoustic barriers for road, high speed rail, passenger and freight rail applications.

Sonobex's technology is based on a new area of physics known as Sonic Crystals first seen in the late 1990s. The technology causes destructive interference to sound signals, cancelling rather than reflecting or absorbing the signals. This is particularly powerful as designs are tuned to particular dominant frequencies to achieve significant reduction levels.

The total project value is £358,000, with an anticipated £161,000 in funding from the Technology Strategy Board.

The project is expected to complete in April 2015 with first CE mark prototypes produced by February 2015.

Paul Gooch, Sonobex Chief Executive, said: "Sonobex is delighted to have secured this funding. These next generation acoustic barriers will revolutionise the market."

For more details go to **www.sonobex.com**

Arup funds research into aircraft noise

Arup is funding a PhD with Manchester Metropolitan University's Centre for Aviation Transport and the Environment (CATE) to investigate ways in which the dialogue between airports and their neighbouring communities, relating to aircraft noise, can be improved and so support sustainable development.

The research will focus on both academic and commercial needs and aims to deliver a better understanding of noise related issues for stakeholders and affected communities. One of the key outputs is anticipated to be a noise illustration and communication toolkit.

The PhD placement has been awarded to Rebecca Hudson who will spend three and a half years undertaking research.

The study will take advantage of the new Arup SoundLab in Manchester, recently constructed as part of the Arup's office move to 3 Piccadilly Place. The SoundLab uses auralisation, which is similar to visualisation, but uses sound instead of images to provide a sound demonstration that reproduces both the loudness (level) and – often more importantly – the character of sound.

Rob Harris, Director of Acoustics, Arup, said: "Balancing environmental quality and development is a complex aspect of airport operations. This work will help build better understanding between airport operators and their surrounding communities."

G.R.A.S. launches UK subsidiary

G.R.A.S, the Denmark-based measurement microphones and related acoustic equipment manufacturer, has launched a UK subsidiary, GRAS Sound and Vibration UK, as part of its long-term growth strategy.

Ivan Sandager, G.R.A.S. Sales Director, said: "The UK subsidiary further builds on our international business and complements our existing ventures in the USA, China and Germany.

"We see it is a major opportunity to further increase market share in the UK."

Paul Rubens has been appointed UK Managing Director and the Technical Director is John Shelton who spent 20 years as Managing Director of AcSoft. Emily Howarth is the Sales Manager. The new company is based in Aylesbury.

G.R.A.S. products have been distributed for many years in the UK by AcSoft and Campbell Associates and both will continue as sub-distributors.

For product information contact Emily Howarth on **01296 681891** or **emilyhowarth@gras.co.uk** or **visit www.gras.co.uk**

Top team: (l-r) Paul Rubens, Managing Director, Emily Howarth, Sales Manager, and John Shelton, Technical Director

New European Export Sales Manager for Cirrus Research

Bart Buermans (left) with Marketing Director Rick Heap

Cirrus Research has appointed Bart Buermans as its new European Export Sales Manager as part of its strategic expansion across the continent.

He joins the company in the newly created role from Scantec, a Cirrus distributor in Belgium, and will be working across Europe with particular emphasis on its Frankfurt and Barcelona offices where he will be supporting the existing sales team.

He will be nominally based in Antwerp but expects to spend at least half his time each month in the other European offices, as well as regular visits to the Cirrus head office in North Yorkshire and its new environmental base in Peterborough, Cambridgeshire.

Nigel Burton joins Bureau Veritas to head Acoustics and Vibration Group

Nigel Burton has joined Bureau Veritas as Technical Director to lead the Acoustics and Vibration Group in its London office.

He joins with extensive experience in acoustic consultancy, having held senior roles within the Acoustics Group at AECOM both in the UK and Australia.

Whilst he has experience in environmental acoustics, his main focus for the last decade has been in building and architectural acoustics. He has worked on a wide range of projects, from commercial office fit-outs to hotel and healthcare facilities.

He was responsible for the acoustic design of the redevelopment of St Pancras Chambers, the historic Midland Grand Hotel which fronts London's Eurostar platforms, and was also the lead acoustician on the first four schools in Newham Council's Building Schools for the Future programme.

On his move Nigel said: "I'm enjoying the new challenges and I'm looking forward to developing our architectural acoustics capabilities. We have some great skills already in house but we are looking to grow our team to better serve our clients."

Nigel Burton

Moise scoops ANC Diploma award

Moise Coulon has won the annual ANC prize for the best project in the IOA Diploma in Acoustics and Noise Control, which was titled *Directivity of wind farm noise at noise sensitive receptor distances.*

Moise, aged 32, a Noise and Technical Consultant at TNEI Services, Newcastle, was presented with the award by TV science presenter Sarah Crudas at the ANC awards evening in Birmingham.

He undertook the Diploma between September 2012 and December 2013 via distance learning at Edinburgh Napier University. He was sponsored by TNEI Services.

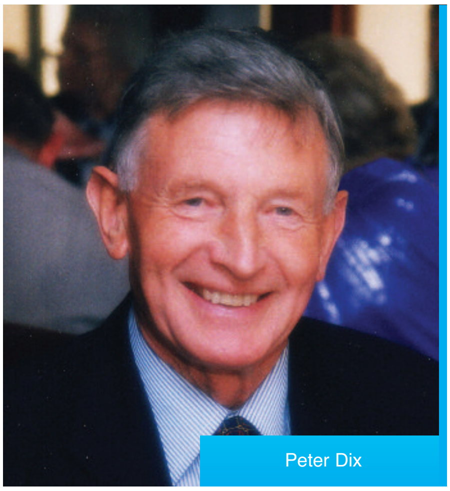
His technical contribution, *The complex wind speed referencing system in wind farm noise assessments*, was published in the July-August 2014 edition of the Bulletin.

Moise Coulon receives his award from Sarah Crudas

Peter Dix (1928-2014): 'unsung hero' of Abbey Road Studios

Obituary

By Neil Spring



Peter Dix

Peter Dix, who died on 26 May, was born on 17 June 1928 in Sidestrand, a small village near Cromer, Norfolk, the fourth of five children. He won a scholarship to The Paston Grammar School, North Walsham, the school attended by Nelson.

After the war he was called up and went into the Royal Artillery and then transferred to REME. He always spoke well of the technical training he received there.

Although Peter had the qualifications for university, he did not have the funds so he went to evening classes and day release for one day a week. He started work at EMI, then left for two years to work at Goodmans Industries, Wembley, designing loudspeakers. He then returned to EMI where he stayed for the rest of his career. He worked in the Advanced Research and Development Department at Hayes, and developed the monitoring loudspeakers used by the classical record producers at Abbey Road. During this period, he was involved with the development of many innovations developed for Abbey Road, including delayed artificial reverberation, ambiophony, a microphone array to discourage operatic soloists from hogging the microphone and highly efficient studio acoustic screens to satisfy the demands of pop recording in Studio 2. From 1964 he was in charge of studio acoustics.

EMI had numerous overseas subsidiaries and he visited many of them to give advice and also spent much time in the USA. He also dealt with various concert halls and performance venues. If EMI was recording at a hall and the conductor or artiste did not like the acoustics, Peter would be called in to get them to their liking. However, Peter spent much time at Abbey Road Studios, by far the most important of all EMI studios. Ken Townsend, former Manager of Recording Operations at Abbey Road, writes: "I first met him in 1953 when I was a trainee engineer and he was the king of loudspeakers. I learnt a lot from him, not only technical knowledge but his devotion and commitment to any project. He was one of several unsung heroes, without whom many iconic recording stars could well have become bus drivers, not multi-millionaires. I shall never forget his contribution to the internal building of Studio One in 1971. We had a problem in that our large orchestral studio was too dead, and experiments such as ambiophony, incorporating 98 loudspeakers fitted to the walls, had been a failure. Together we concocted an ambitious plan to rip out the entire inside and start again. Peter's design was brilliant; it successfully raised the reverberation time from 2.4 to 3.2 seconds, while subtle variations of the angles eliminated unwanted standing waves. It is a tribute to his skills that 40 plus years on it remains unaltered, and has enabled the majority of the music for both classical and the world's best known movies such as *Star Wars*, *Lord of the Rings* and the *Harry Potter* series to be recorded there. His familiar chuckle, when he did not approve of something, lingers in my memory. In this current era technical people never receive the credit they deserve, but to me Peter was one of the greatest stars ever."

Peter was a modest, kind, loving, intelligent and practical man who helped many. He had a keen sense of humour and many a lady had "her leg pulled" by him. He never gave up on life, grabbing every chance of an extra day. His treatment was excruciatingly painful at times and the doctors told him his case had been a huge learning curve but he hoped it would extend his life. Unfortunately it did not but maybe it will help others. He will be missed by many. He is survived by his wife of 58 years, Pam.

Michael Langley (1946-2014): 'very nice man and genius acoustician'

Obituary

By Richard Budd

Michael Langley

Sadly Dr Michael Stephen Langley FIOA died in hospital on 19 June aged 67. He will be greatly missed, especially by his family and friends.

Mike graduated with a BSc in Physics from Queen Mary College London in 1969. He studied for post graduate degrees at Chelsea College London, writing theses on *The Dynamic Mechanical Properties of Silicon Nitride at Elevated Temperatures* for his MPhil and *The Effect of Polymer Additives on the Damping Capacity of Concrete* for his PhD.

Mike joined AIRO for a short time in 1974. He moved to the British Aircraft Corporation and was proud to work on the pioneering development of Concorde in Toulouse amongst other projects. He moved to Wimpey Laboratories in the late 1970s.

Mike was then recruited to Sound Research Laboratories Ltd in 1982 where he stayed until he retired in 2012, working in the company's offices in Covent Garden, Sunbury-on-Thames and finally at Holbrook House in Suffolk.

He was appointed to SRL's board as Technical Director in 1989 and was elected Fellow of the Institute of Acoustics, recognising his contribution to the acoustic industry. Mike was respected for his work on many prestigious projects in the UK and abroad, including BBC, White City; Bordeaux Courts; Metro Centre, Gateshead; Millennium Point Birmingham and the National Assembly for Wales

He was well known for his design solutions on a large number of multi-use cinema, bowling alley, night-club, hotel and restaurant facilities across the UK. On hearing of Mike's death, one of his clients wrote "Mike taught us all how to design cinemas and nightclubs, he was a very nice man and a genius acoustician."

Mike was an avid sports follower and a keen acoustic guitarist. He liked nothing better than to play guitar while his wife Susan sang to accompany him. He was a key part of the family values of SRL and was an influential part of the careers of many acousticians, several of whom remain at SRL today.

On retiring he said: "I have had a wonderful 30 years at SRL full of lovely people who have always given me great support. My philosophy for SRL was to create a profitable business with the welfare of the staff being of paramount importance. I had fun every day."

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New entry-level vibration analysis took from SKF

SKF has announced an entry-level vibration analysis tool designed to be used with an Android tablet or smartphone to assess problems with rotating machinery.

The Wireless MicroVibe offers basic vibration data collection and analysis functions, including root cause analysis and small-scale route-based data collection.

SKF product manager Torsten Bark said: "The wireless sensor will help our customers assess data in a much easier and quicker way than other comparable technologies. Anyone who owns a tablet can check the condition of a machine to ISO standards or bearing condition, or by user-defined alarms. They can even start a simple condition-monitoring programme."

If the vibration measurements result in an alert, an FFT spectrum and waveform function provides information to help find the root cause of the problem.

The CMVL 4000-EN device allows multi-point automation for rapid data collection. It can collect, assess and store data such as enveloped acceleration, acceleration, velocity and displacement, producing both FFT spectrum and time waveform displays.

SKF's wireless MicroVibe lets you monitor machinery via your smartphone

The Wireless MicroVibe

If the vibration measurements trigger an alarm (based on ISO vibration severity standard and SKF bearing condition evaluation), the FFT spectrum analysis can help engineers to pinpoint problems such as unbalanced or misaligned bearings, or other causes. The vibration data can be transferred to a computer for storage and for trending and further analysis.

For more details go to **http://goo.gl/KjlwJ4**

New speech sound source from Brüel & Kjær

Brüel & Kjær has launched a new, battery-powered speech sound source. Used in combination with the DIRAC 6 room acoustics software, the new Echo Speech Source Type 4720 enables users to perform speech intelligibility measurements, which meet standards IEC 60268-16 and ISO 3382-3 (open plan offices).

The echo speech source works as a stand-alone tool with five in-built calibrated signals, which are used by the DIRAC room acoustics software to calculate a range of speech intelligibility parameters, such as STI, STIPA and RASTI based on the impulse response of the room being measured.

Users can measure the speech intelligibility of a sound reinforcement system using an excitation signal, played directly from DIRAC, through the sound device output or from an external device such as a CD or MP3 player.

The Echo/DIRAC combination copes well with high levels of background noise, as the echo speech source uses an intermittent stimulus. The intermittent stimulus consists of a Maximum Length Sequence (MLS) sequence followed by an equally long period of silence. The full stimulus (MLS and silence) is measured in one go. DIRAC then extracts the impulse response and the background noise into two separate channels of a .wav file.

The Echo Speech Source Type 4720

For more information go to **http://goo.gl/gHFSYI**

Rion launches successor to DA-20 four channel data recorder

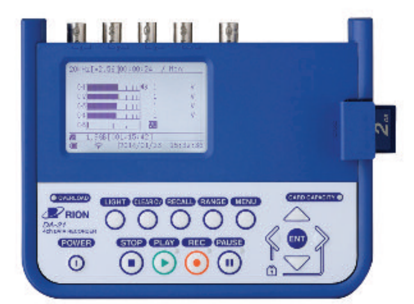
Rion has replaced the DA-20 four channel data recorder with the DA-21. The Rion DA-20 has been/is being used to monitor noise and vibration during the Crossrail tunnels construction in London and was used in the pilot study for the Defra work on vibration in residential premises.

The DA-21 keeps the compact, light, battery operated format of its predecessor but incorporates some significant upgrades. It can provide up to 32GB of storage onto an SD card (a 16-fold increase over the DA-20). There is also a fifth input for a tacograph and two DA-21s can be synchronised to give up to eight coherent channels of data.

The data is stored as standard (but calibrated) wav files (16 or 24 bit) so it can be easy imported into most post processing software.

The DA-21, like the DA-20, provides a self-contained means of four- channel data acquisition without the need for a computer, which, says Rion, can be very handy when testing vehicles or where the power consumption or fan noise associated with traditional computer-based acquisition systems makes them unsuitable. Furthermore, with its simple tape-recorder like controls, there is no learning curve unless you want to use some of the DA-21's extensive trigger options for intelligent data reduction.

For further information contact Bob Lorenzetto or Ben MacIsaac at ANV Measurement Systems on **01908 642846** or e-mail **info@noise-and-vibration.co.uk**



The new Rion DA-21

Marshall Day unveils underwater noise prediction software tool

Marshall Day Acoustics has developed a new software tool to predict underwater noise in a variety of environments.

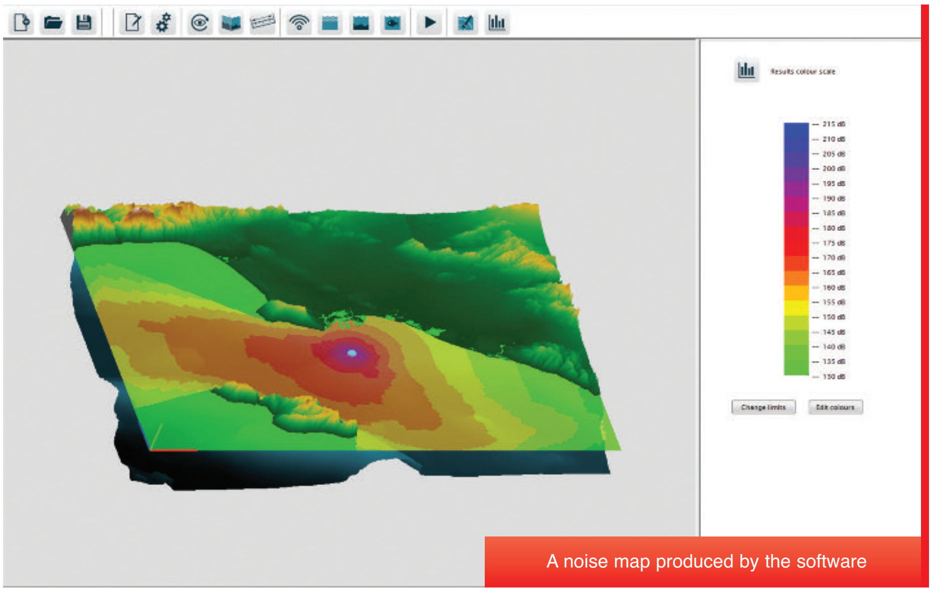
dBSea incorporates an interface and clearly defined workflow that allow models to be quickly developed and modified. The 3D workspace allows visualisation of bathymetry data, noise sources and prediction results.

The solvers incorporated to predict the underwater sound field comprise, say Marshall Day, the most popular calculation methods used in the underwater acoustics industry. The different solver algorithms each find application with different types of problems, adding up to an overall package that covers many underwater acoustics scenarios.

The interface allows rapid modelling of problems including data import and export, input of noise sources, definition of propagation properties and exporting of results.

Models are represented in 3D and may be rotated and zoomed to allow easy navigation of the problem environment and examination of prediction results. The model is built by importing bathymetry data and placing noise sources in the environment. Each source can consist of equipment chosen from either the standard or user defined databases. Noise mitigation methods may also be included. The user has control over the seabed and water properties including speed of sound profile (how the speed of sound changes with water depth), temperature, salinity and current.

A trial version is available at **www.dBSea.co.uk**



A noise map produced by the software

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Committee meetings 2014/15

DAY	DATE	TIME	MEETING
Tuesday	**9 September**	**10.30**	**Council**
Thursday	25 September	10.30	Engineering Division
Monday	29 September	11.00	Research Co-ordination
Thursday	23 October	11.00	Publications
Thursday	30 October	10.30	Membership
Tuesday	4 November	10.30	ASBA Examiners
Tuesday	4 November	1.30	ASBA Committee
Thursday	6 November	11.30	Meetings
Friday	7 November	10.30	Executive
Tuesday	**25 November**	**10.30**	**Council**
Wednesday	26 November	9.30	CCBAM Examiners and Committee
Wednesday	26 November	10.30	CCENM Examiners
Wednesday	26 November	1.30	CCENM Committee
Thursday	27 November	10.30	Diploma Tutors and Examiners
Thursday	27 November	1.30	Education
Tuesday	2 December	10.30	CCWPNA Examiners
Tuesday	2 December	1.30	CCWPNA Committee
Thursday	8 January	11.30	Meetings
Tuesday	20 January	10.30	Diploma Tutors and Examiners
Tuesday	20 January	1.30	Education
Thursday	22 January	10.30	Membership
Thursday	5 February	11.00	Publications
Thursday	12 February	11.00	Medals & Awards
Tuesday	10 February	10.30	Executive
Tuesday	3 March	10.30	Diploma Examiners
Tuesday	**10 March**	**10.30**	**Council**
Thursday	26 March	10.30	Engineering Div
Tuesday	7 April	10.30	CCWPNA Examiners
Tuesday	7 April	1.30	CCWPNA Committee
Wednesday	8 April	11.00	Research Co-ordination
Thursday	9 April	11.30	Meetings
Thursday	7 May	10.30	Membership
Thursday	14 May	11.00	Publications
Tuesday	19 May	10.30	CCHAV Examiners
Tuesday	19 May	1.30	CCHAV Committee
Tuesday	26 May	10.30	Executive

Refreshments will be served after or before all meetings. In order to facilitate the catering arrangements it would be appreciated if those members unable to attend meetings would send apologies at least 24 hours before the meeting.

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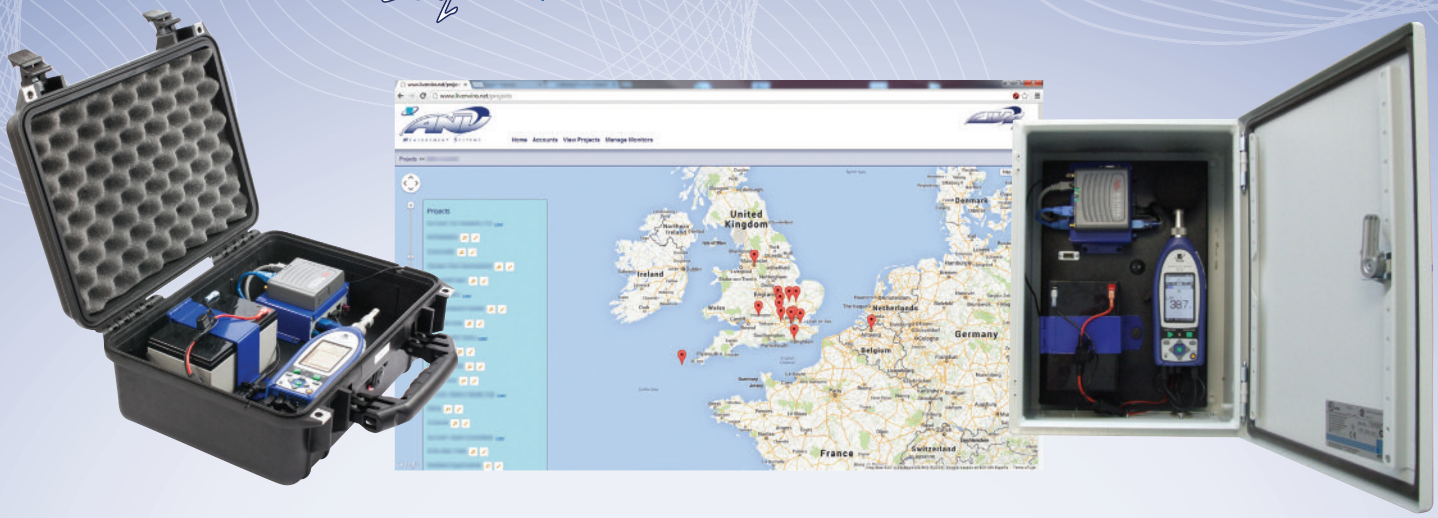

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- Fully IEC 61672 Class 1 compliant system- Including recently achieved independent Type Approval for the Rion WS-15 Double Skinned Windshield this system incorporates.
- User Friendly Instrumentation & Web Interface in true ANV/Rion Style
- User Settable Alarm Levels – up to 5 simultaneous limits, unlimited number of periods in a day and different limits on different days if necessary and receive emails when they are exceeded
- Unrivalled Data Security – Your data is on the SD card in the instrument and at a UK-based data centre on a dedicated Raid 10 Server with nightly off-site backup
- See Your Monitoring Locations on Google Maps – With colour-coded ''traffic light'' icons
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