Vol 43 No 2 **March/April 2018**

ACOUSTICS BULLETIN

in this issue...

Ringing bells enhance architecture

plus... **Sound calibrators - new revised edition of IEC60942**

The 2017 Reproduced Sound Conference

Institute of **Acoustics**

Contacts

Publishing Editor:
Juliet Loiselle

Contributions, letters and information on new products to:
Juliet Loiselle
Email: Juliet.loiselle@ioa.org.uk
Tel: 01778 391067

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

Published and produced by:
The Institute of Acoustics
3rd Floor St Peter's House
45-49 Victoria Street, St Albans,
Hertfordshire AL1 3WZ
Tel: 01727 848195

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

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Annual Subscription (6 issues) £120.00
Single copy £20.00

ACOUSTICS BULLETIN

Vol 43 No 2 **March/April 2018**

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Front cover photograph:

How temple bells contribute to the soundscape

The Institute of Acoustics in 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.

Institute of Acoustics

The Institute has over 3000 members working in a diverse range of research, educational, govern mental and industrial organisations. This multidisciplinary culture provides a productive environment for cross-fertilisation of ideas and initiatives. The range of interests of members within the world of acoustics is equally wide, embracing such aspects as aerodynamics, architectural acoustics, building acoustics, electroacoustic, engineering dynamics, noise and vibration, hearing, speech, physical acoustics, underwater acoustics, together with a variety of environmental aspects. The Institute is a Registered Charity no. 267026

Conference Programme

14 March
Organised by the Measurement and Instrumentation Group
Sound power workshop, theory and applications
Northampton

23-24 April
Annual IOA Conference
Acoustics 2018
Cardiff

5-7 September
Organised by the Underwater Acoustics Group
4th international conference on synthetic aperture sonar and synthetic aperture radar
Lerici, Italy

20 September
Organised by the Physical Acoustics Group
Acoustic materials and metamaterials
Birmingham

4-6 October
Organised by the Building Acoustics Group
Auditorium Acoustics 2018
Hamburg, Germany

27-29 November
Organised by the Electroacoustics Group
Reproduced Sound 2018 – Putting Sound in its Place
Bristol

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

Dear Members

Many of our members either run or work for Small and Medium Sized Enterprises (SMEs), and some could be in a delicate position as a result of the collapse of Carillion – big news at the time of writing. Whilst it is unlikely that acousticians would find themselves on the sharp end of 'retentions', the news that Carillion was holding around £800m in retention of monies due to sub-contractors means we'll have colleagues and clients who are affected. There are understandable reasons for the use of retentions in construction contracts, but they can be misused, and sometimes there are unintended consequences of their reasonable use.

The sums of money involved in the Carillion case have made the headlines. The media coverage caught my attention, revealing a series of events which highlight how ineffective government can be. At a time when the current government is encouraging us to achieve greater productivity, perhaps they might also reflect on that of the political system?

Sir Michael Latham's 1996 report 'Constructing the Team' (commissioned by the government of the day) talked about managing risk in construction contracts, describing it as dealt with by avoidance, abatement, retention and transfer. A Department of Trade & Industry committee considered the issue in 2002-3, reporting that in excess of 70% of survey respondents had lost money through unpaid retention due to upstream insolvency. The report concluded that legislating could be counterproductive, and that distrust within the construction sector meant that industry-led change based on contract and warranty would be more likely to be beneficial. Little changed as a result, outside of public sector contracts. Jumping forward 10 years to 2012, the Patton Group went into administration with £10m of retentions owing to sub-contractors.

Five years later, an attempt was made to bring a Bill before parliament reforming retentions, but it fell victim to last summer's snap General Election. In October 2017 the Department for Business, Energy & Industrial Strategy launched a consultation on 'Retention payments in the construction industry'. It set out the challenges with retentions - in particular the extent to which the practice has a negative impact.

Meanwhile on 9 January Peter Aldous MP successfully launched the first reading of the Construction (Retention Deposit Schemes) Bill which will receive its second reading in April. The Bill seeks to create a retention deposit scheme similar to that used by landlords and tenants for rental property deposits, to ensure that money owing to subcontractors would be managed by a third party, and thus available in the event of upstream insolvency. In his address, Aldous said: "If one of the larger construction companies were to fail, the consequences for SMEs and their supply chains could be disastrous. They could lose all their retentions, adding to the £220m that is already lost annually. The Bill would help to avert such a calamity." Carillion collapsed on 15 January – just six days after Aldous spoke in the House. Those words seem uncannily prescient.

The BEIS consultation closed on 19 January. As a person working primarily in the construction sector, I can only hope that feedback from the consultation is rapidly analysed, and a set of measures (which may be the deposit scheme and/or alternatives) are finally, and quickly, put into legislation.

The national 'Time to Talk' campaign recently caught my attention, encouraging us to speak with our colleagues and friends about mental health problems, to help us overcome the stigma that surrounds them. Having read the article in this edition of the Bulletin about tranquillity trails, perhaps we could explore our environment to find our own particular tranquillity trail – and then maybe share it with colleagues, to help provide relief from the stresses of everyday life.

Jo

Jo Webb, President

Sound calibrators – new revised edition of IEC 60942

By Susan Dowson

Background

Edition 4 of the international specification standard for sound calibrators, IEC 60942, has just been published [1], replacing edition 3 published in 2003 [2]. This article explains the main differences between the two editions and the impact these changes will have on the user.

Sound calibrators are in very widespread use by anyone making a measurement using a sound level meter or microphone. They are designed to produce a known sound pressure level, or levels, at a known frequency, or frequencies. As such they are used primarily in checking or adjusting the overall sensitivity of acoustical measuring devices or systems, but can also be used to determine the pressure sensitivity of a microphone. 'Sound calibrator' is a generic term covering electronic devices as well as pistonphones – for the latter the sound pressure is generated in a fixed air volume by the motion of one or more pistons.

Standardisation process

For most acoustical instruments the specifications are given in international standard documents produced by the International Electrotechnical Commission (IEC), with the relevant committee being IEC/TC29 'Electroacoustics'. This committee is paralleled by a UK National Committee, BSI/EPL29 within the British Standards Institution. Under IEC/TC29 there are a number of specific groups - Working Groups (WG), who are working on new documents, or Maintenance Teams (MT) who are mainly revising existing standards. The group responsible for sound calibrators is MT17 which has 17 countries registered as members, including the UK, and it is this MT that has revised the 2003 edition of the IEC 60942 standard. The UK generally accepts all the standards from IEC/TC29 without change and publishes them as BS EN versions, for example, the 2003 edition was dual-numbered as BS EN 60942:2003 [3] with identical content to the IEC version. There are many benefits with this approach - IEC/TC29 in common with other IEC committees has global membership and it is clearly beneficial for manufacturers, suppliers and users for there to be just one standard giving specifications for a particular device.

The updated text for the new edition 4 of the sound calibrator standard has now completed the full preparation stages required by IEC and has successfully passed the voting process with 100% of the countries recording a positive vote, and it has been published as IEC 60942:2017. In due course it is expected that the UK will adopt this standard without change and issue it as BS EN 60942: Ed. 4.

Key differences between the 2017 Ed. 4 and the 2003 Ed. 3 of IEC 60942

The 2017 edition of the standard is similar to the 2003 edition in that it covers the specifications for the sound calibrator, has an Annex that gives detailed tests for Pattern Evaluation testing of models of instrument, such as would be requested by the manufacturer of the sound calibrator, and an Annex that gives details of Periodic tests relevant to a particular specimen of sound calibrator. Periodic testing would be requested by the user of the calibrator, and typically within the UK such services are provided by laboratories accredited by the United Kingdom Accreditation Service (UKAS).

However, there are several significant technical changes between the 2017 and 2003 editions of the standard of which the manufacturer, calibration/testing laboratories and users need to be aware.

The main changes are listed below:

1. Changes to class designations

Specifications continue to be included in edition 4 for three classes of sound calibrator, class LS - normally only used within the laboratory, and class 1 and class 2 considered as sound calibrators for field use. Acceptance limits (see below) are smallest for class LS and largest for class 2 instruments. Detailed changes to the class designations are:

- Deletion of the class designations class LS/C, class 1/C and class 2/C; in the 2003 edition class LS/C and class 1/C were the designations for those sound calibrators that required corrections for static pressure to meet the performance class. Corrections for ambient temperature and ambient relative humidity were not permitted. Class 2/C was the designation for a class 2 sound calibrator that required corrections for any of static pressure, ambient temperature or ambient relative humidity to meet the performance class.

These corrections were to be to be applied, usually manually, to ensure the sound calibrator met the specifications of the standard. It has now been decided that with modern-day electronic circuitry such corrections are no longer required (and many people did not apply them either!). This means that no corrections are permitted for any of the environmental parameters, so class LS, class 1 and class 2 sound calibrators must meet the specifications given in the standard with no corrections applied. This is a much more straightforward approach and means there is now no need for the user to worry about the effect of environmental conditions on the performance of their sound calibrator, unless it is a pistonphone.

- pistonphones, due to their mechanical principle of operation do of course require corrections to be applied for the static pressure, so two further class designations, class LS/M and class 1/M have been added in edition 4 of the standard, specifically for pistonphones; this means that pistonphones which are designated class LS/M and/or class 1/M depending on their performance are permitted corrections for static pressure but not for any other environmental parameter. 'M' denotes a Mechanical principle of operation.

The following table shows the different class designations described in the 2017 Ed. 4 and 2003 Ed. 3 of IEC 60942, but note this does not necessarily show any direct equivalence of particular classes as other specifications vary between the two editions:

Sound calibrator class designations – comparison of IEC 60942 2017 and 2003 editions

Class designation	IEC 60942:2017 Ed. 4	IEC 60942:2003 Ed. 3
LS	√	√
LS/C	X	√
LS/M	√	X
1	√	√
1/C	X	√
1/M	√	X
2	√	√
2/C	X	√
Key: √ – class included in edition, X – class not included in edition		

2. Amended conformance criteria

In common with other IEC/TC29 standards the 2017 edition of IEC 60942 includes new simplified criteria to demonstrate conformance to the specification of the standard - conformance is now demonstrated when (a) measured deviations from design goals do not exceed the applicable acceptance limits and (b) the uncertainty of measurement does not exceed the corresponding maximum-permitted uncertainty. So, the standard now gives separate acceptance limits, particularly relevant to manufacturers for their design and to users, and also separate maximum permitted uncertainties of measurement for a coverage probability of 95%, relevant particularly to calibration and testing laboratories. In the 2003 edition specifications were in terms of tolerance limits which included the expanded uncertainty of measurement, so the new approach is much clearer.

Two additional Annexes are included in edition 4 – one explaining the new approach to conformance in terms of the relationship between tolerance interval, corresponding acceptance interval and the maximum permitted uncertainty of measurement and one giving useful examples of assessments of conformance to the specifications of the standard.

3. Short-term level fluctuation test

This test has been modified, to improve and make more meaningful the measurement of sound pressure level stability, by considering the mean sound pressure level, and the maximum and minimum levels generated over a period of 60s of operation. This test is performed for pattern evaluation only.

4. Change to some environmental test conditions

Some of the environmental tests to be performed during pattern evaluation have been amended to make them more practical, to avoid icing being produced, which was possible under the tests described in the 2003 edition. This is particularly relevant for the tests of the influence on the sound calibrator of specified combinations of temperature and relative humidity at air temperatures of −10 °C, 5 °C and 0 °C.

5. Addition of an alternative test for immunity to radio-frequency fields

The test for immunity to radio-frequency fields, again to be performed during pattern evaluation testing, has been amended to include an alternative test method using transverse electromagnetic (TEM) waveguides. The requirements for the TEM waveguides and the methods of implementing the testing are described in the more generic emc standards.

How will adoption of IEC 60942 Ed. 4 affect the user?

The changes in edition 4 of IEC 60942 have considerably simplified use of a sound calibrator. The major benefit is that the user will no longer need to apply corrections for ambient environmental conditions, other than for static pressure if using a pistonphone, with the knowledge that within the range of environmental conditions given in the standard the sound calibrator is meeting the specifications. Also, the simplification of the conformance criteria means it is easy for a user to look at the standard and know the acceptance limits around the design goal, a philosophy that also simplifies the approach for manufacturers at the design stage.

As the manufacturers transition from selling devices manufactured to the 2003 edition to new devices manufactured to the 2017 edition of the standard the main change of which users should be aware is the different class designations – for the 2017 edition these classes are class LS, class 1 and class 2, and for pistonphones class LS/M and class 1/M.

References

[1] IEC 60942:2017, Electroacoustics - Sound calibrators
[2] IEC 60942:2003, Electroacoustics - Sound calibrators
[3] BS EN 60942: 2003, Electroacoustics - Sound calibrators

***Susan Dowson** is at the National Physical Laboratory, Teddington, and is currently Chair of IEC/TC29 and Convenor of IEC/TC29/MT17.*

Farewell to Dave Maundrill, a dear friend and colleague

Obituary

Dave Maundrill spent 16 years at WSP and took the lead on the acoustic design of many high profile projects.

On 15 December last year, we said goodbye to a dear friend and colleague, with the passing of David Maundrill BSc(Hons) MIOA.

Dave had a distinguished but all too short career in acoustics, having taken medical retirement from his position as Director of Acoustics at WSP in 2013 when he was diagnosed with a brain tumour.

Dave was born just outside of Bath in Paulton Hospital, on 9 January 1966, the youngest of three siblings. They grew up in the village of Peasedown St John, Somerset, in a house that their parents had built, walking through the village to junior school every day, before attending the nearby secondary school at Writhlington.

After school, Dave attended the University of Surrey in Guildford, studying Physics with Acoustics. It was at university that he met the love of his life, Rosie, who he married in 1990.

Dave graduated in 1988 and went on to join the Research Department of the BBC at Kingswood Warren as a Technician. Before long he moved on to join Hann Tucker Associates as a Senior Consulting Engineer, responsible for many consultancy projects involving architectural and building services vibration and acoustics. This determined the path for the rest of his career.

In 1995 he moved to Stanger Science & Environment as a Senior Consultant in the Noise and Vibration team, before then taking an opportunity in 1997 to set up a new acoustics, noise and vibration team within WSP's Environmental business, a company he remained with for the rest of his career.

Over his 16-year tenure at WSP, Dave built a highly successful and close-knit team of over 30 acousticians, oversaw the integration of new international partners, and took the lead on the acoustic design of some of the most high-profile landmarks in the UK today, such as The Shard, Great Ormond Street Hospital and the London Bridge Station redevelopment. He inspired those in his team with his enthusiasm, passion for acoustics and vibrant style of leadership; everyone in the team felt like Dave 'had their back' and cared about them.

He always found time to give support and guidance, providing clear expectations but allowing room for growth and mistakes. When mistakes were made, Dave would always help to rectify them without hesitation.

The principles, culture and spirit that he instilled at WSP Acoustics still remain in the team today; and beyond within those that have moved on. For many, Dave was a boss who was also considered a friend, which is not an easy situation to create, but for him it came naturally.

Dave had a positive, and yet sometimes unique, approach to life. He was very much a NOW man - if he was ever to do anything it had to be now. This extended to one of his greatest passions in life; music. He never formally learned music – because he said he didn't need to – but his keen ear and characteristic determination gave him the ability to play almost anything. Dave spent a lot of his spare time playing the guitar, bass, keyboards, drums and anything else that took his fancy.

He played various instruments in a number of bands throughout his university and working life, with eclectic names such as 'Hedgehog', 'William Shatner's Pants', and the 'Bearded Mollies'.

When first diagnosed with his brain tumour, it appeared to be harder for his family than it was for him. He never complained, and he remained positive throughout. He pursued new adventures with vigour and enthusiasm; travelling with Rosie, rearing pigs and chickens, growing his collection of musical instruments, and most importantly for him, spending time with family, particularly his niece and nephew. The summer barbecue at the Maundrill house was an annual highlight for friends and family alike, with Dave the ever-generous and gregarious host, seemingly unbowed by his illness.

He regularly told those close to him that he considered himself lucky, saying: "I have lived for seven years with this. Some people don't even get seven weeks." That sentiment was typical of his attitude to his illness.

Dave finally lost his battle on 24 November 2017, passing away peacefully at home beside Rosie and his family.

If there were ever a measure of fondness or affection, a good example would be the number of people who ask after you on a regular basis. This was most certainly true of Dave. He will be sorely missed and those close to him feel immensely privileged to have been a part of his life.

RIP Dave.

Martin Raisborough

Reproduced Sound Conference puts focus on designing for audio quality

By Bob Walker

The 2017 Reproduced Sound Conference, organised by the Electroacoustics Group, moved to a new venue in the Nottingham Conference Centre with the main focus on designing for audio quality.

The conference was held on Wednesday 22 and Thursday 23 November, preceeded by a visit on Tuesday evening to the University of Derby. It was followed on 24 November by an informal visit to Green's Mill and Science Centre in Sneinton, Nottingham.

The conference theme continued from previous years with its exploration of developments in spatial acoustics, electroacoustics, room acoustics, cinema sound and intelligibility. For 2017, the main focus was on designing for audio quality, as indicated by the conference sub-title, *Sound Quality by Design*.

In addition to the Peter Barnett Memorial Award paper, 20 technical papers were presented in seven sessions. These included topics on intelligibility and sound reinforcement, cinema sound, room acoustics, loudspeaker arrays, modelling, measurement and signal processing They provided a very busy and intensive main programme, fully occupying both days from 9:30am until 5:30pm.

The Institute's thanks and appreciation go to Keith Holland for chairing the organising committee and to all the committee members for their contributions over the preceding year in organising the event. Particular thanks go to committee member Adam Hill for his organisation of the visit to the University of Derby and to his colleagues there for arranging the demonstrations and acting as hosts. Thanks also go to the staff of the Nottingham Conference Centre and of the Crowne Plaza Hotel, always friendly, helpful and co-operative, for ensuring the smooth running of the conference and providing excellent and efficient catering for lunches, dinners and refreshment breaks. The committee also expresses its thanks to Linda Canty and the staff of the Institute for their work and constant support.

The technical presentations took place in a large meeting room of the Conference Centre, with an adjoining room being used by the exhibitors, for the refreshment breaks and for the workshop on numerical modelling.

The meeting room had been equipped with an advanced audio system. This had been organised and managed by John Taylor of d&b audiotechnik, assisted by Chris Drew and Jack Page from d&b and Osama Elayan and Harry Blackmore from the University of Derby, who very ably operated the show. The conference organising committee gratefully acknowledges the effort put in by many people in arranging, setting up and managing the technical support. Thanks also go to d&b audiotechnik for the use of their extensive audio system.

The contributions of the exhibitors to the success of the conference are also gratefully acknowledged. Some exhibitors also included sponsorship as part of their exhibition package. Those were valuable and much-appreciated contributions to the conference budget.

The conference was well attended, with 94 registered delegates, of whom 26 were registered as students, nine as Young Members and three as exhibitors. The committee was again pleased to see the large proportion of students and a number of faces new to RS.

The delegates certainly appeared to have had an enjoyable and worthwhile conference. Overall, the Electroacoustics Group committee was very satisfied with the response to the programme and the smooth running and friendly atmosphere. The 2018 event is now being planned, possibly in Bristol, but the details are not yet finalised.

Conference programme

The programme began at with a visit to the University of Derby, with quite a long coach journey in each direction. The university had provided a programme of six demonstrations, preceded by drinks and light refreshments. The visitors were warmly welcomed by The Dean of the College of Engineering and Technology, Dr. Warren Manning, and the Head of the Creative Technologies Research Group, Dr. Bruce Wiggins.

The demonstrations consisted of *Real-time Modular Synthesis using Wave Field Synthesis* by John Crossley, *Diffuse Signal Processing for Live Sound Reinforcement* by Jon Moore and Adam Hill, *Guitars with Ambisonic Spatial Performance* by Duncan Werner and Bruce Wiggins, *Ambisonics for Theatre* by Alex Vilkaitis and Charlie Middlecott, *Tissue Conduction Headset* by Ian Mckenzie and Peter Lennox and *Speech Intelligibility of Lecture Recordings* by Simon Lewis and Mark Dring.

The visit was well attended and the visitors found the evening to have been interesting and thought-provoking. The effort put into organising the evening by all the staff and students involved was greatly appreciated. The Institute's thanks go to the many staff and students who went out of their way to present their work and facilities in an informative and friendly manner.

The following day, registration for the conference proper was open from 8:00 am.

The conference was formally opened at 9:15am by the Electroacoustic Group Chairman, **Keith Holland**, who presented a brief history of Reproduced Sound Conferences and noted the opportunities offered by the conferences for networking. He welcomed the delegates to the venue and said that the conference had been well supported, with many papers submitted and good attendance numbers.

The welcome address was followed by the presentation of the **Peter Barnett Memorial Award** to **Floyd Toole**. The award presentation was followed by the remaining technical sessions of the day.

The first day's technical sessions were followed by a short break until 7:00pm before a reception, followed by the Conference Dinner at 7:30pm. After the dinner, Institute President **Jo Webb** presented three Institute awards. P12 ►

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The first was the RWB Stephens Medal, presented to **Prof. Murray Campbell** of the University of Edinburgh for his long history of contributions to the science of acoustics and the Institute.

The second was the IOA Young Persons Award For Innovation In Acoustical Engineering – sponsored by Cirrus – to **Alex Southern** of Aecom.

The third award was for Services To The Institute to **Simon Kahn** of Mott MacDonald, in recognition of his contributions to the Institute, especially to Education, over a long period. Electroacoustics Group Chairman **Keith Holland** thanked everyone involved in organising and attending the conference, especially the committee members, venue staff and **Linda Canty.** He said that Linda, in particular had, as usual, put a great deal into the organisation of the conference, ably assisted by other members of the Institute staff.

Following the Chairman's after-dinner address, **Gareth Fry** (sound designer) continued and enlarged on his session paper from earlier in the day on the subject of live and recorded binaural presentations to a live audience. The effort put in by Gareth and his colleagues, both for his demonstration as part of his presentation earlier in the day and for the 30 pairs of headphones set up for the after-dinner presentation were much appreciated by the delegates. The conference organising committee offers sincere appreciation and thanks to Gareth for that.

The second day of the conference started at 9:00am with further Technical Sessions. They continued until the last paper of the conference ended at 5:00pm. The sessions were followed by a workshop on numerical modelling by Patrick Macey, in which he gave a hands-on demonstration of his FEM/BEM software.

Later, after the close of the formal conference, there was an informal workshop by Philip Newell, who entertained the substantial audience with tales, anecdotes and personal reminiscences of audio recording in the 70s. The audience expressed surprise when told of the costs of audio equipment in those days – a four-track recorder costing as much as a detached house in Purley. The talk was much appreciated by the 30 or so people present, with a suggestion that a similar presentation should be recorded for posterity – the number of people now with first-hand experience of the early days of audio recording at that level is getting quite small.

The visit to Green's Mill and Science Centre was inspired by the story of a miller's son who developed a mathematical principle, now called *Green's Theorem*, that is today widely used in many physics disciplines, including acoustics. **George Green** (1793 – 1841) had only about one year's formal education at the age of about 8 and was mostly self-taught, before deriving the theorem now known by his name at the age of 35. Only about 10 delegates attended, but they all found it interesting and thought-provoking.

Technical sessions, 22 November

The day started with the presentation of the **Peter Barnett Memorial Award** to **Floyd Toole** by the Institute's President **Jo Webb**. Sadly, Floyd could not be present to receive the award. The citation was read by **Jo Webb** and Floyd's response was read by **Glenn Leembruggen**.

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Floyd Toole, left, with Nick Antonio, Antonio Acoustics, USA

Professor Murray Campbell of the University of Edinburgh receives the RWB Stephens Medal from IOA President Jo Webb

Alex Southern of Aecom (centre) with James Tingay from sponsors Cirrus Research and Jo Webb

Simon Khan of Mott MacDonald receives the Services to the Institute award from Jo Webb

Glenn continued with an accomplished presentation of Floyd's paper *Loudspeakers and rooms: 50 years of research*. Floyd's paper began with some remarks about his early days and audio. His main theme was, however, what he called the 'circle of confusion' – in the development of audio, the indeterminate loop comprising loudspeakers and recordings being assessed in rooms using rooms, loudspeakers and recordings. He continued with discussions of a number of aspects of rooms, loudspeakers and sound fields in rooms.

Session 1, Intelligibility and Sound Reinforcement, Chairman – Glenn Leembruggen

Session 1 began with *Efficient acoustic modelling of large spaces using finite difference methods* by **Simon Durbridge** (Bowers and Wilkins) and **Adam Hill** (University of Derby). The paper was presented by Simon. It described various methods for improving the efficiency of numerical methods. In questions, **Jamie Angus** noted that the focus had been on improving the numerical processing whereas today's limitation might actually be memory access time. Simon suggested that GPU processing could reduce that.

The session continued with *Big pictures and small screens: how television sound research can work with, and for, hard of hearing viewers* by **Lauren Ward**, **Ben Shirley** and **William J. Davies** (University of Salford). The paper was presented by Lauren. It included descriptions of three possible predictors of improvements created by relevant sound effects cues. Glenn Leembruggen asked whether there had been any consideration of masking or spectral adjustments. The answer was that they were on the 'to do' list.

That was followed by *Acoustics of reproduced sound in large spaces* by **Simon Kahn** (Mott Macdonald). In his presentation, Simon reviewed the difficulties with large spaces and suggested that it was best to start with a 'nice' space! He included a number of examples and discussed a list of design parameters, including reverberation time, room geometry, early reflections and loudspeaker positions.

The final paper of the session was *Study on setup, parametrization and implementation of subwoofer arrays suited for active noise control in event noise management* by **Christian Frick** and **Patrick Nüesch** (Rocket Science GmbH, Zurich, Switzerland). The paper was presented by Christian. It described a system for active control of low frequency noise from a venue. Microphones set up in sensitive remote positions had been used to implement adaptive, feed-forward and feed-back LMS algorithms to minimise the noise disturbance at particular receiving points.

The session was followed a break for lunch in the Business School refectory.

Session 2, Cinema sound, Chairman – Adam Hill

After the lunch break, the programme continued with *Soundtrack as auditory interface: exploring an alternative to audio description for theatre* by **Mat Dalgleish** and **Neil Reading** (University of Wolverhampton). The paper was presented by Mat, who noted that up to the early 1800's theatres had been solely governed by voice dominance. After that, theatres became more technical. Now, about 40% of theatres employ some form of audio description to assist visually-impaired audience members.

The next paper was *Distributed loudspeaker array measurement and correction techniques* by **Joules Newell** (Independent Consultant), **Philip Newell** (Acoustic Consultants, Spain) and **Keith Holland** (University of Southampton). The paper was

presented by Philip, who described measurements in a dubbing theatre in Lisbon. The results showed clearly that the measured responses changed with microphone position and also illustrated the "nonsense" of averaging over several positions and attempting to equalise the overall response.

The next paper continued the theme, with *The effect of seats on the calibration of cinema sound systems* by **James Knatt**, **Keith Holland** (ISVR, University of Southampton) and **Philip Newell** (Acoustic Consultants, Spain). The paper was presented by James. He began by presenting a series of measurements at various heights from 1.1 – 2.0m above the seat backs. To the question "can listeners tell the difference?" the answer was "yes". To "Do listeners prefer the correct response?" the answer was that they showed no preference. The paper was followed by quite a lively discussion, with many questions and answers.

The session was completed by **Gareth Fry** (Sound Designer) presenting *The Encounter – the first binaural show on Broadway. The concept, challenges and delivery of live and recorded binaural sound to 850 audience members.* Gareth described the concept of presenting binaural sound to a large audience and the difficulties of setting up the very large number of headphone sets. Live sound from a dummy head and pre-recorded sound had been used in a large-scale theatre presentation, which had toured a number of cities in the USA and Sweden. The presentation included a headphone demonstration to 35 delegates. The attempt to allow all the audience to listen by means of a WiFi network and a 'smartphone app' was only partially successful due to problems with the router. However, the concept was interesting for future presentations.

That was followed by a break for refreshments before the final session of the day.

Session 3, Room acoustics, Chairman – Emma Bigg
The first paper of the session was *Acoustics of a small room: comparison between FEM and measurement* by **Patrick Macey** (PACSYS) and **Kelvin F Griffiths** (Electroacoustics Design). The paper was presented by Patrick and Kelvin in turn. Kelvin described the room and its model, which had a pair of nearly-coincident modes at about 70 Hz. Patrick described the meshing, which he said was adequate for up to 1 kHz. From comparisons of the calculated and measured results, it was evident that the room's more flexible surfaces (doors and windows) had significant effects and, unexpectedly, increased the modal frequencies.

The final paper of the session was *Acoustics in new concert halls in Hamburg and Dresden* by **Wolfgang Ahnert** (ADA Acoustics & Media Consultants, Germany). He presented details of two new or restored concert halls, in Dresden and Hamburg, completed in the last year. These were both large projects. The presentation included many photographs, drawings and measured responses.

Technical sessions, 23 November

Session 4, Arrays and modelling, Chairman – Bob Walker
The second day of the conference started at 9:30 a.m. with *A 2-way loudspeaker array for improved transaural reproduction* by **Marcos Simón**, **Charlie House** and **Filippo Fazi** (ISVR, University of Southampton). The paper was presented by Marcos, who described a joint programme with BBC R&D and others to improve the audio experience for home listening. A long list of target conditions was enumerated. The resulting development of a adaptive loudspeaker array showed good high frequency separation. The presentation was followed by a large number of questions and answers and a lively discussion. P16 ►

The second paper of the session was *Modelling the performance of speaker arrays in domestic listening environments* by **Mark Dring**, **Alexander Vilkaitis**, **Charles Middlicott**, and **Bruce Wiggins** (University of Derby). The paper was presented by Mark, who began with a list of small room problems and their modelling. Conventional 2-D Ambisonics had been used, at 1st, 2nd and 3rd orders, to combine HRTF and binaural coding in convolving anechoic audio for headphones. The results for localisation showed no significant differences with order, with source material or in front/back reversal. In the ensuing discussion, Jamie Angus asked why only four loudspeakers when Gerzon had said the minimum was six?

That completed the session and was followed by a break for refreshments.

Session 5, Measurement, Chairman – Robin Cross
The first paper of Session 5 was *Why is the live sound target Eq curve not flat and what should we measure for a good audience experience?* by **John Taylor** and **Steve Jones** (d&b audiotechnik). The paper was presented by the two authors in turn. John presented a curve derived from experience as acceptable. He referred back to Floyd Toole's 'circle of confusion' and asked how we know what was 'right' when loudspeakers are measured with close microphones and listened to in arrays at distance. Steve continued by presenting some measurement from some venues. He described the difficulties with equalisation and in separating the direct and late-arriving sound. A real-time analyser did not measure what the audience hears and suggested that time-windowing might be used to differentiate between early and later sound.

The second and final paper of the session was *The Gaussian assumption considered harmful: what is the correct audio PDF?* by **Jamie Angus** (University of Salford). Jamie presented measurements on the amplitude distribution of typical audio signals and questioned what the most appropriate signal for testing was. He showed that a Gaussian distribution like random noise was quite unrepresentative of most audio sources.

The session was followed by the Electroacoustic Group AGM and then a break for lunch in the Business School refectory.

Session 6, Signal processing, Chairman – Keith Holland
In *Microphone wind noise reduction using the singular spectrum analysis techniques* by **Omar Eldwick** and **Francis F Li** (University of Salford), Omar began by describing how wind noise frequently causes problems for microphones. The proposed method used adaptive spectral filtering to reduce the effects of wind noise.

The second paper was *The speech conformer for achieving good speech intelligibility for all speakers* by **Xavier Meynial** (Active Audio, France). Xavier presented an algorithm for adapting a speaker's voice for better intelligibility. The algorithm adjusted the spectrum of voice input to conform to an ideal target spectrum. The target spectrum could be a standardised one or a custom one set up by the user. In a live demonstration, the system automatically and effectively equalised a speaker's voice by adjusting three broad frequency bands. The algorithm appeared to be both fast and stable.

The final paper of the session was *Applications of dynamic diffuse signal processing in sound reinforcement and reproduction* by **Jonathan Moore** and **Adam Hill** (University of Derby). The paper was presented by Jonathan. It explored the effects of dynamically de-correlating a signal to reduce spatial variation over a target area using DiSP. The process permitted de-correlation between reflected and direct sound in order to reduce coherent interference effects.

The session was followed by a break for refreshments

Session 7, Loudspeakers and arrays, Chairman – John Taylor.
The first paper of the session was *The electroacoustic design of a handheld hearing device* by **Zachery Simcox** and **Keith Holland** (ISVR University of Southampton). The paper was presented by Zachary. The objective had been to produce a hearing aid for use by a care worker without disturbing the recipient. A substantial design process had included mechanical as well as electro-acoustic developments. The results showed that further development was needed. The presentation was followed by a lively discussion and many questions.

That was followed by *Investigating multiple off-axis listening positions of an OPSODIS sound bar* by **Laurence Haines**, **Takashi Takeuchi** and **Keith Holland** (University of Southampton). The paper was presented by Laurence and continued previous work on the performance of sound bars using the Optimal Source Distribution concept for crosstalk cancellation and the reproduction of binaural audio for multiple listeners simultaneously. The latest development gave satisfactory separation for up to three listeners simultaneously.

The third paper of the session and final paper of the Conference was *Personal Spatial Audio in Cars* by **Charles House**, **Sarah Dennison**, **Dylan Morgan**, **Nicholas Rushton** and **Gregory White** (University of Southampton). The paper was presented by Charles, Dylan and Greg. The presentation described the development, for cars, of 2-dimensional loudspeaker arrays consisting of two rows of small, staggered loudspeakers. The results in an anechoic room had shown good separation for up to four locations (two ears/two people). The in-car performance had been shown to be best using measured transfer functions. A lot of the effort had gone into the hardware design rather than system development.

Workshop – application of FEM and BEM in audio – Patrick Macey (PACSYS)
Patrick presented a step-by-step demonstration of using several software packages to first create a 3-D room design, then create an analysis mesh and finally derive a numerical solution. For the purposes of the workshop, Patrick had made available a restricted version of his commercial software. Quite few of the delegates present had come equipped with computers on which to install the software and follow the demonstration steps.

The allotted one-hour session was, of course, much to short to do much more than simply follow the demonstration. However, a number of the delegates present did manage to get to the solution, despite the very considerable complexity of the software. The delegates also ended up with a working copy to take away and 'practice' at their leisure.

The Conference Committee wish to express their thanks to Patrick for his efforts in preparing his demonstration files and reducing the difficulty in understanding the topic at a practical level.

The workshop concluded the formal conference proceedings at 18:00 hrs.

It more than pays for itself

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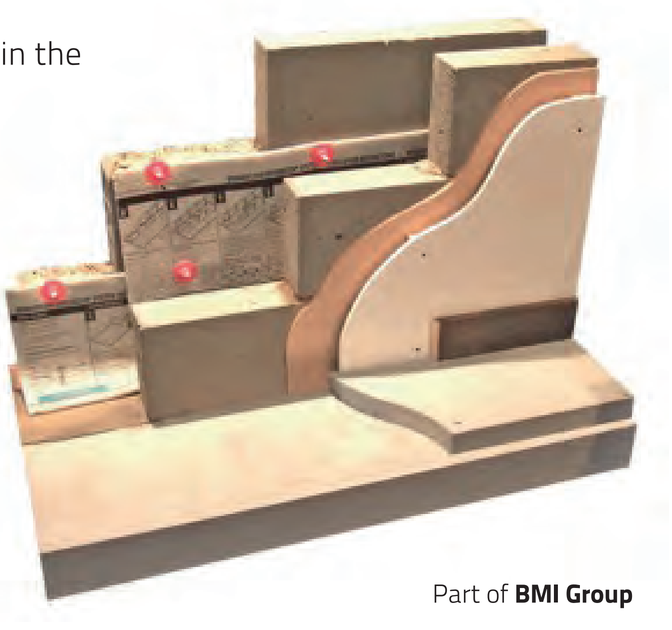
- Isolates party walls from flanking sound transmission.
- Superior acoustic isolation and damping performance.
- Can be used as an isolator for steel where a party or flanking wall is to be built off it.
- Permits the use of a continual slab between dwellings & apartments.
- Facilitates easy detailing for steps and staggers.
- Demonstrates a significant cost saving and flexibility in the design and build of the development.
- Surpasses performance requirements of Approved Document E of the Building Regulations.
- Specified within Robust Details Appendix A2 (as of August 2008).
- Provides 4 credits for the Code for Sustainable Homes & Home Quality Mark.



BS 4142 and Context: Workshops on what it is and moving forward

Two workshops on BS 4142 and Context were held in February. The first was at London South Bank University and the second at the University of Salford. Both were full with a total of 120 delegates contributing to the proceedings.

The meetings were chaired by Phil Dunbavin, chairman of the BSI's EH/1/3 committee responsible for BS 4142 and other environmental standards. Phil gave a presentation which covered the history of BS 4142 from its origins as Appendix XV of the Wilson Report in 1963. He demonstrated that the concept of context is not new and whilst not overtly named in the Wilson report it was clearly articulated even then.

This was followed by a presentation from Stephen Turner (acoustic consultant formerly of Defra) who covered the now large raft of policy documents that use the word 'context' in the framework of sustainability. He made sense of all these policy statements and demonstrated clearly how they are all interlinked and related to each other.

Tony Clayton is the senior noise advisor for the Environment Agency and he considered the context of context. He described how the Environment Agency considered context when undertaking assessments for the permitted processes under the Environmental Permitting Regulations, and how the regulatory approach is consistent with the NPSE. He explained the concepts of BAT, BATNEEC, and Appropriate Measures and how, for noise, they are essentially for all practical purposes the same thing. He also explained the common principles for processes regulated by SEPA, NRW and NIEA.


Tony Clayton, Jon Tofts, Phil Dunbavin, Stephen Turner

Finally, the last speaker of the morning, Jon Tofts, who is a noise advisor in the same team as Tony for the Environment Agency, presented some intentionally fairly controversial case studies and described how he had considered the context of each case.

After lunch each meeting split into six groups to consider four very pertinent questions and then to add to their subsequent report back to the meeting any other concerns or suggestions for improving the standard.

All aboard for London Branch social event at The Admiralty

The London Branch has organised a social event, sponsored by Mason Industries, to coincide with the half-day Building Isolation Workshop on Tuesday, 20 March.

The social event will held in a private function room at The Admiralty pub in Trafalgar Square from 5.30pm. The Admiralty is a step back in time to the decks of HMS Victory and the Battle of Trafalgar. Looking out to Nelson's Column, it's officially London's most central pub.

This evening social event is free to IOA Members and the general public and will allow discussions from the workshop to be continued, and for those who were unable to attend the event to join us, but we request that you pre-register for the event by going to the registration page at:
http://bit.ly/2EN3ovg

If you register and are no longer able to attend this event, please cancel your ticket via Eventbrite so that your place can be offered to someone else.

The closest train station is Charing Cross (approx. 5 min walk). The closest underground station is also at Charing Cross (approx. 2 min walk), Piccadilly Circus (approx. 6 min walk), Leicester Square (approx. 7 min walk) or Green Park (approx. 16 min walk).

For more details of regional branch activities please refer to the IOA website:
http://www.ioa.org.uk/

The Admiralty is at 66 Trafalgar Square, London WC2N 5DS. For more details of the venue please refer to the website:
http://bit.ly/2sNkYdj

London Branch: Presentations review

Environmental noise impacts on planning developments: *Prevention is better than cure*

Presentation based on Stuart Goodbun IOA Diploma final project report.

At the IOA London Branch meeting on 18 January, Stuart Goodbun gave a presentation on his Diploma project. This was the culmination of his studies at London South Bank University.

Stuart studied the Post Graduate Diploma in Acoustics as part of his role at Wycombe District Council. The topic of Stuart's project was the *Environmental noise impacts on planning developments*, specifically railway noise. As part of Stuart's job role he would have to regularly consult on planning applications and give guidance or impose conditions on applications to mitigate the adverse effects from noise on developments.

The reason for selecting this project was to enable Stuart to give an objective view point with which to advise planners, developers, architects or other interested parties when looking to develop or improve areas affected by environmental noise.

Stuart started by identifying various sources of environmental noise such as the M40 motorway and Wycombe Air Park as well as the Chiltern railway line in Wycombe Councils' district. Three discreet locations (urban, semi-urban and rural) were selected for monitoring to give representative samples for each of these types of location. From national time table information and monitoring Stuart was able to calculate hourly impact levels as well as day, evening and night time levels for each of the locations. Stuart reviewed literature including the WHO Guidelines for Community Noise, the National Planning Policy Framework, the Noise Policy Statement (England) and the recently published Professional Planning Guidance 2017. Comparing monitoring results, Stuart proposed *Criteria for adverse effect levels*. He used a traffic light system reflecting differing degrees of adverse health effect levels and the requirement for further assessment of conditions for a proposed development. Stuart also proposed standard noise impact levels for noise sensitive developments affect by environmental noise. These standard levels could be easily reviewed and an assessment made on whether or not a development would be suitable for an area or whether there would be a requirement for conditions to be placed on a planned application to mitigate any adverse effects from environmental noise.

Stuart went on to demonstrate how his proposed criteria for adverse effect levels and standards for noise sensitive developments affected by environmental noise can be used. Using derived day, evening and night-time exposure levels Stuart modelled the environmental noise impact for a current development. He also went through a selection of control measures to reduce the noise impact on the environment, which also highlight the need for good acoustic design, a key principle of the Professional Planning Guidance 2017.

Stuart's presentation and project were well received by the industry professionals and questions were focused on

Question time with Ben Dixon and Stuart Goodbun

P22 ►

the project application, notably the need for the acoustic environment to be considered early on during the planning process and for developers, planners, architects and local authorities to work more closely together. This would help deliver projects that would not adversely affect the health and welling being of those who live in the area and reduce the risk of costly reworking.
http://www.lsbu.ac.uk/courses/postgraduate
http://lsbu-acoustics.blogspot.co.uk/

The viability of an abbreviated impact sound insulation testing method

Presentation based on Ben Dixon IOA Diploma final project report

Ben Dixon delivered a presentation about the viability of an abbreviated impact sound insulation testing method to members.

Ben is an acoustic engineer with over five years' experience of testing in the field and has recently concluded his Diploma studies at London South Bank University.

During his presentation, he stated that the impetus behind his work is partly due to issues on building sites arising from time constraints, logistics, interruptions and extraneous noise. All of these factors can make completing an ISO 16283-2:2015 compliant impact sound insulation test an arduous and possibly overly-complex task. This is because the single-figure result that is produced is often not required by developers so much as a 'pass or fail' mark. He postulated that if a 'pass mark' is all that's required, it may be possible to demonstrate a representative result from an abbreviated test procedure where fewer discreet measurements are taken.

The other reason he put forth for this research was the idea that a shorter testing method could actually save the client money and incentivise developers to get more comprehensive design advice at earlier stages of development. He made the case that there have been many times where the floor design far exceeds the sound insulation performance requirement of building regulations. The presentation also included an example of separating floor that failed to meet building regulations. This was because it was not originally identified as a potential problem area and was subsequently not tested post competition.

The abbreviated method used ISO 16283-2:2015 as the frame work for the test procedure but used a reduced number of source locations. Examination of the results from preliminary ISO tests showed that source locations near flanking elements typically yielded worse results overall and the research progressed under the premise that it was possible to exploit common flanking weaknesses in isotropic floor make-ups. 14 partitions in total were tested and the results compared.

A number of tests were carried out on the same isotropic floor partitions to assess the robustness and repeatability of the method, along with the same number of ISO tests and the results compared. The Abbreviated Method test results produced consistent results that were 3dB worse than the ISO test results on the same partition. Comparison of the results to the permitted standard deviations as expressed in 1/3octaves in ISO 12999-1 showed that the deviations (with the exception of 160Hz) fell within the permitted range for repeatability. However the tests on anisotropic floor make-ups were for more erratic and unreliable.

He concluded that although not extensive enough and by no means exhaustive, an abbreviated test procedure could be utilised in certain conditions. Considering that the Abbreviated Method test results produced an arguably 'worst case' result, could developers be incentivised to save on testing fees and spend more on design advice?
http://www.lsbu.ac.uk/courses/postgraduate
http://lsbu-acoustics.blogspot.co.uk/

The Branch Committee would like to thank Stuart and Ben for their presentations and WSP for providing the venue.

Midlands Branch: Lancashire shale gas exploration: drilling noise and the planning process

By Young Youn

In November 2017, David Hiller of Arup Acoustics gave a talk on his involvement addressing noise issues in relation to a planning application (then later planning appeal inquiry) for two proposed shale gas exploration sites in Lancashire that he also presented to the London Branch in June 2017.

He kicked-off by giving some background information on hydraulic fracturing techniques, commonly known as 'fracking'. David then described the noise prediction method and presented the journey to reach an agreement on the assessment criteria between the client and the local authority. It was fascinating to learn that of all the potential objections to 'fracking', noise was a key sticking point in gaining planning permission; ultimately leading to some stringent noise limits and a high burden on the client for noise mitigation measures.

The Branch committee would like to thank David for sharing his experience on a unique case study and the University of Derby for providing the venue.

Sound Masking

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

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- Other people's conversations can be an irritating distraction
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Acoustic design of stadia for sound management

By Mike Breslin

In December 2017, Jim Griffiths of Vanguardia gave a highly entertaining presentation which gave an insight into the issues faced by acousticians involved in the design of stadia for sport and music events. He introduced the concept of *The Atmosphere Wheel*. This is a concept Vanguardia uses, to explain the importance of, and interaction between, the team, the sound system, supporters and the acoustics of the stadium.

Jim explained how the ambience could be manipulated to make the experience of playing at a particular stadium exciting and uplifting for the home supporters and team but intimidating for the away team. Replaying sampled crowd noise, rhythmic drumming or someone leading the chanting through the sound system, for instance, can be used to promote a charged atmosphere.

In order to build atmosphere in a stadium, a degree of reflection is required but this, of course, makes achieving good speech intelligibility for the sound system difficult to achieve so there is a balance to be struck.

Jim outlined the four levels of sound system design. Tier 1 – voice announcement, Tier 2 – voice announcement and some limited capacity for music, Tier 3 – designed for music and Tier 4 – a production quality sound system. Some audio samples, used to illustrate the differences between these degrees of fidelity to clients, were played during the presentation.

Many stadia are also used for major musical events and this brings an additional set of issues. Dealing with the first and second order reflections can be a particular problem (think of the huge dimensions involved and consequent long arrival times). Getting the delays right on the delay towers so that the system is time aligned is also a critical issue. Some acts bring their own sound systems so these issues may need to be addressed multiple times at a particular stadium.

It is only when the artists begin the sound check that the acceptability of the sound on stage becomes apparent. Jim entertained us by recounting the difficulties of trying to meet the aspirations of artists such as U2, Madonna, Eminem and their attendant engineers.

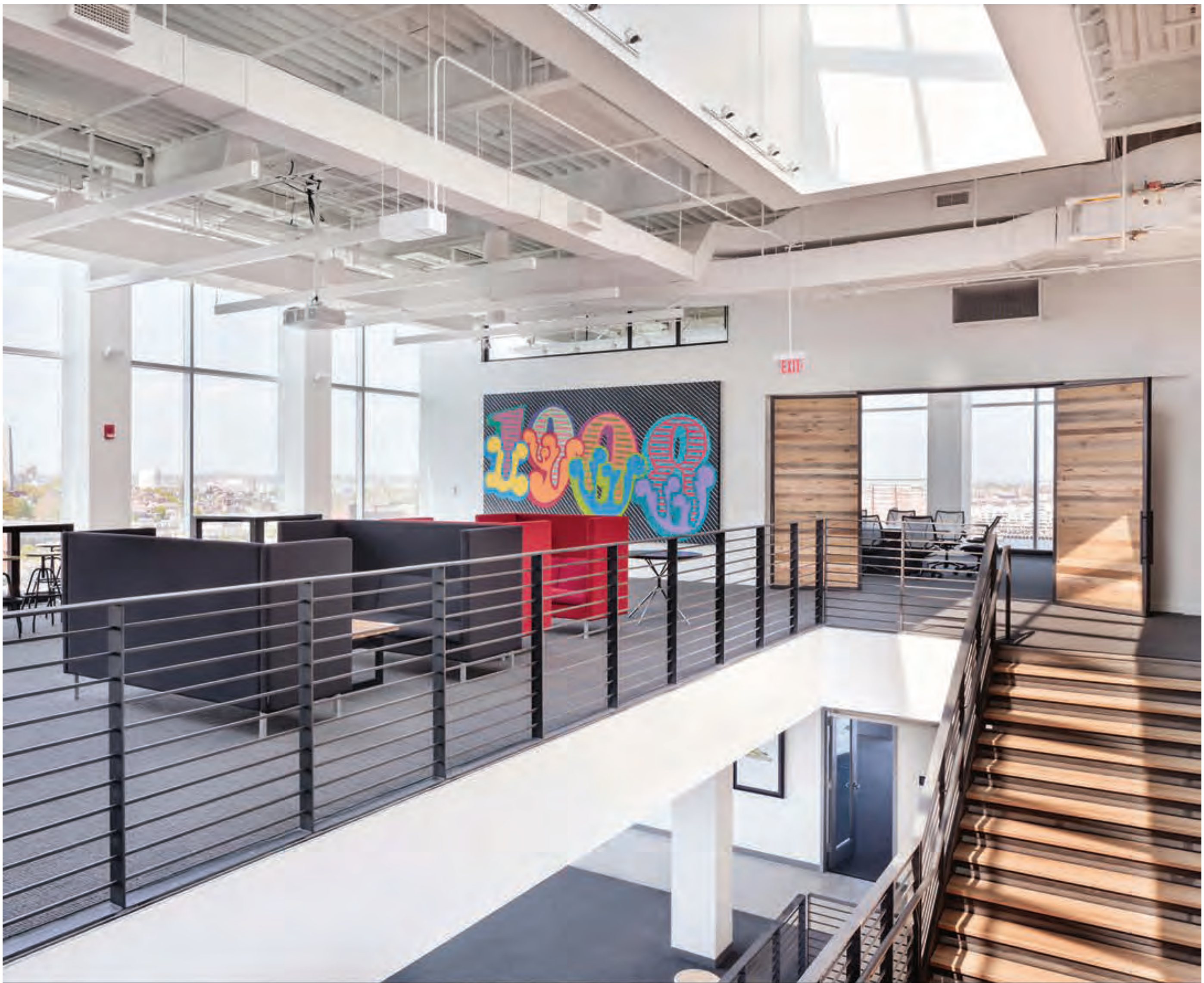
Atmosphere can be manipulated in arenas and stadia (Courtesy of Vanguardia)

Of course, getting the sound right for those inside the stadium is only one aspect of the job. Controlling the environment impact outside the stadium (or event) is a significant element of entertainment sound/noise. In stadia low frequency absorption can be a challenge, especially when the act turns up with multitudes of low frequency drivers. With regard to stadium design, leaving gaps in the terraces can cause particular problems in this regard (as well as making it more difficult to use the positive impact of reflections to enhance the atmosphere in the stadium).

Before taking questions, Jim talked about how Vanguardia had used the Me Trao system (manufactured in Holland but distributed by Vanguardia in the UK) to control the environmental impact of multiple stage festivals. The system has an attractive interface and incorporates a messaging service so that the engineers and consultants can all see what is going on. The system employs a method of comparing the level vs time signals in contiguous 15 second level samples in each third octave band in order to evaluate which stage (source) is the principle noise source at off-site positions.

The Midlands Branch Committee is grateful to Jim Griffiths for an entertaining and illuminating presentation and to the University of Derby for providing the venue, refreshments and facilities to enable the event to take place.

Atmosphere can be manipulated in arenas and stadia (Courtesy of Vanguardia)



Scottish Branch: Getting excited by science

By Alistair Somerville

Once again our Institute is sponsoring education and outreach through the EISF Generation Science programme. Through this we aim to encourage the young to get excited about science, choose STEM subjects at school and make them aware of acoustics related career opportunities.

I attended the EISF programme launch in Edinburgh on 7 February, when the IoA was thanked for its support of the Generation Science programme by EISF Director, Dr Simon Gage OBE, in his launch presentation.

Our input takes the form of supporting two activities, **Careers Hive** and the **Generation Science** shows. Careers Hive is their newest education project and is designed to open students eyes to the wealth of opportunities available to those who have studied STEM subjects.

In 2017, this immersive experience included school sessions for groups of S1-S3 pupils during a special schools week, attracting more than 2,400 pupils and around 200 teachers from 38 high schools in 12 local authorities across Scotland. The Generation Science shows and workshops started on 29 January and run until 18 May. Our funding will provide for the delivery of Generation Science performances to 20 primary schools.

Burns and film night

The Scottish Branch hosted a traditional Burns Night fare supper on 25 January, before a viewing of the film *In Pursuit of Silence*, directed by Patrick Shen and part funded by the IOA.

The film is a meditative exploration of our relationship with silence, sound and the impact of noise on our lives. Beginning with an ode to John Cage's ground-breaking composition *4 minutes and 33 seconds*, it takes us on an immersive cinematic journey around the globe – from a traditional tea ceremony in Kyoto, to the streets of the loudest city on the planet, Mumbai, during the wild festival season – and instantly inspires us to experience silence and celebrate the wonders of our world.

It was a good night out socialising over the meal and all agreed that the film was a worthwhile project for our Institute to sponsor. Many thanks to RMP for hosting it and Nicola Robertson for most of the organisation.

Addition to Diploma results published in Jan/Feb issue of Acoustics Bulletin

Diploma Awarded
Distance Learning (Bristol)
Shire, N

IOA Diploma Results Chart for 2017

Centre Name		GPA	Project	Labs	BA	NVCE	RA	EN	
Distance Learning (Bristol)	Merit	8	5	5	3	3	3	3	
	Pass	4	6	8	4	1	3	5	10
	Fail	1	4	0	2	0	1	0	
Distance Learning (Edinburgh)	Merit	5	2	1	1	0	1	3	
	Pass	3	6	8	7	2	1	3	10
	Fail	2	2	0	1	2	0	2	
Distance Learning (St Albans)	Merit	9	7	6	5	2	3	4	
	Pass	10	13	12	4	7	2	6	15
	Fail	3	3	1	8	1	1	6	
DLDUBLIN	Merit	5	4	5	0	0	2	2	
	Pass	1	2	3	4	2	1	5	6
	Fail	3	4	0	1	1	0	1	
Leeds Beckett University	Merit	7	3	5	0	0	0	2	
	Pass	5	11	10	4	6	9	7	10
	Fail	6	5	1	2	0	2	4	
London South Bank University	Merit	12	6	11	2	3	0	1	
	Pass	7	14	12	17	17	1	0	18
	Fail	9	5	1	6	7	0	0	
Southampton Solent University	Merit	7	4	3	0	2	0	0	
	Pass	4	5	7	7	7	1	3	9
	Fail	3	5	1	4	2	0	1	
University of Derby	Merit	7	4	9	3	2	0	5	
	Pass	6	9	9	5	8	0	5	12
	Fail	5	5	0	3	3	0	3	
Totals	**Merit**	**60**	**35**	**45**	**14**	**12**	**9**	**20**	
	Pass	**40**	**66**	**69**	**52**	**50**	**18**	**34**	**90**
	Fail	**32**	**33**	**4**	**27**	**16**	**4**	**17**	

Subjective evaluation of tonality and impulsivity in accordance with BS 4142: 2014 – an analysis of the audience results from five IOA branch meetings (Part 2)

By Mike Breslin

Commentary on tonal assessments

Sample 1: Axial fan

Sample 1 was a relatively steady noise in terms of amplitude and frequency content.

78% of the respondents selected a correction of 2, 3 or 4 which compares reasonably well with the Joint Nordic 2 correction of 3.4 dB. However, 14% of the respondents rated Sample 1 as meriting no correction for tonality and 7% gave it the full 6 dB correction.

One respondent rated Sample 1 as meriting a 9 dB correction for tonality.

Sample 2: General industrial machinery noise

Sample 2 was slightly less steady than Sample 1 with a number of relatively small changes in level and character.

The Joint Nordic 2 assessment for Sample 2 resulted in a 4.8 dB correction. 47% or respondents gave this sample a correction of 4 and the next most popular correction was 2, chosen by 32%.

About 8% gave this sample a 0 dB tonality correction with about 9% choosing the full 6 dB correction.

One respondent rated Sample 2 as meriting a 9 dB correction for tonality.

Sample 3: Machinery and air handling noise

Sample 3 was a relatively steady noise in terms of amplitude and frequency content.

The Joint Nordic 2 assessment for Sample 3 identified the most affected critical band as being 7260.5 – 8873.9 Hz (i.e. a fairly high frequency) and with a resulting 2 dB correction.

2 dB was the mode of the subjective responses with 47% of respondents choosing a 2 dB correction. 33% chose a 0 dB correction. More people chose a 0 dB correction for Sample 2 than any other sample. 3 respondents (~ 1%) rated Sample 3 as being highly tonal giving it a correction of 6.

Sample 4: Air handling noise

Sample 4 was a relatively steady noise in terms of amplitude and frequency content.

The Joint Nordic 2 assessment for Sample 4 resulted in a 5.6 dB correction. However, highest tonal component was as 67 Hz with additional components in the same critical band at 50 and 100 Hz (i.e. relatively low frequency).

The modal subjective result was a correction of 2 dB (51% of respondents) with 30% rating Sample 4 as having a 0 dB correction.

Less than 20% of the respondents rated Sample 4 as meriting a correction of 4 dB or more.

2 respondents (~ 1%) rated Sample 4 as being highly tonal giving it a correction of 6.

Sample 5: Stack

Sample 5 was a relatively steady noise in terms of amplitude and frequency content.

The modal and average subjective results for Sample 5 (4 and 4.1 dB respectively) were pretty consistent with the Joint Nordic 2 result of 4.4 dB. 22% of respondents gave Sample 5 a full 6 dB correction with 4 respondents (~ 2%) deciding that Sample 5 did not merit a tonal correction at all.

Sample 6: Large press and fan

The Joint Nordic 2 assessment for Sample 6 identified tonal components in a critical band centred on 212 Hz which are than 12 dB above the threshold of audibility meriting a full 6 dB correction.

52% of respondents gave Sample 6 a tonal correction of 4 dB and 21% gave it a 6 dB correction (and 2% rated it as having a 5 dB correction).

12 people (around 6%) did not think that Sample 6 merited any tonal correction at all.

There are a two factors specific to Sample 6 which would be taken into account when considering the results for this sample:

- there are distinctive amplitude fluctuations which may be the predominant acoustic feature that people notice; and
- the principal tonal components are relatively low frequency.

There may also have been a reluctance for some respondents to choose the maximum available correction.

Sample 7: Fan

Sample 7 was a relatively steady noise in terms of amplitude and frequency content.

The Joint Nordic 2 assessment for Sample 7 resulted in a full 6 dB correction due to tonal components in the critical band with a centre frequency of 158 Hz being 17 dB above the masked threshold.

9% of respondents did not think that Sample 7 merited a tonal component. Perhaps there is an element of people not identifying relatively low frequency tones as being tonal.

4 dB was the modal result chosen by 42% of respondents with around 31% choosing a 6 dB correction.

Reluctance to choose the extremes of a subjective scale may have been a factor.

Sample 8: Forklift and loading operations

Sample 8 was the sound of fork lift trucks carrying metal components across uneven yard and road surfaces with a background of general machinery and air handling noise. There was intermittent use of tonal warning signals.

The tonal warning signals were evident in the Joint Nordic 2 assessment despite the influence of 1 minute linear averaging. The influence of the tonal warning signals was not evident in the third octave measurement of Sample 8 partially because of the way in which frequent impulsive noise affects short-term Leq.

The Joint Nordic 2 assessment resulted in a full 6 dB correction due to the tonal warning signals and 6 dB was the modal subjective result chosen by around 53% of respondents.

Around 10% of respondents did not consider that Sample 8 merited any tonal correction.

Sample 9: Tyre fitting
Sample 9 was a minute of activity recorded around 100 metres from the open façade of a tyre and brake facility. The sounds included the use of air tools, air being let out of a tyre, a tyre being dropped and, occasionally, a telephone claxon.

The Joint Nordic Method assessment did not result in a tonal correction.

The subjective results for tonality for Sample 9 show no clear consensus other than people choosing 0, 2, 4 or 6 rather than 1, 3 or 5 dB.

Sample 10: Transformer
Sample 10 was a highly tonal recording of noise from a transformer. The Joint Nordic 2 assessment showed a 100 Hz tone nearly 30 dB above the masked threshold with a resulting correction of 6 dB. Higher harmonics of the 100 Hz tone were also present.

84% of responded recognised Sample 6 as highly tonal and gave it a 6 dB correction. About 3% only gave it a correction of 4 dB and there was a smattering respondents rating it at 2, 3 or 5.

Around 4% gave Sample 10 a 0 dB correction.

Sample 11: Air conditioning condenser unit
The Joint Nordic 2 assessment for Sample 11 suggests tonal components in a critical band centred on 109 Hz 4.1 dB above the masked threshold resulting in a 0.1 dB correction.

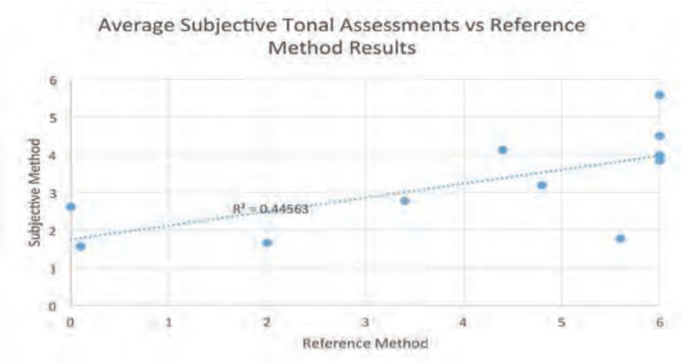
The modal value of the subjective assessments was 2 dB perhaps accurately reflecting the advice in the commentary 9.2 (Subjective Method) of BS 4142 (2014) which suggests a penalty of 2 dB for a tone which is just perceptible.

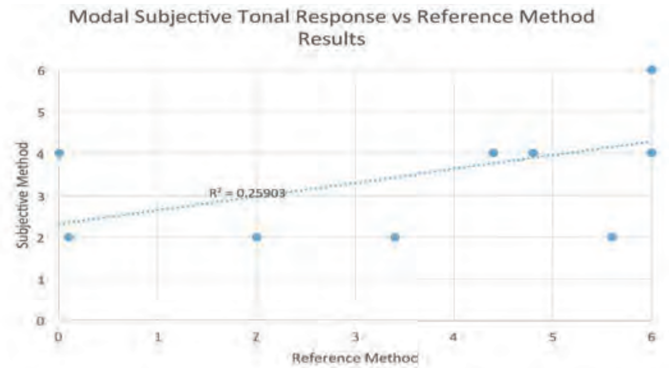
There is a slight contradiction here between the BS 4142 (2014) commentary on the subjective method and the Joint Nordic 2 (reference) method. No correction is applied in the Joint Nordic 2 method unless the tonal component is more than 4 dB above the masked threshold.

Only one respondent considered Sample 11 to merit a 6 dB correction with 33% choosing 0 or 1 dB and 10 % choosing 3 or 4 dB.

Average and modal subjective responses vs reference method results for tonal assessment

The relationship between the average and modal subjective responses and the reference method results for all the samples are shown below.





The subjective results for Sample 9 (Tyre Fitting) are perhaps the furthest from correspondence with the reference method. This can be explained by respondents hearing a tonal telephone claxon at times during the sample but this not being reflected in the reference method due to the 1 minute averaging of the FFT.

Results of impulsive noise assessments

The results are presented below for each of the samples. The tables show:-

the total number of respondents that chose each tonal correction (0 – 9) for the sample;

the modal value and the arithmetic average;

the maximum and minimum values chosen;

the estimate of the population standard deviation (i.e. the sample standard deviation calculated using n-1);

the total number of submitted results (this varied slightly between samples – some people were late and missed, perhaps the first sample or two, and for some reason attendees chose not to submit their results for some samples); and

the results of the objective method for the sample.

A histogram is also provided to illustrate the spread of the subjective assessment results for each sample graphically.

Commentary on impulsive assessments for samples 2, 6, 8 and 9

Sample 2: General industrial machinery noise
Sample 2 was mostly steady machinery noise. There is a transient noise event clear on the time history for Sample 2 in the last 10 seconds or so of the sample.

38% of the respondents gave Sample 2 a correction of 3 dB with 37% choosing a 0 dB correction.

14% gave Sample 2 a 6 dB correction with small numbers choosing 1, 2 and 4 dB.

3 respondents chose the maximum 9 dB correction.

It is possible that a proportion of the respondents choosing a 0 dB correction were not paying attention at the time of the single transient noise event in the otherwise steady machinery noise.

About 16% of respondents chose 6 or 9 dB.

The result of the objective method for Sample 2 was a 2 dB correction. The standard, of course, suggests potential subjective corrections of 0, 3, 6 or 9 dB. 84% of respondents chose corrections between 0 and 4 dB and 43% chose between 1 and 3 dB.

Sample 6: Large press and fan
40% or respondents rated Sample 6 as meriting a 6 dB correction and 39% chose 9 dB.

81% in total chose 6, 7, 8 or 9 dB.

9% chose 0 dB and a further 9% chose 3 dB.

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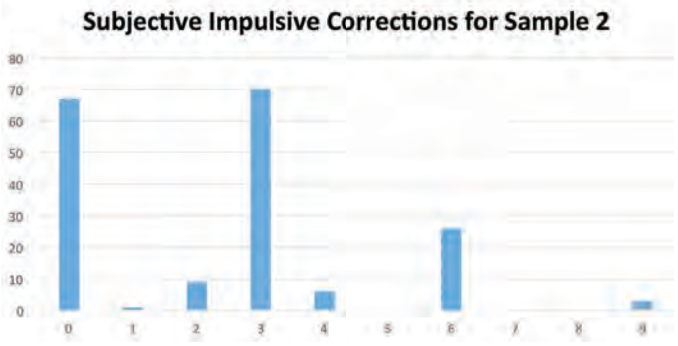
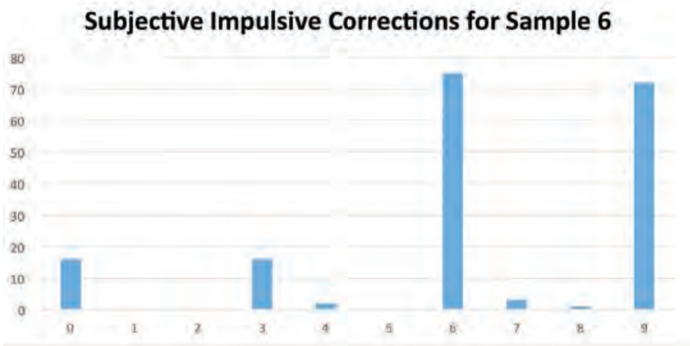
Sample 2: General Industrial Machinery Noise	
Correction	Number of People
0	67
1	1
2	9
3	70
4	6
5	0
6	26
7	0
8	0
9	3
Analysis of Subjective Assessments	
Mode	3
Average	2.4
Max	9
Min	0
Standard Deviation (n-1)	2.2
Number of Submitted Results	182
Objective Method Results	
Level Difference	5.3 dB
Onset Rate	35.3 dB/s
Prominence	6.1
Correction	2.0 dB

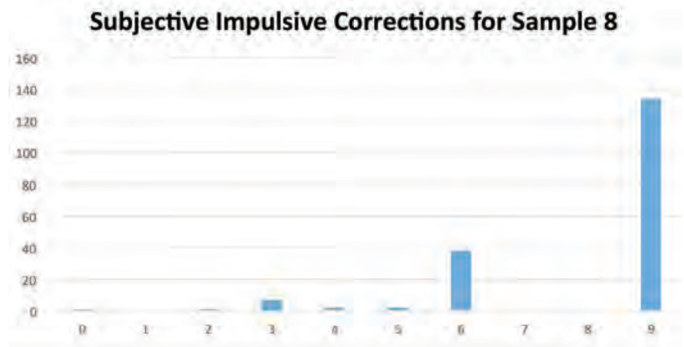
Sample 6: Large Press and Fan	
Correction	Number of People
0	16
1	0
2	0
3	16
4	2
5	0
6	75
7	3
8	1
9	72
Analysis of Subjective Assessments	
Mode	6
Average	6.4
Max	9
Min	0
Standard Deviation (n-1)	3.0
Number of Submitted Results	186
Objective Method Results	
Level Difference	4.0 dB
Onset Rate	17.1 dB/sec
Prominence	5.0
Correction	0 dB

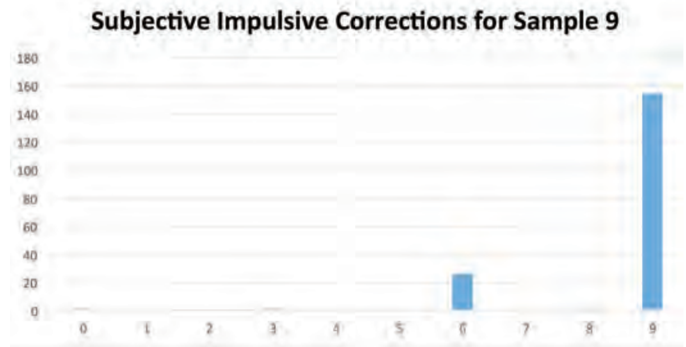
Sample 8: Fork Lifts and Loading Operations	
Correction	Number of People
0	1
1	0
2	1
3	7
4	2
5	2
6	38
7	0
8	0
9	134
Analysis of Subjective Assessments	
Mode	9
Average	8.0
Max	10
Min	0
Standard Deviation (n-1)	2.6
Number of Submitted Results	186
Objective Method Results	
Level Difference	19.5 dB
Onset Rate	162.6 dB/sec
Prominence	9.2
Correction	7.6 dB

Sample 9: Tyre Fitting	
Correction	Number of People
0	1
1	0
2	0
3	1
4	0
5	0
6	26
7	0
8	1
9	154
Analysis of Subjective Assessments	
Mode	9
Average	8.5
Max	12
Min	0
Standard Deviation (n-1)	2.4
Number of Submitted Results	185
Objective Method Results	
Level Difference	25.0 dB
Onset Rate	227.6 dB/sec
Prominence	9.9
Correction	8.8 dB









Most people considered the impulsive component in Sample 6 to be clearly or highly perceptible but nearly 20% thought it was either not impulsive at all or that the impulsive element was just perceptible.

The press certainly gave rise to a clearly perceptible thump in this sample (even those scoring the 0 or 3 really must have been aware of it). It is reasonable to postulate that those rating Sample 6's impulsivity as 0 or 3 did not consider a relatively low frequency thump to be an impulse.

Running Sample 6 through the objective method resulted in a maximum prominence of 5 which results in a 0 dB correction. The size of the potential impulses was only around 4 dB(A) and the onset rates were quite limited, especially in comparison to Samples 8 and 9.

The press was inside a large building and the rise time of the sound would be affected by both the physical characteristics of the direct sound from the source and the build-up of the reverberant field resulting in a sort of smeared impulse. So, even though 81% of the respondents considered Sample 6 to be clearly or highly impulsive the objective method did not result in a correction for impulsive noise.

Sample 8: Forklift and loading operations

Sample 8 was the sound of fork lift trucks carrying metal components across uneven yard and road surfaces with a background of general machinery and air handling noise. There was intermittent use of tonal warning signals.

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Impact Testing for Gymnasia Flooring

In Partnership with Salford University

Specifying and designing an isolation system subject to heavy impact is difficult. Most commonly a problem for free weights zones and high energy activities such as CrossFit, the impact energy can be high and easily capable of causing significant disturbance.

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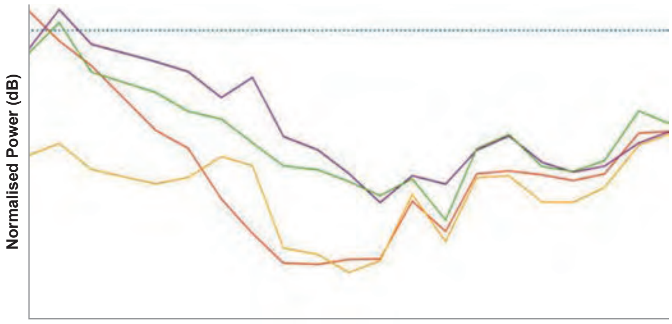
The type of impact, the floating floor and the structure are all part of the same complex system but as with all types of projects Mason UK strives to support industry and produce the best possible solutions.



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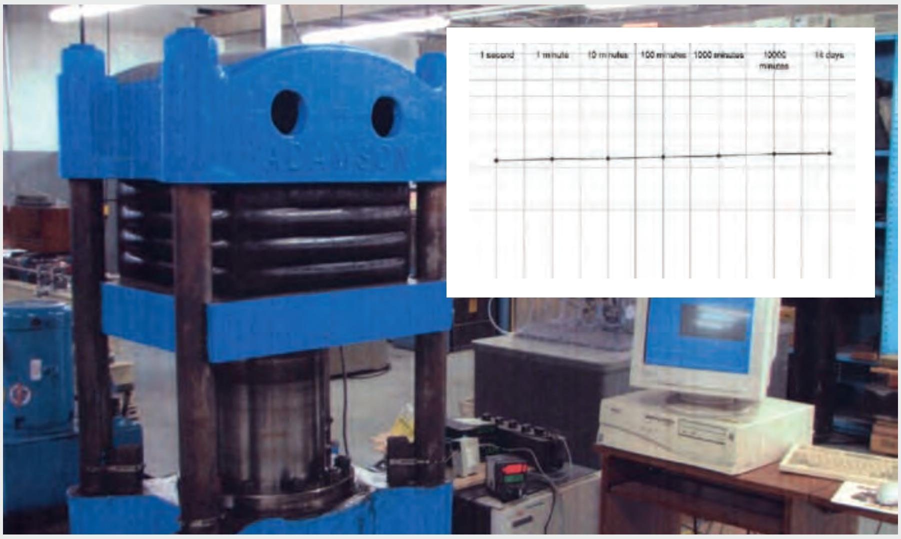

Bearing creep testing and results chart

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90% of respondents considered Sample 8 to be clearly or highly impulsive.

4% chose 3 dB which corresponds to the impulsivity being just perceptible in the advice given in BS 4142 (2014).

The objective method resulted in a correction of 7.6 dB.

Sample 9: Tyre fitting

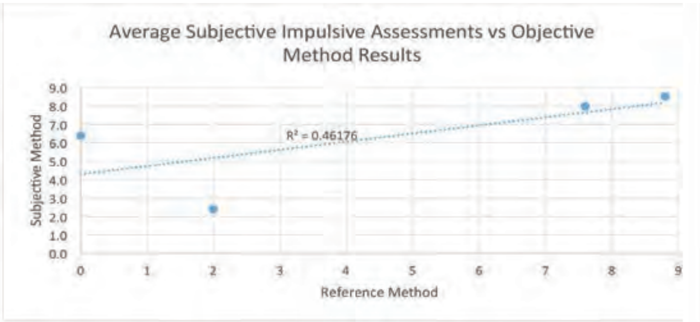
Sample 9 was a minute of activity recorded around 100 metres from the open façade of a tyre and brake facility. The sounds included the use of air tools, air being let out of a tyre, a tyre being dropped and, occasionally, a telephone claxon.

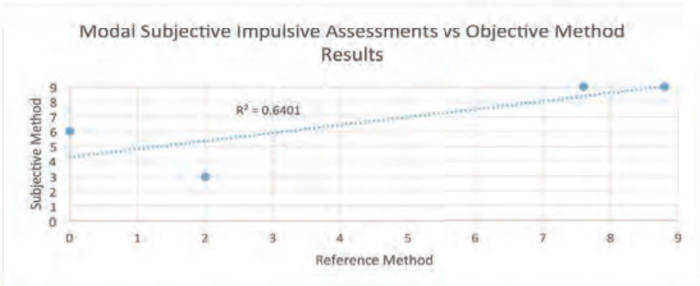
83% of respondents chose correction of 9 dB, and 14% chose 6dB. In all 98% of respondents chose between 6 and 9 dB.

The objective method resulted in an 8.8 dB correction

Average and modal subjective responses vs reference method results for impulsive assessment

The relationship between the average and modal subjective responses and the reference method results for all the samples are shown below.





Most subjects considered Sample 6 to be impulsive. The reference method is based upon identifying impulsive components by their rapid rise time. The impulsive element of Sample 6 was a press located within a reverberant space and the reference method applied to Sample 6 did not give rise to a correction. Recognising this a potential shortfall of the reference method and removing the results for Sample 6 from the analysis makes the comparison of subjective and objective result look much better but, of course, the comparison is then based on only 3 samples, two of which were highly impulsive.

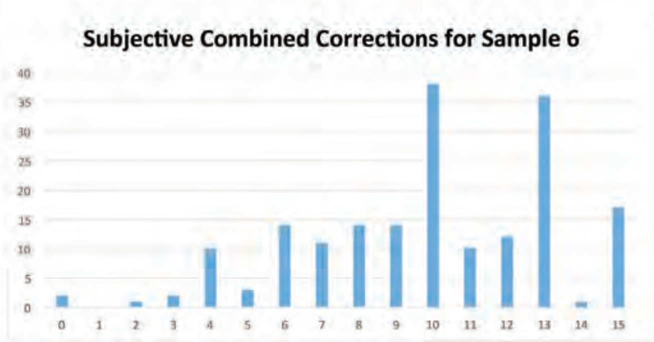
The results of combined assessments

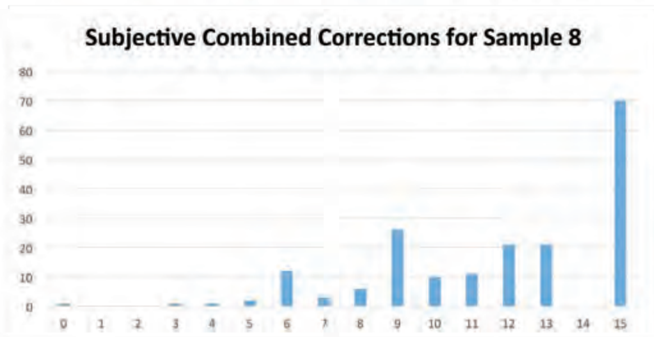
The respondents' combined corrections for Samples 2, 6, 8 and 9 are shown below.

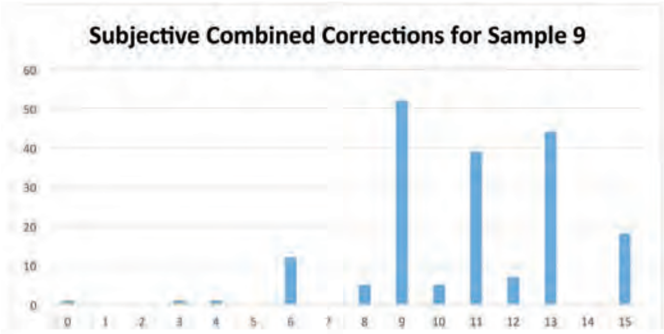
Commentary on combined assessments for samples 2, 6, 8 and 9

Sample 2: General industrial machinery noise

Sample 2 was mostly steady machinery noise but was a transient noise event in the last 10 seconds or so of the sample.







The respondents' subjective combined assessments ranged from 0 – 13 dB (with only 1 dB not being chosen by anyone with this range). The estimate of the population standard deviation was 3.1 dB.

The average and modal results are summarised in Table 3.

Table 3: Results of combined assessments for Sample 2

	Individual Corrections		Sum of Individual Assessments	Combined Assessments
	Tonal	Impulsive		
Average Subjective	3.2	2.4	5.6	5.2
Mode Subjective	4	3	7	4
Objective/Reference	4.8	2.0	6.8	

The average of the subjective combined results is slightly below the sum of the average individual subjective impulsive and tonal assessments. This suggests that just a few P36 ►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respondents did not arithmetically add the two individual corrections.

Both the mode and average subjective combined results were lower than the arithmetic sum of the sums of the objective method results (considering only the reference method for tonal assessment).

Sample 6: Large press and fan

Sample 6 was the sound of a large press inside a building and a fan.

The respondents subjective combined assessments ranged from 0 – 15 dB (with only 1 dB not being chosen by anyone with this range). The estimate of the population standard deviation was 4.0 dB.

The average and modal results are summarised in Table 4.

Table 4: Results of combined assessments for Sample 6

	Individual Corrections		Sum of Individual Assess-ments	Combined Assessments
	Tonal	Impulsive		
Average Subjective	3.8	6.4	10.2	9.9
Mode Subjective	4	6	10	10
Objective/Reference	6.0	0.0	6.0	

The average of the subjective combined results is only very slightly below the sum of the average individual assessments suggesting that most respondents did arithmetically add the two individual corrections.

The combined subjective assessments were higher than the sum of the objective assessments principally because of the discrepancy between the objective and subjective results for impulsivity for this sample.

Sample 8: Forklifts and loading operations

Sample 8 was the sound of fork lift trucks carrying metal components across uneven yard and road surfaces with a background of general machinery and air handling noise. There was intermittent use of tonal warning signals.

There was a fairly strong modal result with 38% of respondents choosing the maximum 15 dB penalty. The respondents subjective combined assessments ranged from 0 – 15 dB (with 1, 2 and 14 dB not being chosen by anyone with this range). 59% of the respondents chose a combined correction of between 6 and 13 dB. The estimate of the population standard deviation was 4.2 dB.

The average and modal results are summarised in Table 5.

Table 5: Results of combined assessments for Sample 8

	Individual Corrections		Sum of Individual Assess-ments	Combined Assessments
	Tonal	Impulsive		
Average Subjective	4.5	8.0	12.5	11.9
Mode Subjective	6	9	15	15
Objective/Reference	6.0	7.6	13.6	

The average of the subjective combined results is slightly below the sum of the average suggesting that most respondents did arithmetically add the two individual corrections.

Sample 9: Tyre fitting

Sample 9 was a minute of activity recorded around 100 metres from the open façade of a tyre and brake facility. The sounds included the use of air tools, air being let out of a tyre, a tyre being dropped and, occasionally, a telephone claxon.

The respondents' subjective combined assessments principally ranged from 6 – 15 dB (with only 7 and 14 dB not being chosen by anyone with this range). The estimate of the population standard deviation was 3.6 dB.

The average and modal results are summarised in Table 6.

Table 6: Results of combined assessments for Sample 9

	Individual Corrections		Sum of Individual Assess-ments	Combined Assessments
	Tonal	Impulsive		
Average Subjective	2.6	8.5	11.1	10.8
Mode Subjective	4	9	13	9
Objective/Reference	0.0	8.8	8.8	

The average of the subjective combined results is slightly below the sum of the average suggesting that most respondents did arithmetically add the two individual corrections.

The sum of the objective assessments is lower than the average and mode combined assessments because Joint Nordic Method 2 gave a 0 tonal penalty, probably because of the 1 minute averaging time, whereas most of the respondents rated Sample 2's tonality as 1 – 6.

Conclusions

A precautionary note

The results of this exercise must be treated with caution. Subjective assessment results were generated from five IOA evening branch presentations given in five different venues and each individual subject will have experienced a unique soundfield affected by many factors such as the room acoustics, distance from the speakers and directivity of the speakers. There were many other elements that would need to be controlled in order to get a detailed understanding of the acoustics profession's subjective response to a range of commercial/industrial sounds with differing degrees of impulsive and tonal elements. Some of the more obvious elements include the exclusion of order effects (the samples in the presentations were always played in the same order) and audiological screening.

It should be noted that, although the audience was predominantly made up of Associate and Corporate Members of the Institute of Acoustics, there was a small number of members of the audience, such as visiting students, who were active in acoustics but not engaged in environmental acoustics. It is possible that some of the more outlying data points were attributable to these respondents.

The response of all 5 audiences was predominantly that the presentation was interesting and illuminatory. There was no plan to publish these results prior to the presentations being given but many attendees said that they thought that the results of the exercise would be of value so the decision was taken to prepare this article.

The conclusions presented below must therefore be treated with a suitable degree of caution.

Clear conclusions

In the commentary for 9.2 (Subjective Method) BS 4142 suggest, for a tonal component, a penalty of 2 dB when it is just perceptible, 4 dB where it is clearly perceptible, and 6 dB P38 ►

where it is highly perceptible and, for an impulsive component, a penalty of 3 dB when it is which is just perceptible, 6 dB where it is clearly perceptible, and 9 dB where it is highly perceptible. Respondents predominantly chose these specific penalties rather than the numbers between them.

The way in which respondents interpreted the advice on the commentary for 9.2 effectively results in making the resolution of the subjective assessments 2 dB for tonality and 3 dB for impulsivity. Resolution has a direct effect on mathematical uncertainty and the effect of this is to increase the spread of results (where people might have been torn between an impulsivity rating of 4 or 5, for example, they would be weighing up whether to choose 3 or 6 instead). Uncertainty calculations for resolution assume a rectangular distribution. The expanded uncertainty (k=2) for 2 dB resolution is 1.2 dB and for 3 dB it is 1.7 dB. The combination of these two uncertainties is 2.1 dB (i.e. there is 2.1 dB of uncertainty in the results of the combined subjective assessments due to this resolution issue alone).

For the four samples which contained both tonal and impulsive components, the average combined subjective assessments was just slightly lower than the sum of the average subjective tonal and impulsive assessments. This suggests that the respondents generally arithmetically added the individual assessments in arriving at their combined assessments for each sample in direct accord with the advice given in the standard.

The average estimated population standard deviation for the subjective tonal assessments was 1.8 dB.

For every sample, excluding Sample 11 (the air conditioning condenser unit), multiple respondents chose each of the main subjective tonal ratings (i.e. 0, 2, 4 and 6 dB).

The average estimated population standard deviation for the subjective impulsive assessments was 2.6 dB.

The average estimated population standard deviation for the combined assessments was 3.3 dB.

For normal distributions, expanded uncertainty is calculated from the estimated population standard deviation by multiplying by a k factor (typically a k factor of 2 to cover 95% of the results). It might be reasonable to do this for average results near the middle of the permitted ranges (0 – 6 for tonal and 0 – 9 for impulsive) resulting in expanded uncertainties for subjective assessment of 3.6 dB for tonality and 5.2 dB for impulsivity. However, where the average results were close to the upper or lower limits it would not be reasonable to assume that the results form a normal distribution so this relationship between uncertainty and the population standard deviation would not be applicable.

There was one sample which the respondents predominantly rated as having a clearly or highly perceptible impulsive component but the reference method resulted in a 0 dB correction. The source was impulsive but it was located in a large reverberant space so the audio signal (recorded externally) did not exhibit the combination of fast rise time and level difference required to trigger an objective impulsivity correction.

For 6 of the 11 samples, although the reference method for tonal assessment indicated a tonal noise of at least 5 dB above the masked threshold, the third octave method did not indicate the presence of a prominent discreet-frequency spectral component.

Observations and commentary

Significant inter-subject variability in response to sound is referred to in the foreword to BS 4142: 2014 wherein it is also stated that the standard should be used by appropriately qualified and experienced people. The standard contains both subjective and objective methods for assessing tonality and impulsivity but the objective methods are to be employed if the subjective method is not sufficient. The inference is that appropriately qualified and experienced people can overcome the inherent inter-subject variability of subjective evaluation of sound to the degree that objective assessment of tonality and impulsivity will generally be unnecessary for the purposes of the standard.

Torjussen [7] recently published a paper comparing the results of the subjective reference methods for tonal assessment based upon sounds presented to 30 consultants, 17 environmental health officers and 10 academic staff or students. The sounds were mostly presented using headphones in the subjects' workplaces. Torjussen's analysis of the results of this exercise demonstrated that the subjective method gave rise to significant inter-subject variability. The analysis of the respondents' results presented in this article support this conclusion (see especially the tonal assessment results for Samples 1, 6, 7, 8 and 9).

The standard deviation for the respondents' subjective impulsive assessments was higher than the standard deviation for the subjective tonal assessments suggesting that the subjective impulsive method will also be subject to significant inter-subject variability.

The standard deviation for the respondents' combined assessments was higher than the standard deviations for either of the individual (tonal and impulsive) subjective assessments suggesting that the inter-subject variability for combined assessments is larger than the inter-subject variability for either of the individual subjective assessments alone.

Torjussen's subjects, and a majority of attendees at the presentations upon which this article is based, would consider themselves appropriately qualified and experienced to carry out a BS 4142 assessment yet the results of their subjective assessments showed significant inter-subject variability.

In both the presentations which are subject of this article and Torjussen's work, the sounds to be assessed were not masked by any significant additional noise (such as transportation noise). Arguably being able to hear the sounds clearly gave respondents a better chance of rating them accurately for tonality and impulsivity than they would have in the field. It might therefore be reasonable to expect inter-subject variability in real-life situations to be greater than described in this article and Torjussen's paper.

At the end of the presentations there was a considerable degree of discussion.

Much of the discussion focussed upon the degree of inter-subject variability which was almost universally considered as being problematic.

There was also some discussion regarding how the implementation of the subjective methods could be improved through:

- Further development of the subjective methods including clear definitions of "tonal" and "impulsive"; and

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Always keep an eye
on vibrations

- Training, including development of and general access to a database of shared audio samples.

There was also discussion on other factors which contributed to inter-subject variability including:

- Hearing thresholds are variable, even for otologically normal 18 – 25 year old adults.
- Hearing thresholds change with age, especially at higher frequencies, and this can be exacerbated by long-term exposure to noise.
- The changes to hearing due to age or damage from noise are not restricted to changes in threshold. Changes in frequency discrimination, for instance, affect the perception of tonality.

Changes in the loudness function (recruitment) can also significantly affect the perception of sound.

- It is not widely established practice within the acoustics profession to undergo frequent audiological testing.
- Conscious bias – regulators may consciously lean towards achieving the maximum protection for their residents and consultants my try to get achieve the most advantageous result for their client and subjectively assess sounds accordingly.
- Unconscious bias – despite best efforts to assess a noise independently regulators are likely to unconsciously lean towards achieving the maximum protection for their residents and consultants are likely to unconsciously try to achieve the most advantageous result for their client.

Taking these factors into account, the subjective methods are likely to continue to give rise to significant inter-subject variability even if training and improvements were to be widely implemented.

Mike Breslin *is the Managing Director of ANV Measurement Systems. A corporate member of the IOA, he has been professionally engaged in acoustics after graduating from the ISVR. In this period he has been involved in research, consultancy, lecturing and, for the last 15 years or so, instrumentation.*

Reference

7. A comparison of the subjective and reference methods for evaluating the tonal character correction in BS 4142: 2014. Torjussen. M. Proceedings of ICSV 24. 2017.

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We welcome contributions from readers.

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Institute of Acoustics

Acoustical analysis of bell sounds from two temples in Maharashtra and Gujarat

By Anirvan B Gupta and Vijay H Raybagkar

Introduction

For any temple, its ringing bells make an important statement by enhancing its architecture and contributing to the soundscape [1]. Choosing the right bell or set of bells for a temple is an important and delicate task: details of the right material, wall thickness, shape, size and number of bells have to be studied before acquisition. Musically, bells are tuned percussion instruments and all the bells in a set have to be in tune with each other. The perceived pitch of each enables the listener to assign its position on a musical scale based primarily on the vibration frequency [3, 4]. However, the pitch cannot readily be measured because of the complex harmonics (partials) in the sound. In order to differentiate objectively between sounds, a complex sound analysis in both in the time domain and the frequency domain is necessary.

Physical methods have previously been applied to the analysis of religious or art objects as well as their cleaning and maintenance [5-7]. In this case, acoustics provides answers concerning the characteristics of the sounds emitted by temple bells. To begin with, the purpose of the research was to clarify the mechanisms by which the human auditory system can analyse and discriminate between complex sounds [4]. Scientific research in the field continued to develop continuously, and present-day complex computer-assisted programs are capable of recording and/or importing sounds with certain file formats and analysing them in both the time domain as-recorded, and in the frequency domain, using Fourier transforms of the original recordings. This specialised computer analysis can check the harmonic content and the entire spectra of the sounds emitted by the bells system, and thus characterise it without the variability inherent in human perception. In the current work Wavanal [8] and Sigview [9] programs were used.

Figure 1: Jain Temple, Nasik, Maharashtra

Theory

The sound emitted by a bell consists of the sum of its specific partials and residual noise. In general, all musical instruments except those in the percussion family have partials at integer multiples of the fundamental frequency. In the case of bells the partials represent fractional multiples of the fundamental frequency [3].

The sound spectrum of a bell includes peaks corresponding to the partials, with a background provided by the bell's noise. The partials with frequencies greater than those of the fundamental are known as *overtones* or *upper partials* and they have specific names, in increasing order of frequency: *hum, prime, tierce, quint, nominal* and *superquint* [2-4, 10-14].

The acoustic intensity *I* is defined as the sound power per unit area, expressed in W/m^2. The sound intensity level is defined as [2]

$$\text{Sound intensity level} = 20 \log \frac{I}{I'} \quad (1)$$

where *I′* is the reference intensity.

The reference intensity is usually 10^{-12} W/m^2 but in case of bells, the reference intensity is that of the partial from the sound spectrum with frequency closest to the note of 440Hz (the A above middle C), whose intensity level thereby comes out to be zero [1][2][3].

Experimental analysis

Sound file recordings of about 10 seconds' length from bells at Jain Temple, Nasik and Neelkantheshwar Mahadev Temple, Vadodara were analysed. Wavanal software was used for the analysis of the resulting .wav files. The two bells selected were of different sizes and were placed in two temples which differed in dimensions and structure. The bell at Nasik was approximately 40cm in diameter, and that at Vadodara was 15cm in diameter. However, both the recordings were made with the microphone 0.3m below the centre of bell. Both bells were hung at approximately 2.5m above ground level. The comparative study sought to identify the structural dissimilarities in terms of acoustical parameters.

The Wavanal program can perform a Fourier transform on the original sound recording and display the resulting sound spectrum on which the characteristic partials are also identified. This program can also build up a sound from its individual partials. This allows a precise analysis of the bells' sounds in terms of frequency identification of each partial, and its exact amplitude and intensity as they contribute to sound perception. This analysis

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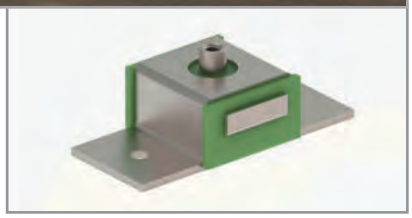


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Figure 2: Neelkantheshwar Mahadev Temple, Vadodara, Gujarat

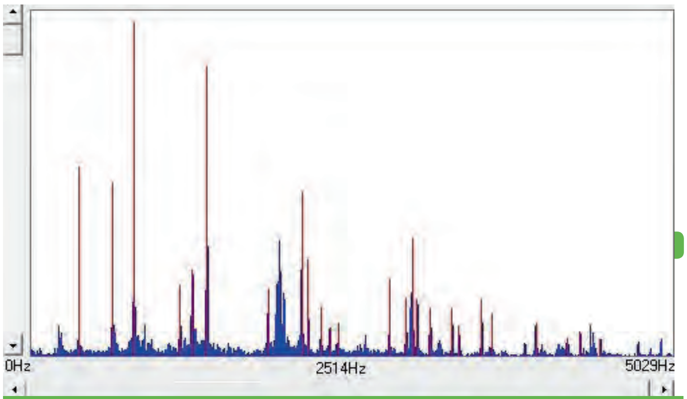

Figure 3: Fourier transform of bell sound from Jain Temple, Nasik (Wavanal)

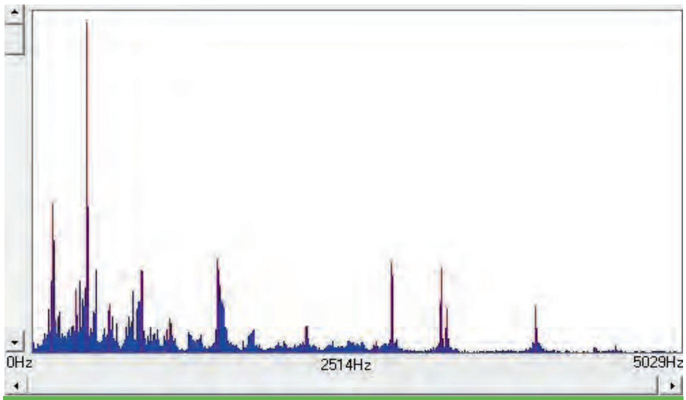

Figure 4: Fourier transform of bell sound from Neelkantheshwar Mahadev Temple, Vadodara (Wavanal)

on both the recorded sound files allowed comparison of, and identification of the differences between, the two sounds [2]. The Sigview program can plot the waveform of each sound recording, and perform a Fast Fourier Transform (FFT) on the sound recordings. It also helps by plotting two- and three-dimensional correlations between the parameters important for sound analysis, such as amplitude, intensity, frequency and time [13]. In the following, 'amplitude' is used for intensity of sound and 'intensity' refers to the intensity level in decibels.

Results: Wavanal analysis

Figures 3 and 4 show the Fourier transforms of the recorded sounds from the two temples from the Wavanal program. Tables 1 and 2 present the acoustical and musical characteristics of all the identified peaks in the spectra from Figures 3 and 4, via Wavanal and calculation. The frequency and the amplitude of each peak are given in columns 2 and 3, and the calculated sound intensity level dB for each partial in column 4. The main upper partials are identified in column 5. Column 6 contains each note's name and octave, followed by a number in the range -49 to +50 indicating the number of cents away from the exact note. Column 7 shows the deviation in cents from the note with 440Hz frequency [3, 8].

The cent is a logarithmic unit of measure used for the musical interval between two frequencies ν1 and ν2 given by:

$$1\ cent = 3986.31\ \ log\frac{\nu 2}{\nu 1} \quad (2)$$

There are 100 cents in one semitone, and an octave (which has a frequency ratio of 2:1)) is equal to 1200 cents. An interval of one cent is much too small to be heard between successive notes, but its multiples are useful in the measurement of extremely small musical intervals.

Column 8 and column 9 from Tables 1 and 2 present the results of the computation of the ratios ν/ν_0 and ν/ν_{nom}, respectively, of each peak's frequency to that of the lowest frequency (ν_0) and to that of the nominal (ν_{nom}) . The last four rows of Tables 1 and 2 show the minimum and maximum values of each parameter, the average value of each parameter, and the standard deviation.

No.	Freq. Hz	Relative amplitude	Sound intensity level dB	Partial	Note	Cents	Ratio to lowest freq.	Ratio to nominal
1	380.0	11.362	0	hum	F#(1) +44	-2241	1.000	0.274
2	647.0	10.486	-0.697	prime	E(2) -31	-1317	1.705	0.467
3	813.0	20.009	4.916	tierce	A♭(2) -36	-922	2.142	0.587
4	1168.0	4.329	-8.381	quint	D(3) -9	-294	3.078	0.844
5	1265.0	5.285	-6.649		E♭(3) +28	-156	3.333	0.914
6	1385.0	17.417	3.710	nominal	F(3) -14	0	3.648	1.000
7	1861.0	4.073	-8.910		B♭(3) -3	512	4.903	1.344
8	2122.5	9.934	-1.167		C(4) +24	740	5.593	1.533
9	2170.0	5.878	-5.725		D♭(4) -36	778	5.718	1.567
10	2272.0	3.003	-11.557		D♭(4) +42	858	5.987	1.641
11	2344.5	1.769	-16.160		D(4) -3	912	6.178	1.693
12	2409.5	2.097	-14.677		D(4) +44	959	6.349	1.740
13	2806.5	4.694	-7.678	oct nom	F(4) +8	1223	7.395	2.027
14	2935.0	3.576	-10.041		F#(4) -14	1301	7.734	2.120
15	2986.0	7.160	-4.010		F#(4) +15	1331	7.868	2.157
16	3023.5	3.455	-10.341		F#(4) +37	1352	7.967	2.184
17	3123.0	2.947	-11.722		G(4) -6	1408	8.229	2.256
18	3295.5	2.956	-11.696		A♭(4) -13	1501	8.684	2.380
19	3348.0	1.846	-15.784		A♭(4) +13	1529	8.822	2.418
20	3519.5	3.516	-10.189		A(4) +0	1615	9.274	2.542
21	3605.0	2.630	-12.713		A(4) +41	1657	9.499	2.604
22	3949.5	2.070	-14.790		B(4) +0	1815	10.407	2.853
23	4192.0	1.188	-19.614		C(5) +2	1918	11.046	3.028
24	4293.5	1.576	-17.157		C(5) +44	1959	11.314	3.101
25	4451.5	1.121	-20.114		D♭(5) +6	2022	11.730	3.215
Min.	379.5	1.121	-20.114			-2241	1.000	0.274
Max.	4451.5	20.009	4.916			2022	11.730	3.215
Average	2574.6	5.375	-9.246			818	6.784	1.860
STDEV	1167.4	4.921	6.811			1089	3.076	0.843

Table 1: Characteristics of Nasik bell (Wavanal program)

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No.	Freq. Hz	Relative amplitude	Sound intensity level dB	Partial	Note	Cents	Ratio to lowest freq.	Ratio to nominal
1	161.5	2.735	-6.861		E(0) -34	-3785	1.000	0.112
2	340.0	1.187	-14.112	hum	F(1) -45	-2496	2.105	0.237
3	427.5	6.026	0.000		A(1) -49	-2099	2.647	0.297
4	603.0	0.902	-16.493	prime	D(2) +46	-1504	3.734	0.420
5	850.0	1.539	-11.856	tierce	A♭(2) +40	-910	5.263	0.591
6	1066.5	0.666	-19.133	quint	C(3) +33	-517	6.604	0.742
7	1437.5	1.729	-10.845	nominal	F(3) +50	0	8.901	1.000
8	2120.5	0.519	-21.305	superquint	C(4) +23	673	13.130	1.475
9	2658.5	0.250	-27.655		E(4) +14	1064	16.461	1.849
10	2781.5	1.666	-11.167		F(4) -7	1143	17.223	1.935
11	3162.5	1.571	-11.677		G(4) +15	1365	19.582	2.200
12	3207.5	0.846	-17.053		G(4) +39	1389	19.861	2.231
13	3891.5	0.872	-16.792		B(4) -25	1724	24.096	2.707
14	4350.5	0.124	-33.710		D♭(5) -32	1917	26.938	3.026
Min.	161.5	0.124	-33.710			-3785	1.000	0.112
Max.	4350.5	6.026	0.000			1917	26.938	3.026
Average	1932.0	1.474	-15.618			-145	11.968	1.345
STDEV	1413.5	1.480	8.395			1784	8.753	0.983

Table 2: Characteristics of Vadodara bell (Wavanal program)

In all, 25 peaks were observed in the Nasik spectrum and 14 peaks in the Vadodara spectrum (shown by vertical red lines). The range of frequencies from Nasik was 380 to 4452 Hz, and that from Vadodara was 162 to 4351 Hz.

Figures 5 and 6 show the amplitude dependencies on frequency, and Figure 7 and 8 intensity versus frequency, for the two recorded bell sounds. It can be seen from the graphs that the partials (hum, prime, tierce, quint and nominal) have almost the same frequency values in both bells. The range of difference is merely -53 to +102 Hz, which is small compared with the entire frequency range, although to a listener the sounds of the two bells differ greatly. This shows that the contribution of this parameter to the entire perception of sound (pitch) is not very important in differentiating between the two different bell sounds. The partials are slightly separated in frequency and are not in harmony because of inevitable departures from perfect symmetry. Temple bells are known not to have perfect harmonic natural frequencies [15].

The peak distributions in the two intensity versus frequency graphs are quite similar. The intensity levels increase towards medium frequencies, then decrease and rise again towards the top of the frequency range. The maximum intensity of the Nasik bell was 20dB and that of the Vadodara bell was 34dB.

The analyses of main partials for the two bells are shown in Figures 9 and 10 (only for the main partials). In Figure 9 there are important differences between the amplitudes of the main partials of the two bells, especially at lower frequencies, while in Figure 10 the differences between the intensities of the partials of the two bells are greater at high frequencies.

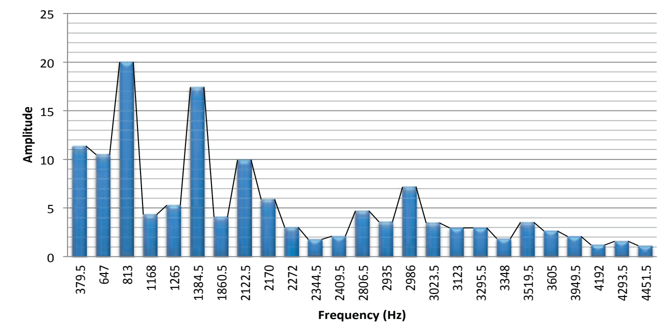


Figure 5: Amplitude dependence on frequency (Jain Temple, Nasik)

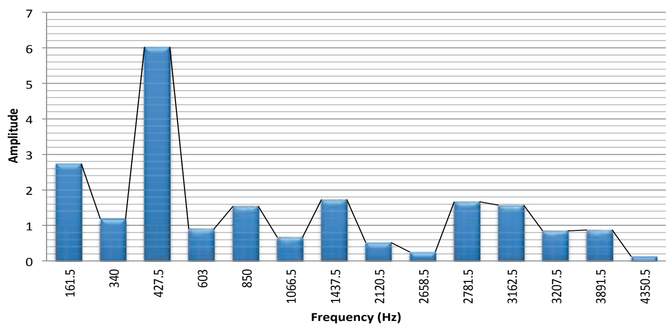


Figure 6: Amplitude dependence on frequency (Neelkantheshwar Mahadev Temple, Vadodara)

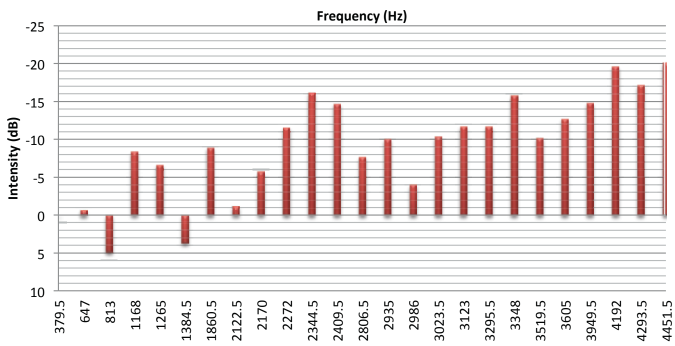


Figure 7: Intensity versus frequency (Jain Temple, Nasik)

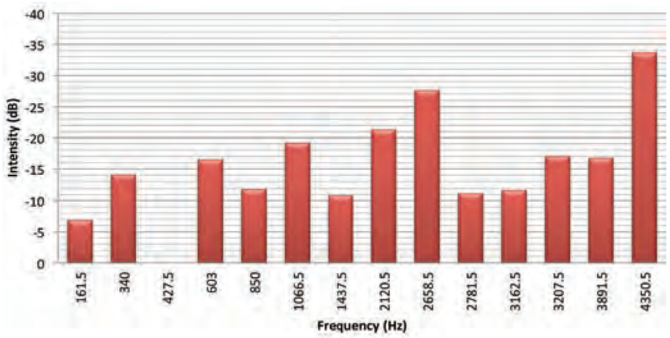


Figure 8: Intensity versus frequency (Neelkantheshwar Mahadev Temple, Vadodara)

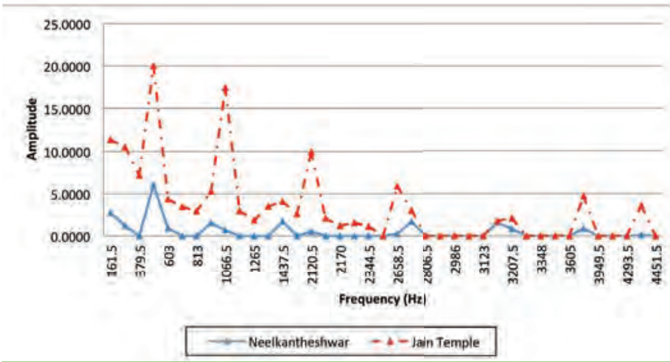


Figure 9: Amplitudes of bell sounds versus frequency plots for the main partials of the two sounds from two temples

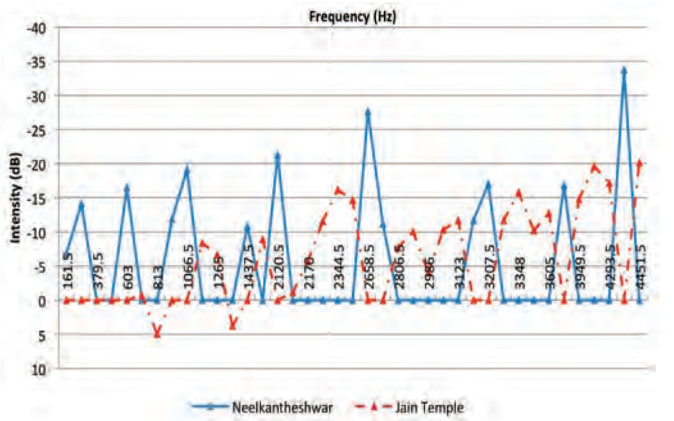


Figure 10: Intensities of bell sounds versus frequency plots for the main partials of the two sounds from two temples

Results: Sigview analysis

Figures 11 and 12 present the waveforms of the two analysed sounds as plotted using Sigview. The recorded patch of sound for Nasik lasts for around ten seconds, while that for Vadodara lasts for around six seconds.

Figures 13 and 15 present the Fast Fourier Transforms (FFT) corresponding to the two sounds computed by Sigview. Figures 14 and 16 respectively show the same information with the amplitude axis adjusted so as to render the maximum peak visible. These FFTs are another type of spectral representation in a different frequency range, zero to 1500Hz. The frequency range for the FFTs was chosen depending on the hum, prime, tierce, quint and nominal partials for each bell.

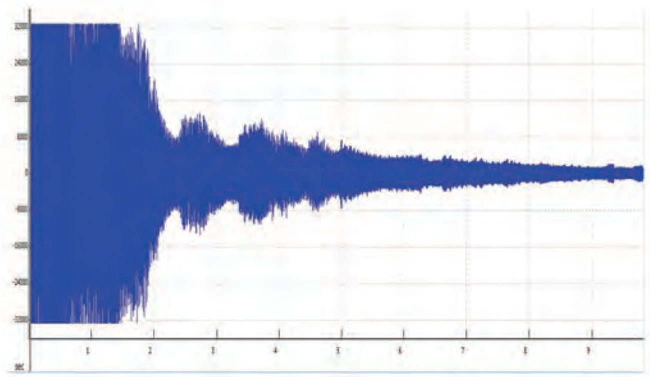


Figure 11: Waveform for the bell sound at Jain Temple, Nasik

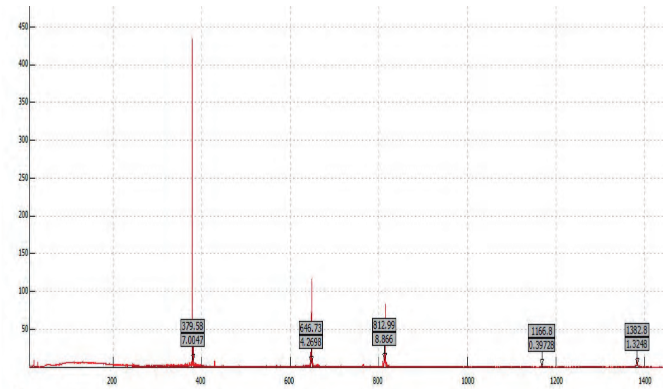


Figure 14: FFT showing the maximum peak, Jain Temple bell

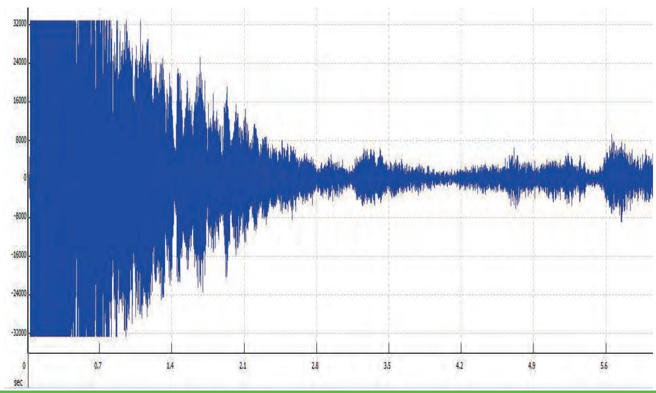


Figure 12: Waveform for the bell sound at Neelkantheshwar Mahadev Temple, Vadodara

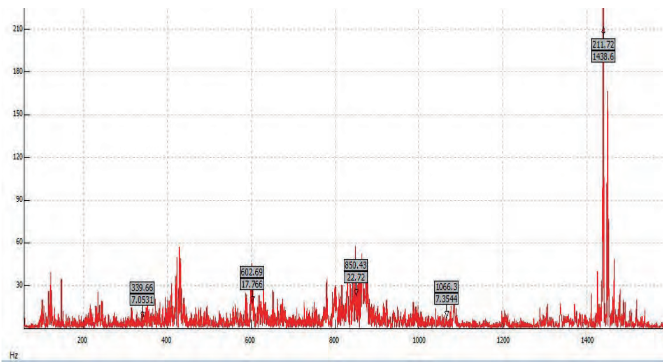
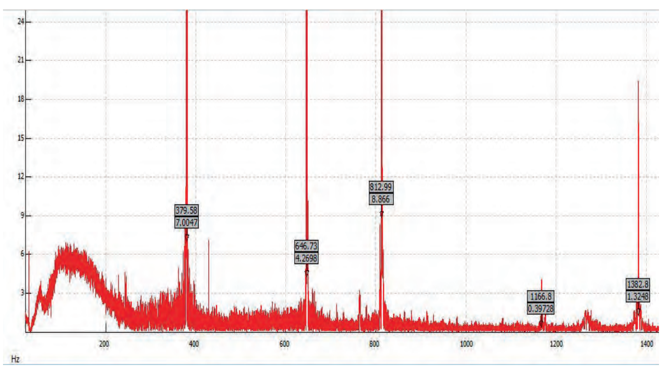


Figure 15: FFT in the zero to 1600Hz range, Neelkantheshwar Mahadev Temple bell, Vadodara



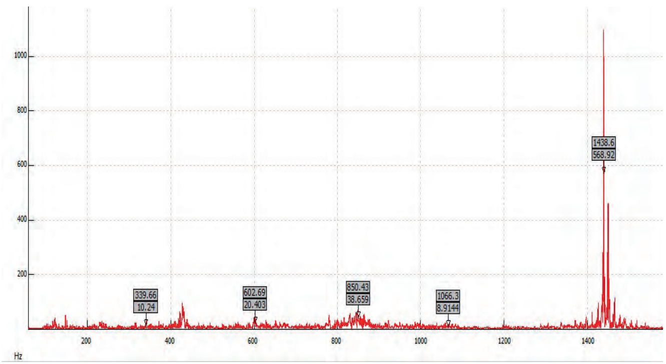


Figure 16: FFT showing the maximum peak, Neelkantheshwar Mahadev Temple bell, Vadodara

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From Figures 13 and 15 it can be seen that the spectral distributions for the two recorded sounds are different, so the sound perceptions of the two bells will also be different. The maximum amplitudes are 380Hz for the Jain Temple bell and 1439Hz for the Vadodara bell. Satellite frequencies are also noticeable in these plots, and their contributions to the entire sound perception should not be neglected even though the human ear may not perceive them.

Figures 18 and 19 present the time evolutions of the amplitudes of the partials taken from the FFTs given in Figures 13 and 15 ('waterfall' plots) for the two bells. The frequency range for both plots is 47 to 4969 Hz. There is a clear higher density of peaks in the 3D plot for Jain Temple. The lower frequency partials are more prominent for that bell, while the intermediate frequency partials are more prominent for the Vadodara bell. However, in both recordings the partials do not maintain their amplitude in time: the peaks tend to diminish as time passes.

Figures 20 and 21 are surface plots showing the dependence between the amplitude of sound, intensity of sound and frequency of sound for the two bells: note the scatter. Figures 22 and 23 give mathematical relationships between the amplitude and intensity parameters for the two bells. P52 ►

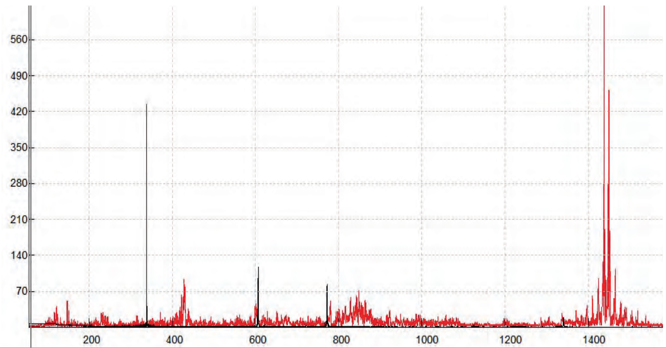

Figure 17: FFT graph overlay for the two bells (Black, Nasik; red, Vadodara)

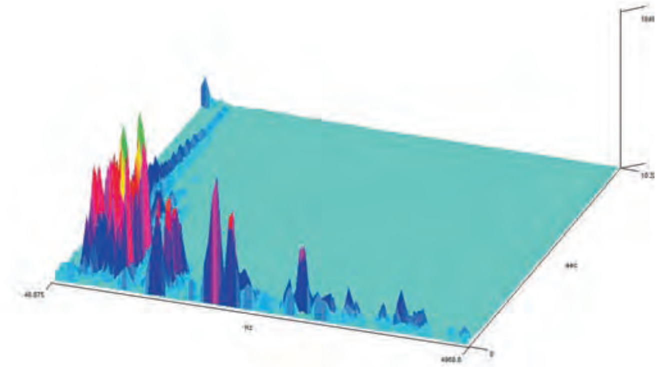
Figure 18: 3D time FFT analysis for Nasik bell (x-axis, time; y-axis, frequency Hz; z-axis, amplitude)

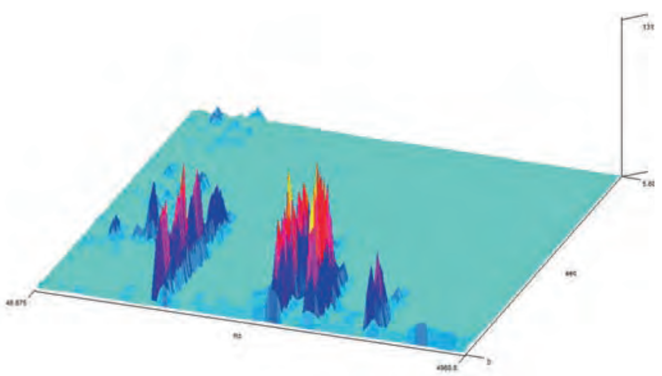
Figure 19: 3D time FFT analysis for Vadodara bell (x-axis, time; y-axis, frequency Hz; z-axis, amplitude)

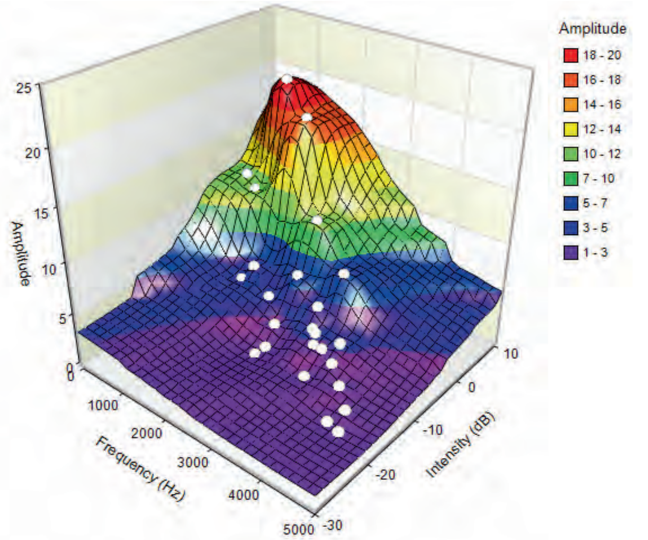

Figure 20: 3D plot of amplitude (y-axis) versus intensity (z-axis) and frequency (x-axis) for Nasik bell

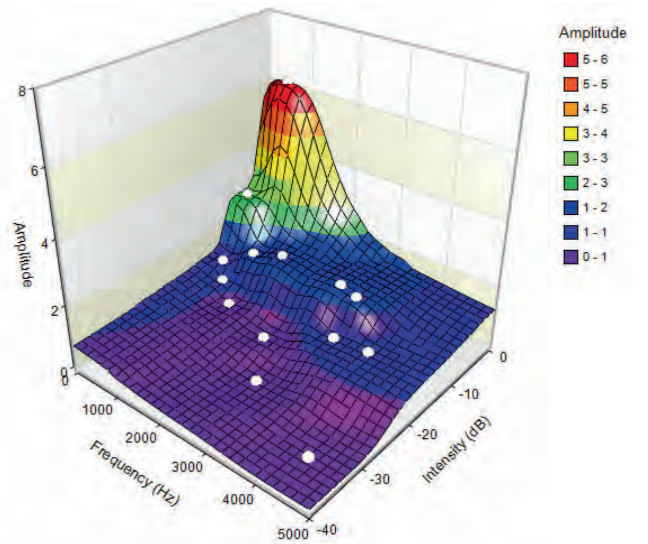

Figure 20: 3D plot of amplitude (y-axis) versus intensity (z-axis) and frequency (x-axis) for Nasik bell

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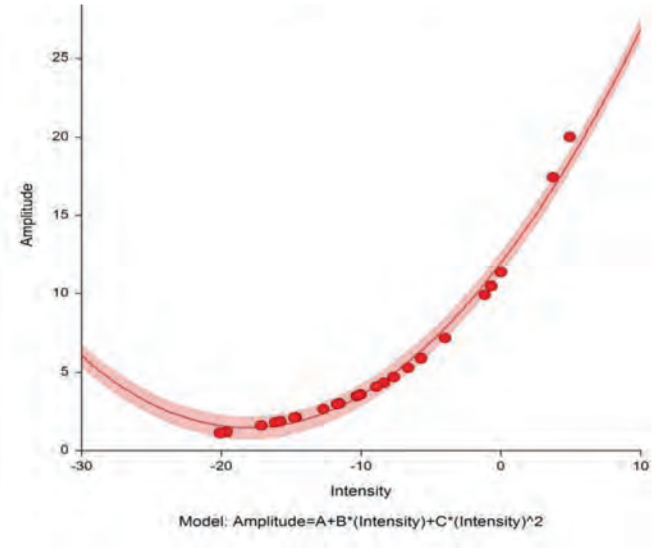

Figure 22: Amplitude versus intensity curve for Nasik bell

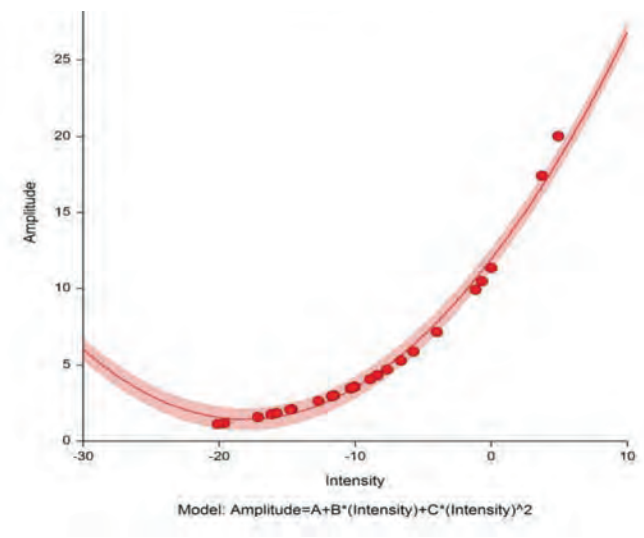

Figure 23: Amplitude versus intensity curve for Vadodara bell

Conclusions

The comparative study investigated the similarities and differences between the sounds of tow bells differing in both structure and dimensions. The results show that although the sounds were perceived differently by a listener, the main partials occur at similar frequencies.

The amplitudes and intensities of bells' sounds were also studied and it was found that peaks appear at different frequency values. The complex analysis demonstrates each bell's unique acoustical characteristics. The 2D and 3D plots of sounds show that significant differences exist between the two bells in terms of amplitude and intensity of the main upper partials.

When making a temple bell, changes in shape, dimensions, thickness, material of construction, and manufacturing process all play important roles in the acoustical characteristics of the ringing bell. Scientific analysis using complex programs can help to identify such parameters and provide assistance to manufacturers when making bells to suit the architecture of a temple.

Anirvan B Gupta *is with the Department of Engineering Physics, Sandip Institute of Engineering and Management, Nashik, India, email g.anirvan@gmail.com*

Vijay H Raybagkar is with the Department of Physics, Nowrosjee Wadia College, Pune, India, email raybagkars@gmail.com

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Tranquillity Trails for promoting well-being in urban areas

By Gregory Watts

Tranquil spaces can be found and made in the city and their promotion and use by residents and visitors is an important means of building resilience.

Studies have shown that spaces that are rated by visitors as tranquil are more likely to produce higher levels of relaxation and less anxiety that should ultimately result in health and well-being benefits. Such spaces can therefore be classed as restorative environments. Tranquil spaces are characterized by a soundscape dominated by natural sounds and low levels of man-made noise. In addition, the presence of vegetation and wild life has been shown to be an important contributory factor. Levels of rated tranquillity can be reliably predicted using a previously developed model TRAPT and then used to design and identify tranquil spaces, improve existing green spaces and develop Tranquillity Trails to encourage usage.

Tranquillity Trails are walking routes that have been designed to enable residents and visitors to reflect and recover from stress while receiving the benefits of healthy exercise. This paper describes Tranquillity Trails designed for four contrasting areas. Predictions of the rated tranquillity have been made along these routes and feedback from users was elicited at one site that confirmed the expected benefits.

Introduction

Much research has shown that tranquil spaces are restorative environments that can help reduce stress and relieve anxiety [1,2,3,4,5,6]. Questionnaire surveys of open green spaces have shown a strong association between rated tranquillity of a place and percentage of visitors feeling more relaxed after their visit [7].

Laboratory studies conducted at the University of Bradford have shown that the significant factors affecting rated tranquillity of a place *TR*, are the average level of man-made noise and the percentage of natural and contextual features in the landscape [8]. The equation TRAPT (Tranquillity Rating Prediction Tool) expresses this relationship in urban areas [7] as:

$$TR = 10.55 + 0.041\, NCF - 0.146\, L_{day} + MF \qquad (1)$$

Where *TR* is the tranquillity rating on a 0 to 10 rating scales. *NCF* is the percentage of natural and contextual features and L_{day} is the equivalent constant A-weighted level during daytime (e.g. from 7am to 7pm) from man-made noise sources. Contextual features include listed buildings, religious and historic buildings, landmarks, monuments and elements of the landscape, such as traditional farm buildings, that directly contribute to the visual context of the natural environment. It can be argued that when present, these visually cultural and contextual elements are as fundamental to the construction of 'tranquil space' as are strictly natural features.

The behaviour of this equation has been studied by examining trends in *TR* with L_{day} at different levels of *NCF*. It was noted that at the extremes of L_{day} where *TR* becomes greater than 10 or less than 0 then *TR* values are set to 0 and 10 respectively. *MF* is a moderating factor that was added to the equation following a study that was designed to take account of the presence of litter and graffiti that would depress the rating, or natural water sounds that would improve it [9]. This minor adjustment is designed to take account of the actual environmental conditions at the time of assessment and is unlikely to influence the calculated *TR* by more than ±1 scale point.

TR values in urban open spaces have been related to the level of rated relaxation of people after visiting such spaces where there was a very close relationship $R^2 = 0.96$ [7]. For example, for a *TR* value of 5.0 nearly 50% of visitors report that they are "more relaxed" after visiting the park while at a value of 8 approximately 80% report being "more relaxed". These results have been used to validate the following category limits for *TR* defined previously [7]:

<5	unacceptable
5.0 – 5.9	just acceptable
6.0 – 6.9	fairly good
7.0 – 7.9	good
≥ 8.0	excellent

A previous study [10] employed TRAPT to gauge the benefits of "greening" urban areas. However, in this article we look at a means of encouraging people to visit existing green and tranquil spaces. The study described in this paper uses TRAPT to identify tranquil spaces and then to develop Tranquillity Trails (TTs). TTs are walking routes that have been designed to enable residents and visitors to reflect and recover from stress while receiving the benefits of healthy exercise.

On a community level it is important that people use green spaces so they experience, connect and benefit from contact with nature and so are more likely to support nature friendly policies now and in the future [11].

Four TTs designed for contrasting areas are described and then predictions of the rated tranquillity have been made along these widely different walking routes. The *TR* profiles of the TTs have then be compared and contrasted by examining the percentage of time a walker would spend experiencing the different levels of *TR* described above.

It is important to consider the benefits of walking around the TTs since this will help gauge usefulness and could be used to promote usage. Feedback from one site was used to assess the benefits of using that TT. These benefits were then related to the extraversion scale of personality using a shortened form of the Eysenck Personality Questionnaire [12]. It was considered that those scoring lower on the extraversion scale (i.e. more introverted) would value tranquillity more highly due to the tendency to require more peaceful surroundings to perform more efficiently.

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Method

Study sites

The present study used the insights gained from these previous surveys and experiments to devise walking routes or Tranquillity Trails (TTs) that link quiet green spaces in urban areas using relatively tranquil paths and roads. The aim is to design a route that is simple and safe to follow and will allow users to experience a relatively degree of tranquillity despite being in an urban area. Clearly the challenge is greater in a city with higher concentrations of people and traffic than for a town. The first four TTs that have been designed are in Bradford, Kingsbridge, Guildford and Ilkley. These are all in England though further ones are currently being developed in Ireland.

Bradford forms part of the West Yorkshire Urban Area conurbation which in 2001 had a population of 1.5 million and is the fourth largest urban area in the United Kingdom with the Bradford subdivision of this urban area having a population of nearly 530,000. In contrast, Kingsbridge is a market town and tourist hub in the South Hams district of Devon, England, with a population of just over 6,000 at the 2011 census. Of intermediate size is Guildford that is a large town with a population of 143,00 lying 43 km south west of central London. Ilkley is a popular tourist centre in West Yorkshire with a population of nearly 15,000 and lying 12 miles north of Bradford and 17 miles north west of Leeds.

Determination of TR profile

To compare and contrast levels of tranquillity achieved at each site it was considered necessary to determine the variation of *TR* values around each TT. This involved calculating the values of the important factors L_{day} and *NCF* (see equation (1)) at a sufficient number of points to define a profile.
Noise predictions of $L_{A10,18hr}$ were carried out along each route using the UK traffic noise prediction method "Calculation of Road Traffic Noise" or CRTN [13] and subsequently converted into L_{day} [14]. Where flows were low or road layout complex spot readings of the average A-weighted levels were carried out near the middle of the day informed by advice given in CRTN and subsequently used to estimate L_{day}.

As in previous studies in order to calculate the percentage of natural and contextual features *NCF* an eye height of 1.5m was also assumed. The field of view was restricted in the vertical plane to ± 20 degrees. This was approximately the angle of view using a standard camera lens and relates well to studies of the eye's central field of view i.e. the angle over which objects can be recalled without moving the eyes [15]. In the horizontal plane calculations were made over 360 degrees as it is assumed that the observer would make scanning movements in the horizontal plane to take in the full scene. These assumptions were made in earlier surveys which found a close relationship between predicted tranquillity using such a measure and average ratings given by participants visiting a variety of open spaces [7].

For the present study calculations were made of the variable *NCF* by using image processing software (ImageJ). By using a cursor to draw around natural features the program calculates the number of pixels within these areas. This is then compared with the total number of pixels by drawing around the landscape excluding the sky. This process is followed for each of 6 or 7 contiguous photographic images covering 360 degrees in the horizontal plane and the average value taken. The value *NCF* is given by:

$$NCF = \frac{\sum_{\theta=1}^{7} \frac{An_\theta \cdot 100}{(At_\theta)}}{7} \qquad (2)$$

Where Anθ and Atθ are the areas (number of pixels) in the photographic images of natural (including contextual) features and total area, excluding sky, respectively, in image θ. Note that in order to facilitate analysis at the Ilkley site the 6 pictures at each location were pasted into PowerPoint and arranged in 2 rows of 3 contiguous images. The resulting slide was converted into jpeg file suitable for the imageJ analysis. Each block of 3 pictures was treated as a single analysis unit that reduced analysis time.

Guidelines for route selection

Using this technique it is possible to make predictions of TR for city streets, squares and parks, alongside major roads as well as residential roads and shopping streets. In this way, it is possible to consider the type of spaces and roads in a city that are likely to have acceptable levels of tranquillity. This is the first step in producing a TT that links tranquil spaces so that the average and range of tranquillity levels experienced on the route provides appropriate levels of tranquillity to facilitate health and wellbeing. Further guidelines for route selection have been considered based on predictions and survey information. These can be summarised as:

- Access is important and so trails that commence near a public transport hub will be useful e.g. town or city centre
- Locate larger open spaces within easy reach of the start as these are likely to have the highest levels of tranquillity and could act as a focus for the walk
- Consider various routes both to and from these larger open spaces
- Locate smaller open spaces on these routes that although not having the highest levels of *TR* to match the larger open spaces may nevertheless have acceptable levels. These could act as "stepping stones" to the larger open areas
- Consider the links to the small and larger open areas selecting where possible routes that avoid heavily trafficked roads and where there are relatively high levels of vegetation visible e.g. hedges, trees, grassy verges
- Consider suitable road crossing points and state of footpaths for safe walking
- Consider points of interest that add interest and motivate the walker to continue e.g. historic sites, interesting architecture, beautiful trees and flowers, view points
- Walk the alternative route options that are expected to have relatively high levels of tranquillity and interest and collect relevant data i.e. traffic flow to predict traffic noise and photographic records so that *NCF* can be calculated
- Analyse data and predict *TR* in open spaces and along the possible linking paths and roads
- Choose a suitable route that has the highest average and smallest range of predicted tranquillity levels but consider points of interest and safety aspects among the options that may prove a deciding factor where alternatives have similar *TR* values

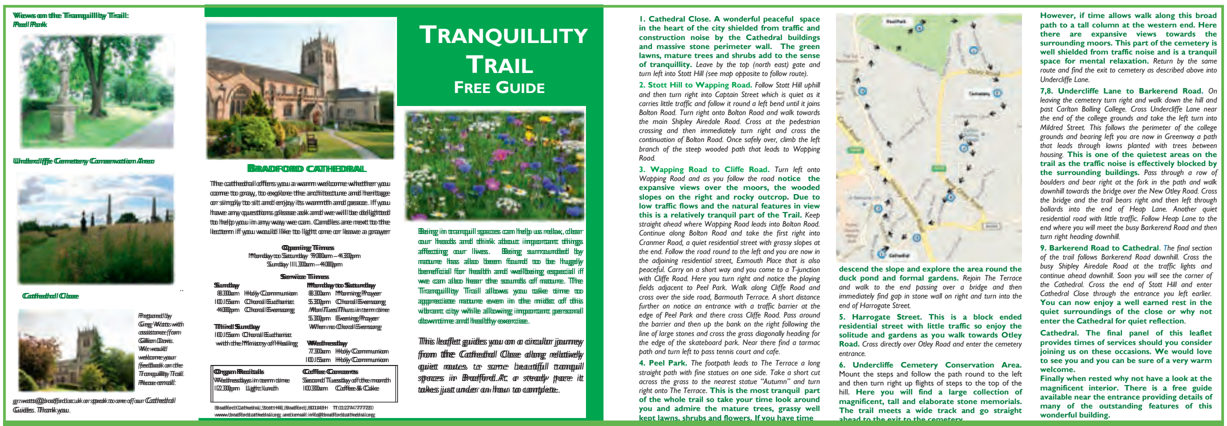

Figure 1: Leaflet describing the Bradford City TT

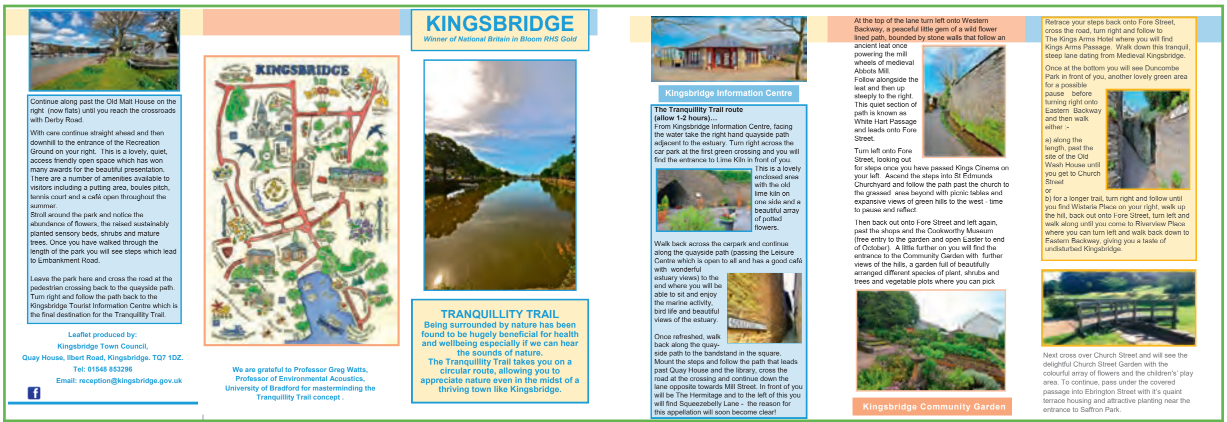

Figure 2: Leaflet describing Kingsbridge TT

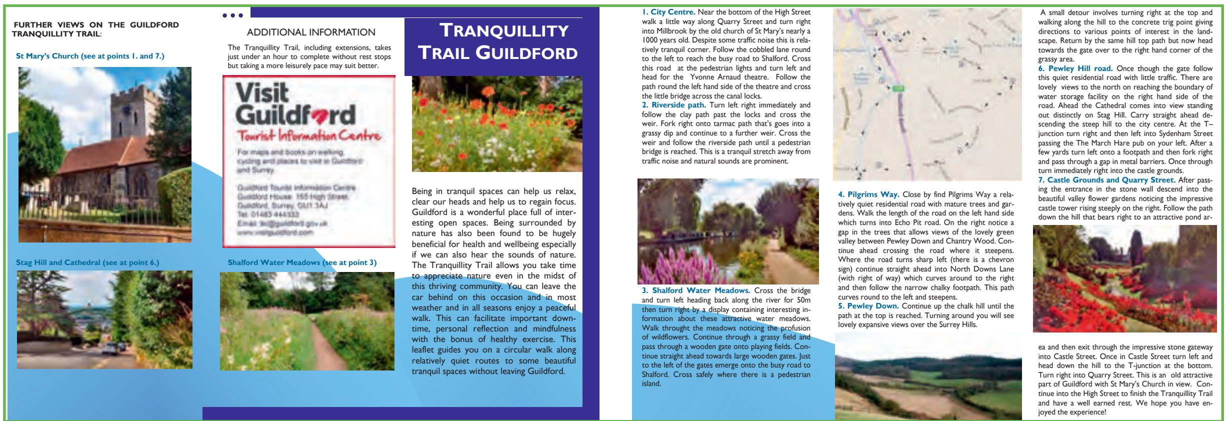

Figure 3: Leaflet describing Guildford TT

Figure 4: Leaflet describing Ilkley TT

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Description of Tranquillity Trails

Figure 1 shows the leaflet designed for Bradford City. The leaflet is folded into 3 panels with the inside panels describing the route with numbers corresponding to points on the map. The leaflet is available at the tourist office and the cathedral and can be downloaded at: http://bit.ly/2lTRvHT

The TT for Kingsbridge is shown in Figure 2. Again, the leaflet is folded into three panels. This was subsequently amended by Kingsbridge Council to fit with their need to align with the Britain in Bloom map and the revised form can be downloaded at: http://bit.ly/2GVMKXX

A TT for Guildford in the UK is shown in Figure 3. The TT takes just under an hour to complete without rest stops but taking a more leisurely pace may suit better. The guide can be downloaded at: http://bit.ly/2sceep1

An app for smart mobile devices describing interesting features of this route together with a map and cursor showing current position is freely available from: http://www.handheldtours.co.uk/

A TT for Ilkley is shown in Figure 4. The TT takes just under an hour to complete without rest stops and again a more leisurely pace may be more appropriate. The guide can be downloaded at: http://bit.ly/2EaMLWk

The introduction on the front of all four leaflets describes the health and well-being benefits of being in tranquil environments in terms of stress reduction and the healthy exercise required to complete the route. Also, an indication of the time required to complete the route at a steady walking pace.

Questionnaire

It was considered important to obtain feedback from users of the TT to determine if there were perceived benefits and to understand the nature of any problems that might preclude further visits. In Kingsbridge a questionnaire was used to gather opinions from those who had completed the route. To improve participation a £10 (approximately equal to $12) supermarket voucher was given out to those who had completed route and subsequently completed the questionnaire.

The questions included:

- Importance of tranquillity
- Rating of the overall tranquillity of the TT
- Changes in states of relaxation and anxiety
- Problems encountered
- Benefits
- Biographic information
- Short series of questions to indicate place on extraversion-introversion scale

Results

TR profiles

The predicted Tranquillity ratings (*TRs*) over elapsed time from the start assuming a steady walking speed of 4.8 km/h are given for each of these contrasting trails in Figure 5.

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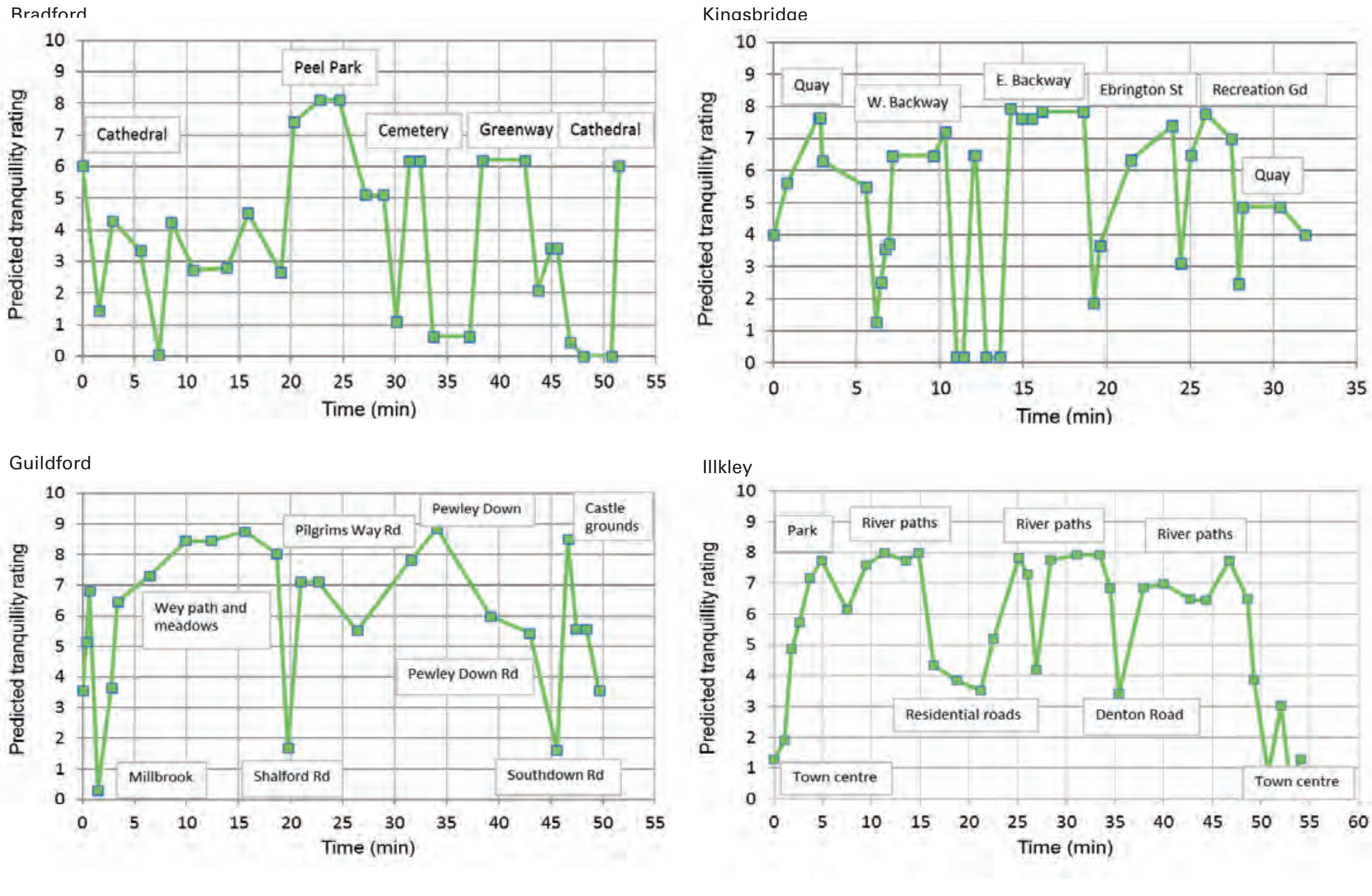

Figure 5: Tranquillity Rating profiles

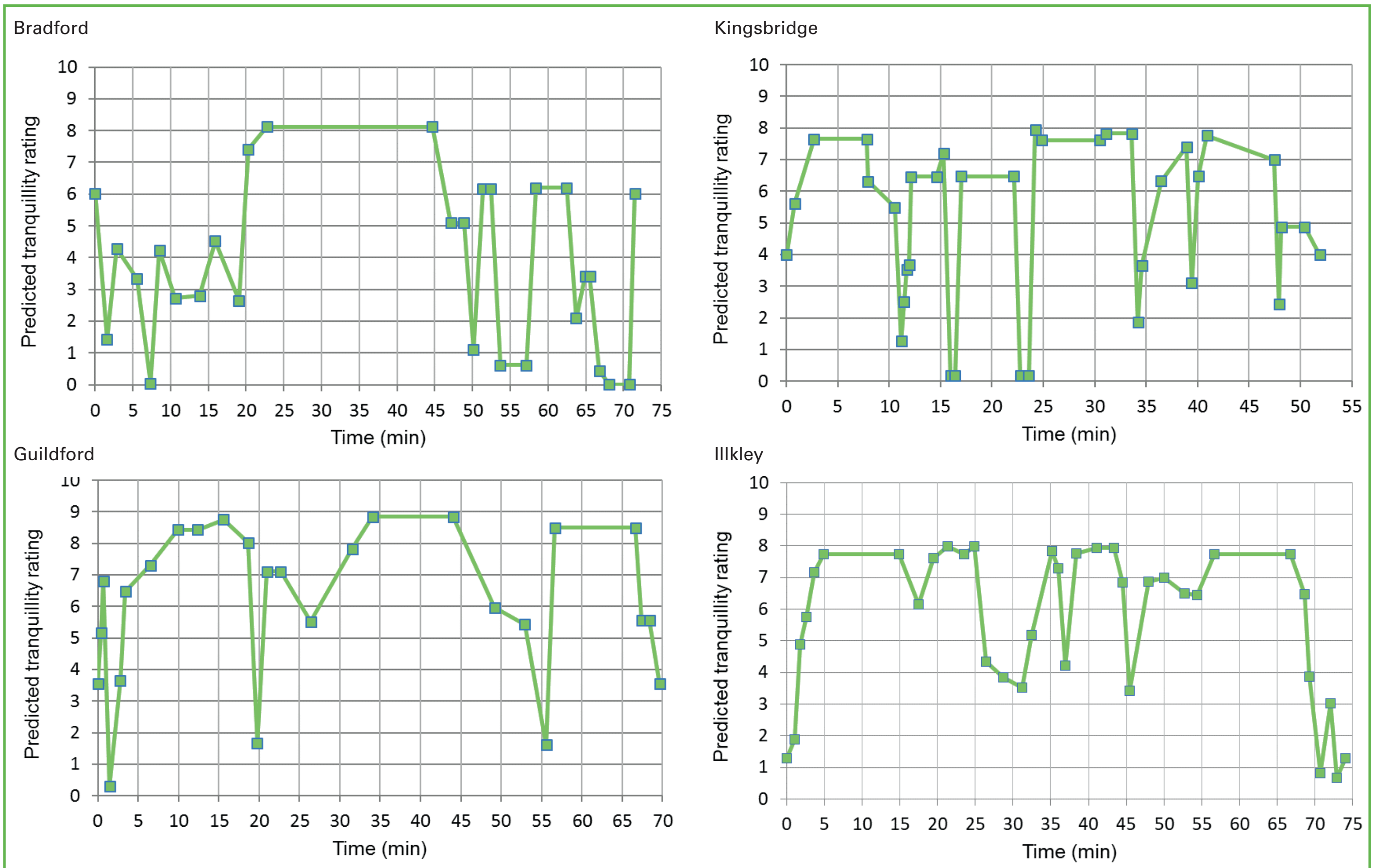

Figure 6: Tranquillity Rating profiles with extra 20 minutes

The average *TR* values for the Bradford, Kingsbridge, Guildford and Ilkley trails are 3.7, 5.6, 6.8 and 6.0 scale points respectively. These averages can be increased if additional time is spent in the most tranquil spaces. To illustrate this 20 extra minutes could be spent in Peel Park in Bradford resulting in an average *TR* of 5.0. If 5 minutes are spent in each of the four quiet spaces in Kingsbridge the average rises to 6.2. For Guildford if 10 minutes were spent at Pewley Down and a further 10 minutes in the Castle Park the average would rise to 7.3. In Ilkey 10 minutes in the Riverside Park and a further 10 minutes alongside the river Wharfe increase the average *TR* value to 6.6. The resulting profiles are shown in Figure 6.

Figure 7 indicates the percentage of the time in each *TR* range with and without stops. Clearly with stops in the most tranquil places, the exposure to relatively high levels of tranquillity increases substantially. With stops the percentage of time with "good" or "excellent" levels of tranquility ranged from 35% in Bradford to over 60% for the Guildford TT.

Questionnaire results

Twenty-three replies were obtained from the Kingsbridge questionnaire over a period of 11 months, though two did not complete the course successfully due to steps and steep inclines and one because the Community Garden was closed. Of the 20 valid replies the average age was 57.7 years with a range from 28 to 80 years.

All respondents replied that they considered the tranquility of the route as "very important" or "fairly important". It has been found that introverts are more likely to perform better in quiet environments and would therefore tend to consider tranquil places as more desirable [16,17]. Therefore, it was considered that those who were more introverted would consider the tranquillity of the trail as "very important" rather than "fairly important" or "unimportant" but there was no evidence for this from the replies collected.

It was shown that 75.0% indicated that they were more relaxed and 60.0% were less anxious after completing the TT. It should be noted that none of the respondents indicated that they were less relaxed or more anxious. 75.0% said that they had no problems on the TT (including route finding). Problems included route finding and steep slopes or steps.

As to benefits, 45.0% mentioned healthy exercise and 30.0% said that they had new and interesting experiences while 15.0% mentioned social aspect of following the route with a friend or family member.

The average tranquillity rating given by respondents after completing the TT was 7.1 while the predicted value was lower at 6.2. This may be because participants spent longer in the tranquil spaces than assumed. This can be inferred from the fact that the total time assumed for completing the TT and spending 20 minutes in the most tranquil spaces was 52 minutes in contrast to the much longer average reported completion time of 89 minutes.

The question on what would assist in encouraging more use of the TT produced a diversity of replies. The main ones are listed below:

- Less busy
- Living closer
- Improving parts of TT
- Better weather

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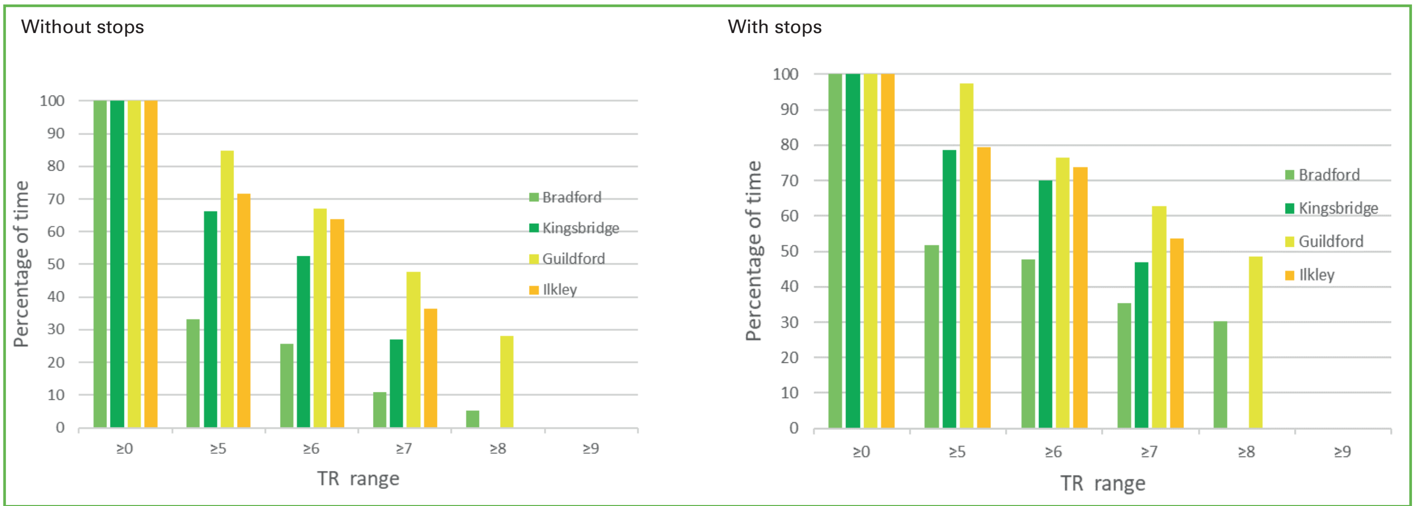

Figure 7: Percentage of time in each tranquillity range

The fencing along parts of the Western Backway is broken could be improved and sometimes there is uncollected litter. It is known that litter depresses TR values [9] and it is also likely that dilapidated conditions would have a similar effect. Consequently, there are actions that can be taken by the Town Council to address these issues and hence promote greater usage.

A previous survey of visitors to 8 green spaces in Bradford, UK also asked a question on factors that would encourage more visits. In this case the sample was much larger with 169 replying to this question.

The breakdown of these responses is shown in Figure 8. Some of the replies relate to playground equipment so are not directly relevant here. However, the need for better maintenance and safety aspects appear applicable to the present study. It seems probable that if litter and graffiti are not dealt with on a sufficiently frequent basis then the environment becomes less pleasant and feels unsafe. Both may lead to less future visits.

Discussion and conclusions

There is abundant evidence in the literature that tranquil environments can provide relief from stresses of everyday of life and can be considered restorative environments. For example, it has been established that tranquillity levels relate well to a measure of well-being such as state of relaxation [7]. The prediction tool (TRAPT) has been used to make estimates of the benefits along TTs in terms of perceived tranquillity. The tool has been validated and calibrated by relating *TR* predictions in green spaces with average ratings obtained from visitors [7]. It was found that there was a good correlation between these two sets of values $r = 0.94$ ($p < 0.001$). A further study in Hong Kong looked at whether the method could be applied across residents from diverse countries [9]. These studies indicate that the tool can be used with some confidence. The effects on predicted perceived tranquillity of town squares, city parks alongside major roads and residential roads and gardens under varying conditions have all been examined [10]. This illustrates the approach that can be taken by concerned groups such as planners, environmentalists, civic leader and citizens in order to determine changes in tranquillity levels brought about by various interventions both positive and negative. In particular, the method can be used to select suitable green spaces and linking paths and roads to create viable TTs that have demonstrable well-being benefits.

The literature shows that in the past TTs have been confined to rural locations [18,19,20] because of the absence of disturbing noise sources and natural surroundings. The concepts of linking tranquil spaces to form a walking route in urban areas is entirely novel and addresses the need to provide relief from the stresses and strains of urban living and healthy exercise. Because these walking routes can all be easily accessed from urban centres it reduces the need to use private or public transport and is therefore additionally a sustainable solution.

It was clear that there were generally high levels of tranquillity along the four TTs. The Guildford TT had the highest overall average Tranquillity Rating followed by Ilkley, Kingsbridge and then Bradford. For example with stops in Guildford nearly 50% of the time the TR value ≥ 8 i.e. “excellent” rating. In Kingsbridge the TR ≥ 7 (“good”) was reached nearly 50% of the time, in Ilkley just over 50% of time while in Bradford TR ≥ 6 (“fairly good”) was found nearly 50% of the time. The layout of the towns and cities and density of traffic constrain what is possible to achieve but the study has demonstrated that across diverse urban environments it was possible to find acceptable levels of tranquillity starting from the urban centre.

The questionnaire results obtained from a sample of participants on the Kingsbridge TT must be judged as preliminary because of the relatively small sample size (19). However, returns showed that overwhelmingly participants reported improved levels of relaxation and reduced anxiety after completing the TT. The average *TR* given for the TT was 7.1 and 75.0% said they were more relaxed after completing the TT and 60.0% recorded they were less anxious. An 8 park survey showed a similar relationship between rated tranquillity of a green space and the percentage feeling more relaxed [7] after visiting. For an overall rating of 7.1 the predicted percentage reporting being more relaxed was 73.4% and that is close to that reported for the Kingsbridge TT survey (75.0%). Benefits of completing the TT in addition to relaxation and reduced stress included healthy exercise, new experiences and social aspect where the walk was conducted with friends. An important means of encouraging the usage of TTs was to improve the conditions on the walk. For example, reducing the amount of litter and improving infrastructures such as walls and fences where they have become dilapidated. Further improvements involving greening measures along the route and reduction

P60 ►

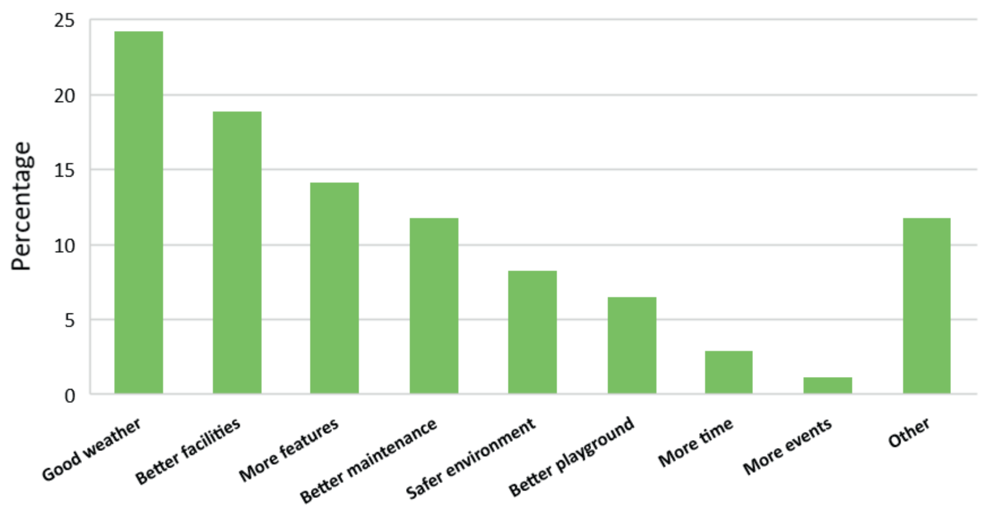

Figure 8: Factors promoting more visits to green spaces

of noise along linking roads could be informed by TRAPT. Currently efforts are being made to identify and characterize TTs both in the UK and abroad.

Making residents and visitors aware of the presence of the TT is another issue that has to be considered. One approach that is currently being explored is to add the TT under "Things to do" on the Tripadvisor website. An example is given at https://www.tripadvisor.co.uk/Attractions-g551682-Activities-Kingsbridge_Devon_England.html. This should increase the numbers requesting the leaflet and subsequently completing the route. It is expected that the posted comments will be a useful additional source of information on benefits and problems.

Gregory Watts *is Professor of Environmental Acoustics at the University of Bradford.*

Acknowledgement

This project has been funded by the Bradford Centre for Sustainable Environments in the Faculty of Engineering and Informatics at the University of Bradford. The assistance of the tourist information centres in Bradford, Kingsbridge, Guildford and Ilkley is gratefully acknowledged.

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Royal Academy of Engineering appoints director to lead new Policy Centre

The Royal Academy of Engineering has appointed a Policy Director to head up its new Policy Centre – an expansion of the academy's well-established policy function that will enhance its ability to provide government with expert advice from the profession on national challenges that involve engineering or have an engineering dimension.


Dr Nick Starkey is the Academy's new Policy Director

Dr Nick Starkey joined the academy in January from the Department of Business, Energy and Industrial Strategy, where he was Deputy Director, Science & Research. Previous positions include Deputy Director, Office for Civil Society and Innovation at the Cabinet Office, and policy adviser at the Department for Environment, Food and Rural Affairs.

The Policy Centre represents a significant increase in the capacity of the academy to work with partners including the professional engineering institutions, industry and other learned societies to provide a coordinated voice; and to expand and deepen its relationships with government. It will define and develop workstreams on the biggest issues that engineering can address, for the benefit of both the profession, and society as a whole.

Dr Starkey said: "Engineering makes an enormous contribution to society and I am excited by the chance to work with engineers and government to help develop good policy to maximise that benefit."

Dr Hayaatun Sillem, Chief Executive of the Royal Academy of Engineering, said: "Nick was an outstanding candidate for the role of Policy Director and has a wealth of relevant expertise and experience. We are delighted that he will be joining us in January to take forward the work on the Engineering Policy Centre and drive a step-change in the visibility and influence of the profession as a whole at the highest levels of government."

For more information contact Victoria Runcie at the Royal Academy of Engineering Tel. 020 7766 0620; email: Victoria.Runcie@raeng.org.uk

Engineering Council provides EQA for Trailblazer Apprenticeships

The Engineering Council actively supports the delivery of high quality apprenticeships that meet the needs of employers and apprentices, support individuals on their journey towards professional registration, and assure the public about the competence of those who are successful.

Employers are now able to nominate the Engineering Council as the provider of quality assurance (known as External Quality Assurance or EQA) for engineering-related Trailblazer Apprenticeships. This has been agreed by the Engineering Council's Board, following a successful trial in autumn 2017. The Institute for Apprenticeships (IfA) website sets out the quality assurance requirements for apprenticeships and how these will ensure quality, consistency and credibility.

The Engineering Council supports the alignment of Trailblazer Apprenticeships with professional registration and welcomes the IfA's guidance that *'Apprenticeship standards must link to professional registration where this exists at that level in the occupation'*. The engineering profession has embraced the opportunity afforded by this new approach to apprenticeships to raise standards and to encourage professional registration. At a time when engineering skills have never been more valued and sought after – as being crucial to the UK's future economic success – it is critical that we reinforce not only the value of engineering but the trust that society has in the knowledge, skills and commitment of professional registered engineers and technicians.

The Engineering Council is the most appropriate body to carry out this quality assurance for engineering-related apprenticeships, because it currently licenses 35 professional engineering institutions to carry out the assessment of individuals seeking registration, in accordance with required Engineering Council standards and prescribed processes. These standards apply across the profession, regardless of sector or discipline, making the Engineering Council the sole UK body that can assure consistency and quality of assessment of professional standards across the professional engineering institutions.

In line with the Engineering Council's role and remit, its quality assurance activity will be limited to professional competence. It will work in partnership so that other elements of the assessment, such as occupational competence, are quality assured by bodies with that expertise.

Employers interested in nominating the Engineering Council as their quality assurance provider for will find more details on our website on how to make a request and what information is required.

The Engineering Council will review this quality assurance activity after 12 months, and may choose to modify its approach.

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London, "Towergate Insurance"restaurant
Hutchison Kivotos architects, London, 2017

Revised strategic noise maps for Wales published

The Welsh Government has announced the publication of new strategic noise maps for Wales.

The Environmental Noise Directive requires member states to review, and revise if necessary, its strategic noise maps at least every five years. The Welsh Government reviewed its 2012 noise maps in 2015 (http://bit.ly/2nNqI1N) and concluded that there was no need to revise the maps of railway noise in Wales prior to proposed electrification works, nor to recalculate noise from non-major roads in urban agglomerations.

However, the maps of noise from major roads across Wales and from industry in urban agglomerations were judged to be out of date and in need of revision. These have now been recalculated and reported to the European Commission by the 31 December 2017 reporting deadline specified in the Directive.

The 2017 noise maps for major roads and agglomeration industry in Wales may be viewed, overlaid with air pollution background maps, at http://bit.ly/2FUv6CJ. The railway noise layers and agglomeration boundaries remain as they were in 2012. The 2012 map layers showing noise action planning priority areas and quiet areas also remain as they are for the time being, though they will be reviewed and updated during the course of 2018 as we draw up a new five-year noise action plan for Wales.

The 2017 noise maps may also be viewed and downloaded as GIS shapefiles by going to http://bit.ly/2nKrQD4

The 2012 noise maps remain available, and can be viewed and downloaded as GIS shapefiles by going to http://bit.ly/2EJBVY9

By opening the 2012 and 2017 noise maps for major roads or industry in separate tabs/windows you can compare them side by side and see how things have changed over a five-year period. Every effort has been made to calculate the 2017 maps in such a way that they may be compared to the 2012 maps.

However, slight changes to the ways in which input data are captured and processed result in some differences between rounds that do not represent real-world changes in noise levels. In particular, an update to the software means that between 3.5m and 7.5m from the source (which is closer to the source than the CRTN calculation method was designed for), the 2012 software set noise levels equal to the value at 7.5m, while the 2017 software has noise levels increase upwards from the value at 7.5m the closer you get to the source.

So some of the major roads look noisier in 2017 than in 2012 when you zoom in to the source itself (e.g. by appearing as thin blue lines rather than thin lilac lines on the map), but don't look noisier beyond a distance of 7.5m. The maps should therefore only be considered to indicate a potential increase in noise levels from 2012 to 2017 when that increase is observable more than 7.5m from source.

Regulations made in 2017 (http://bit.ly/2C3qvvr) require public services boards to take the noise maps into account when producing their assessments of local well-being. Statutory guidance issued in 2017 (http://bit.ly/2shPSdc) requires local authorities to consider the noise maps when reporting policies on tackling airborne pollution in their local air quality management annual progress reports and consider potential synergies and conflicts with noise management when drawing up local air quality action plans.

A new five-year noise action plan for Wales will be drafted in the coming months which will bring noise policy in Wales firmly into line with the principles and ways of working in the Well-being of Future Generations (Wales) Act 2015, and will also reflect changes being made to Planning Policy Wales. It is anticipated that the noise action plan will be ready for public consultation over the summer.

Further information on the calculation of the 2017 noise maps may be found at http://bit.ly/2scG8kL

Major roads in Wales included in the 2011/12 noise mapping (based on 2010 traffic flow data)

Major roads in Wales potentially to be included in the 2016/17 noise mapping (based on 2014 traffic flow data)

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University of Salford investing in audio research consultancy services and loudspeaker testing

Leonardo Weber joined the Acoustics Group at the University of Salford as an Audio Research Consultant last December. He will be responsible for providing bespoke research and testing services specifically for the audio and acoustics industry. Formerly at BDP, Leonardo brings experience from his physics and acoustics background, and audio knowledge such that the Acoustics Research Group can increase the strength and depth of the audio services it offers.

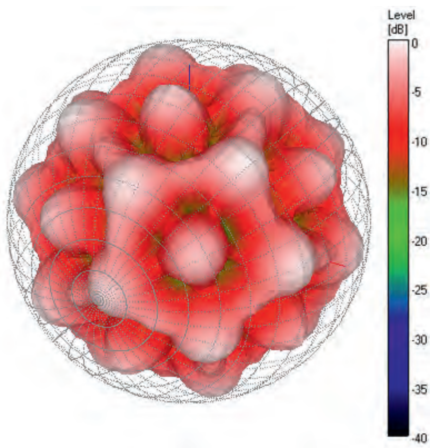
In 2017, the Acoustics Group celebrated 60 years of Acoustics Research at Salford. Prof Peter Lord established the first test chambers in 1957, since which time the Acoustics Group has built up a long track record of word-leading research. Prof Lord's ethos of making research relevant to the industry has remained a central theme for the Group, resulting in a wide range of collaborations with the industry, and a range of UKAS accredited testing and calibration services. Key to Acoustics Research Centre are the test facilities, which boast an impressive anechoic chamber, transmission suite and BS1116 standard listening room, as well as other smaller chambers and studios.

As well as their roles in teaching and research, these facilities enable the Acoustics Research Centre to act as a test house and consultancy for audio engineering and acoustics companies, offering services from standard tests and calibration, through to bespoke research projects and testing including perceptual assessments, loudspeaker design, audio processing applications and vibro-acoustic consultancy services.

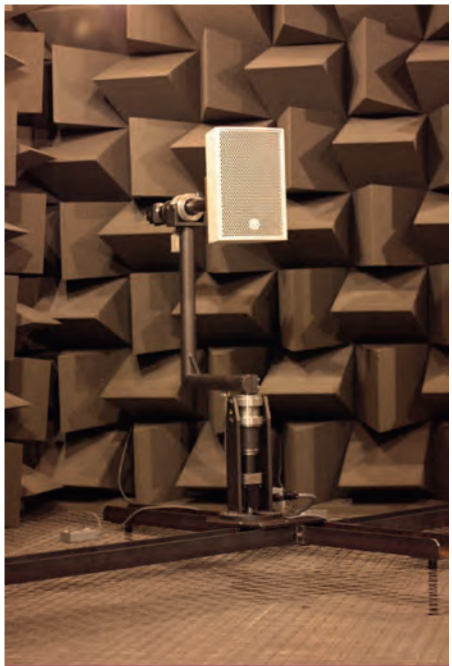
Building on its excellent heritage, the university is now further investing in the expansion of the range of laboratory testing and consultancy services it provides, with the addition of another audio research consultant to the team and the provision of a UK first 3D loudspeaker measurement service to better serve the demands of industry.

The Acoustics Group is also investing in new equipment for its testing facilities. Among which is a new loudspeaker robotic measurement system, which allows three-dimensional directivity data to be measured in the laboratory's anechoic chamber, with an angular resolution of up to one degree in both the azimuth and elevation planes. This measurement system enables data to be analysed using common acoustic modelling packages, such as EASE, and the production of detailed 3D loudspeaker response plots. Additionally, traceable test procedures can be applied to measure other loudspeaker parameters, such as on-axis frequency response, sensitivity, maximum sound pressure level, and impedance.

This three-dimensional measurement system can provide loudspeaker manufacturers with valuable information for the design of new products and also help to improve the audio performance of existing ones. But most importantly, independent testing done at the university will allow a direct comparison between different products, and therefore will enable professionals to make better predictions and more well-informed decisions when modelling and designing sound systems. In order to define how independent loudspeaker testing can facilitate and contribute with the work of Acoustics and AV consultants, the university intends to liaise with professionals in the area to better understand the challenges experienced in designing sound systems and comparing different products available in the market.



A three-dimensional loudspeaker directivity plot produced with the new measurement system



The new robotic loudspeaker measurement system

Following all the latest improvements and upgrades, the Acoustics Research Centre at the University of Salford is welcoming professionals interested in visiting their facilities and learning more about the work they do.

For more information, please contact Leonardo Weber on 0161 295 0253 or l.weber1@salford.ac.uk, or alternatively visit www.salford.ac.uk

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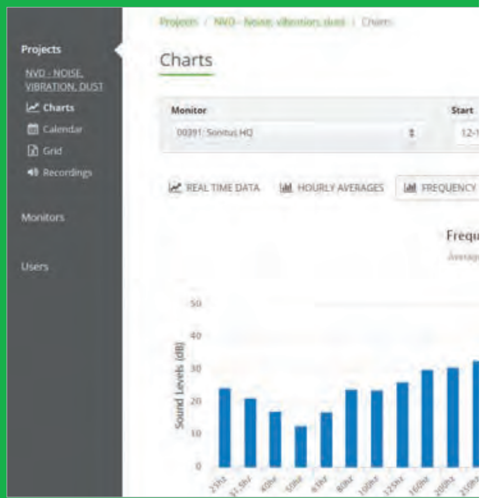

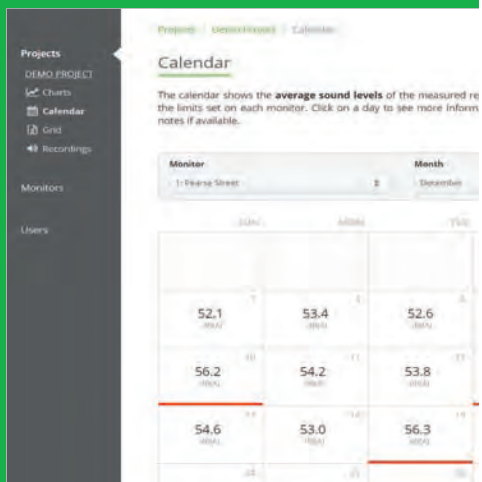

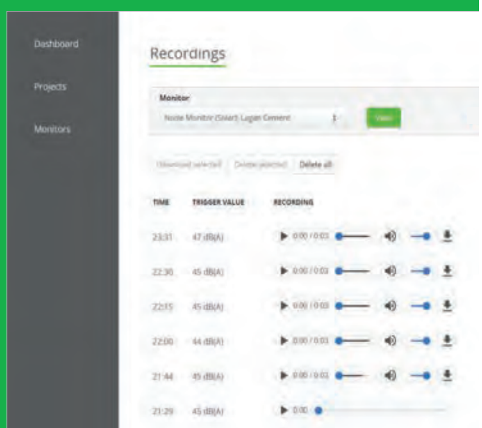

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Cirrus Research welcomes new Sales Manager

Yorkshire-based noise monitoring specialists Cirrus Research have appointed Martin Ellison as its new Sales Manager, following a re-alignment across the company's senior management team.

Martin, 55, has more than 15 year's direct sales experience having worked in several sectors including the automotive, manufacturing, construction and engineering acoustic industries.

Originally from Manchester, Martin will be based at the company's headquarters in Hunmanby, North Yorkshire, leading a team of 10 across national and global territories.

Martin Ellison(Left) and Daren Wallis (Right)

He said: "I'm very excited about this new role and my priorities are to maintain Cirrus' leading reputation as well as grow the business via our own sales team and distributors in the UK and abroad. There will undoubtedly be challenges such as Brexit to prepare for, but also opportunities, in Eastern Europe and China for instance, that we are very keen to explore."

Cirrus Managing Director Daren Wallis agrees: "2018 is going to be a pivotal year for Cirrus and we are delighted to have Martin on board to lead our expanding sales team. His experience across so many sectors means he has hit the ground running. We are already anticipating another record year to build on the growth we enjoyed in 2017 where we saw some of the biggest orders come into Cirrus in the company's history."

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Committee meetings 2018

DAY	DATE	TIME	MEETING
Thursday	11 January	11.30	Meetings
Thursday	18 January	10.30	Membership
Thursday	1 February	11.00	Publications
Thursday	1 March	10.30	Diploma Tutors and Examiners
Thursday	1 March	1.30	Education
Tuesday	6 March	10.30	Diploma Examiners (London)
Wednesday	8 March	10.30	Medals & Awards
Wednesday	8 March	10.30	Executive
Wednesday	21 March	10.30	Council
Tuesday	27 March	11.30	Meetings
Tuesday	10 April	10.30	CCWPNA Examiners
Tuesday	10 April	1.30	CCWPNA Committee
Thursday	26 April	10.30	Membership
Thursday	10 May	11.00	Publications
Thursday	17 May	10.30	CCHAV Examiners
Thursday	17 May	1.30	CCHAV Committee
Wednesday	23 May	10.30	Executive
Tuesday	24 May	10.30	Research Co-ordination (London)
Wednesday	13 June	10.30	Council
Tuesday	26 June	10.30	ASBA (Edinburgh)
Tuesday	3 July	10.30	CCENM Examiners
Tuesday11	3 July	1.30	CCENM Committee
Tuesday	3 July	10.30	CCBAM
Wednesday	4 July	10.30	Distance Learning Tutors WG
Wednesday	4 July	1.30	Education
Thursday	5 July	11.30	Meetings
Thursday	2 August	10.30	Diploma Moderators Meeting
Thursday	9 August	10.30	Membership
Wednesday	12 September	10.30	Executive
Thursday	20 September	10.30	Engineering Division
Wednesday	26 September	10.30	Council
Thursday	11 October	10.30	Meetings
Thursday	18 October	11.00	Publications
Thursday	1 November	10.30	Membership
Tuesday	6 November	10.30	Research Co-ordination(London)
Tuesday	20 November	10.30	CCWPNA Examiners
Tuesday	20 November	1.30	CCWPNA Committee
Wednesday	21 November	10.30	Diploma Tutors and Examiners
Wednesday	21 November	1.30	Education
Thursday	22 November	10.30	CCENM Examiners
Thursday	22 November	1.30	CCENM Committee
Thursday	22 November	10.30	CCBAM Examiners
Tuesday	27 November	10.30	ASBA Examiners (Edinburgh)
Tuesday	27 November	1.30	ASBA Committee (Edinburgh)
Wednesday	28 November	10.30	Executive
Wednesday	12 December	10.30	Council

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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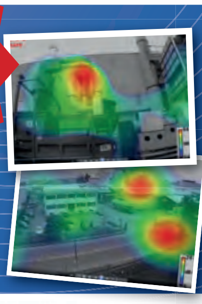

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