Proceedings

Internoise 2022


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This book of abstracts for *Internoise 22* was compiled from the titles, authors and abstracts submitted to the programme committee for approval prior to completion/submission of the full paper.

During the preparation of the full paper many authors (about 33%) chose to edit their abstract to ensure it was an accurate abstract of the final paper. Some authors (about 10%) also revised their title and a small number revised the list of authors.

On the advice of the wider committee full papers were submitted in PDF format to provide as much flexibility as possible for authors. The consequence of this is that it is harder to change the abstracts, title and authors.

Therefore, this book of abstracts contains the original abstract which may be different from the more accurate version that is included with the paper. However, where a title change has been made then this change is included in this document. In some cases, the list of authors, or the order of authors, has changed. This has not been updated in this document.

The document has two parts. The first part has a list of papers with title, authors and addresses. The second has the same information together with the original abstract and a hyper-link to the full paper (online).

The papers are ordered alphabetically by the submitting author. This may be different from the presenter or first author.

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¹Netherlands Aerospace Centre NLR, Amsterdam, Netherlands

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¹Norwegian Institute Of Public Health, Department of Environmental Health, Norway, 2Norwegian Institute of Public Health, Centre for Disease Burden, Norway, 3Occupational and Environmental Medicine, School of Public Health and Community Medicine, Institute of Medicine, Sahlgrenska Academy, University of Gothenburg, Gothenburg, Sweden, 4Department of Occupational and Environmental Medicine, Sahlgrenska University Hospital, Gothenburg, Sweden, 5Danish Cancer Society Research Center, Copenhagen, Denmark, 6National Institute for Health and Welfare, Finland, 7Institute of Environmental Medicine, Karolinska Institutet, Sweden, 8Center for Occupational and Environmental Medicine, Region Stockholm, Stockholm, Sweden

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¹Institute for Hearing Technology and Acoustics, Aachen, Germany, ²Welding and Joining Institute, Aachen, Germany

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¹Queen Mary, University of London, Mile End Rd, Bethnal Green, London, United Kingdom, ²University of Bristol, Bristol, United Kingdom

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¹Technische Universität Berlin, Berlin, Germany, ²University College London, London, United Kingdom
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1Univ Lyon, ENTPE, LTDS UMR 5513, 3 rue Maurice Audin, 69518 Vaulx-en-Velin, Lyon, France, 2LTDS - CNRS UMR 5513, Vibroacoustics & Complex Media Research Group, Ecole Centrale de Lyon, Écully, 69134, Lyon, France, 3Laboratoire Vibrations Acoustique, Univ Lyon, INSA-Lyon, LVA EA677, Villeurbanne, F-69621, Lyon, France

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1Theatrum Mundi, London, United Kingdom

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1Instituto de Ingeniería Mecánica y Biomecánica, Universitat Politècnica de València, Camino de Vera, s/n, 46022, Valencia, Spain, 2Institute of Sound and Vibration Research, University of Southampton, Southampton SO17 1BJ, United Kingdom

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²The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong

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¹Tokyo University Of Science, 2641, Yamazaki, Noda- si, Chiba, Japan, Japan

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¹Institute for Hearing Technology and Acoustics, RWTH Aachen University, Aachen, Germany

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¹Dipartimento Energia - Politecnico Di Torino, Corso Duca Degli Abruzzi 24, Italy

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¹Open University, Milton Keynes, United Kingdom, ²Open University, Leighton Buzzard, United Kingdom

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¹UMRAE, Université Gustave Eiffel, CEREMA, France, ²CEREMA/DTeclTM, Sourdun, France

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¹University Of Southampton, Southampton, United Kingdom

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¹Bauhaus-Universität Weimar, Weimar, Germany

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1The ECO2 Center for Vehicle Design, KTH Royal Institute Of Technology, Stockholm, Sweden, 2The Marcus Wallenberg Laboratory for Sound and Vibration Research, KTH Royal Institute of Technology, Stockholm, Sweden, 3Department of Engineering Mechanics, KTH Royal Institute of Technology, Stockholm, Sweden

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1University of Quebec at Chicoutimi, 555 Bd De L’université, Chicoutimi, QC, Canada, 2Lund university, John Ericssons väg 3, 223 63 Lund, Sweden, 3Technological Institute FCBA, All. de Boutaut, 33000 Bourdeaux, France

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1University of Quebec at Chicoutimi, 555 Bd De L’université, Chicoutimi, QC, Canada, 2The Pennsylvania State University, 104 Engineering Unit A, University Park, USA, 3Lund university, John Ericssons väg 3, 223 63 Lund, Sweden, 4Technological Institute FCBA, All. de Boutaut, 33000 Bourdeaux, France

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1London South Bank University, School of the Built Environment and Architecture, London, UK

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1University Of Salford, Salford, United Kingdom

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1Jacobs, 2020 SW 4th Ave, 4th Floor, Portland, OR 97201, United States

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1AECOM, Nottingham, United Kingdom, 2Defra, London, United Kingdom

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1Subsonic Designs, 1383 Winged Foot Place, Copperleaf, Centurion, South Africa

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1Munich Aeroacoustics, Kirchheim, Germany, 2Kopter Germany GmbH, Hoehenkirchen–Siegertsbrunn, Germany

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1University Of Southampton, Southampton, United Kingdom, 2Vestas aircoil, Lem, Denmark
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¹Force Technology, Venlighedsvej 4, 2970 Hørsholm, Denmark, ²LÄRMKONTOR GmbH, Hamburg, Germany, ³SINTEF, Trondheim, Norway

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¹Instituto de Investigación para la Gestión Integrada de Zonas Costeras, Valencia, Spain, ²Universitat Politècnica de València, Valencia, Spain, ³Instituto Universitario de Automática e Informática Industrial, Universitat Politècnica de València, Valencia, Spain

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¹Valeo, La Verrière, France

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¹University of Milano-Bicocca -- Department of Earth and Environmental Sciences, Piazza della Scienza 1, 20126, Milan, Italy, ²University of Milano-Bicocca -- Department of Physics, Piazza della Scienza 3, 20126, Milan, Italy

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¹SINTEF AS, Strindvegen 4, NO-7034 Trondheim, Norway, ²Gdansk University of Technology, ul. Gabriela Narutowicza 11/12, 80-233 Gdansk, Poland

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¹SINTEF AS, Strindvegen 4, NO-7034 Trondheim, Norway, ²Acoustic Consultant, Weissach, Germany

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¹Bruitparif, 32 Boulevard Ornano, 93200 SAINT-DENIS, France, ²Ademe, 500 Rte des Lucioles, 06560 VALBONNE, France
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1Bruitparif, 32 Boulevard Ornano, 93200 SAINT-DENIS, France

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1DTU Wind Energy, Roskilde, Denmark, 2DTU Wind Energy, Lyngby, Denmark, 3Yangzhou University, Yangzhou, China,
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1University of Bologna, Via Dell’università, 50, Italy

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1Chair of Acoustics, Faculty of Physics, Adam Mickiewicz University, Poznan, Poland

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1Pliteq UK, London, United Kingdom

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1CAPS Lab - MAVT Dept - ETH Zürich, Zürich, Switzerland

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1German Centre For Rail Traffic Research at the Federal Railway Authority, Dresden, Germany
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¹National Institute of Public Health and the Environment (RIVM), Bilthoven, Netherlands

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¹Department of Environmental Health, Norwegian Institute Of Public Health, Norway, ²Centre for Disease Burden, Norwegian Institute of Public Health, Norway, ³Danish Cancer Society Research Center, Denmark, ⁴Occupational and Environmental Medicine, School of Public Health and Community Medicine, Institute of Medicine, Sahlgrenska Academy, University of Gothenburg, Gothenburg, Sweden, ⁵Department of Occupational and Environmental Medicine, Sahlgrenska University Hospital, Gothenburg, Sweden, ⁶National Institute for Health and Welfare, Finland, ⁷Institute of Environmental Medicine, Karolinska Institutet, Stockholm, Sweden

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¹KIT-IPEK, Kaiserstr. 10, Germany

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¹Acoustic Technology, Department of Electrical Engineering, Technical University of Denmark, 2800 Kongens Lyngby, Denmark, ²Department of Applied Mathematics and Computer Science, Technical University of Denmark, 2800 Kongens Lyngby, Denmark, ³Department of the Built Environment, Eindhoven University of Technology, 5612 AZ Eindhoven, The Netherlands

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¹Ghent University, Gent, Belgium

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²Mecanum Inc., Sherbrooke, Canada

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¹Università Degli Studi Della Campania Luigi Vanvitelli, Aversa, Italy, ²Department of Architecture, Biskra University, Biskra, Algeria

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¹Laboratoire d’Acoustique de l’Université du Mans (LAUM), UMR CNRS 6613, Institut d’Acoustique - Graduate School (IAGS), Le Mans, France

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¹International Well Building Institute, New York City, United States
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¹Entpe-Universite de Lyon, 69518 Vaulx-en-velin, France, ²University Austral of Chile, Institute of Acoustics, Valdivia, Chile

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¹Pliteq Inc., Toronto, Canada

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¹CSIC, Madrid, Spain, ²Ecole Centrale Marseille, Marseille, France

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¹Hellenic Mediterranean University, Rethymno, Greece, ²Physikalisch Technische Bundesanstalt, Braunschweig, Germany, ³Federal Institute for Occupational Safety and Health (BAuA), Dortmund, Germany

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¹German Centre for Rail Traffic Research, Dresden, Germany

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¹Swiss Federal Office for the Environment, Bern, Switzerland, ²City of Zurich, Department of Health and Environment, Zurich, Switzerland, ³University of Zurich, Department of Psychology, Zurich, Switzerland

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¹Institute for Transport Studies, University Of Leeds, Leeds, United Kingdom, ²Department of Civil and Environmental Engineering, Faculty of Engineering and Physical Sciences, University of Surrey, Guildford, United Kingdom, ³Institute for Environmental Design and Engineering, University College London, London, United Kingdom, ⁴Noise and Statutory Nuisance Team, Department of Environment, Food and Rural Affairs, London, United Kingdom, ⁵Acoustics Audio, Visual and Theatre Team, Arup, Manchester, United Kingdom

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¹Technical University of Munich, School of Engineering & Design, Department of Engineering Physics and Computation, Munich, Germany

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¹Environment Agency, United Kingdom
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1DTU Electrical Engineering, Kgs. Lyngby, Denmark

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1Grolimund + Partner AG - environmental engineering, Bern, Switzerland, 2Swiss Federal Office for the Environment FOEN, Noise and NIR, Bern, Switzerland

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Erik Bühlmann, Felix Schlatter

1Grolimund + Partner AG - environmental engineering, Bern, Switzerland

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Felix Schlatter, Ulf Sandberg, Truls Berge, Luc Goubert, Erik Bühlmann

1Grolimund + Partner AG, Bern, Switzerland, 2VTI, Swedish National Road and Transport Research Institute, Linköping, Sweden, 3INTEF, Trondheim, Norway, 4BRRC, Belgian Road Research Centre, Brussels, Belgium

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Cesar Bustos, Vincent Jurdic

1Arup, Glasgow, United Kingdom

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1Farrat Isolevel Ltd, Altrincham, United Kingdom, 2University of Salford, Salford, United Kingdom

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Yangsheng Cai

1Fujian University Of Technology, Fuzhou, China

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1School of Electrical and Computer Engineering, University of Campinas, Campinas, Brazil, 2Durham School of Architectural Engineering and Construction, University of Nebraska - Lincoln, Omaha, USA

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1Université Gustave Eiffel, Bouguenais, France, 2Ville de Rezé, Rezé, France

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1Hoare Lea LLP, Bristol, United Kingdom

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MSI-DFAT Services LLC, 4900 Wethererdsville Rd, United States

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Maria Luiza Carvalho, William J. Davies, Bruno Fazenda
Acoustics Research Centre, University of Salford, Salford, United Kingdom, Faculty of Arts, Federal University of Goias, Goiania, Brazil

Optimization of a contra-rotating propeller rig for reduced psychoacoustic impact
Fabio Casagrande Hirono, Antonio Torija Martinez, Andrew Elliott
University Of Salford, Manchester, United Kingdom

Porous top layer optimization of cement concrete slabs for tyre/road noise reduction
Philippe Klein, Julien Cesbron, Simon Bianchetti, Éric Gennesseaux, Thierry Sedran, Julien Waligora
UMRAE, Univ Gustave Eiffel, IFSTTAR, CEREMA, F-44344, Bouguenais, France, UMRAE, Univ Gustave Eiffel, IFSTTAR, CEREMA, Univ Lyon, F-69675, Lyon, France, Univ Gustave Eiffel, MAST-MIT, F-44344 Bouguenais, F-44344, Bouguenais, France, EIFFAGE Infrastructures GD, F-69964, Corbas, France

Genetic algorithm for the optimization of damping material
Jain Chacko, Stefanie Retka
University Of Applied Sciences Würzburg-Schweinfurt, Schweinfurt, Germany

Equivalent source method based Near-field acoustic holography using machine learning
S K Chaitanya, Siddharth Sriraman, Srinath Srinivasan, Srinivasan K
Indian Institute Of Technology Madras, Chennai, India, SSN College of Engineering, Chennai, India

A large-scale study of the social response to construction noise in Hong Kong
Silver Chan, K.C. Lam, C.L. Wong, Richard Kwan, Wilson Ho, Morgan Cheng, Max Yiu
Environmental Protection Department, The Government Of The Hong Kong Special Administrative Region, Department of Geography and Resource Management, The Chinese University of Hong Kong, Wilson Acoustics Limited
Reflections on an EDI Survey of UK-Government-Funded Research Networks in the UK
Simon Chandler-wilde¹, Debra Fearnshaw², Oliver Fisher³, Eleri Jones⁴, Samantha Kanza⁴
¹University Of Reading, Reading, United Kingdom, ²University of Nottingham, Nottingham, United Kingdom, ³University College London, London, United Kingdom, ⁴University of Southampton, Southampton, United Kingdom

Sound Radiation from a Plate with Embedded Active Acoustic Black Holes
Kristian Hook¹, Jordan Cheer¹, Stephen Daley¹
¹Institute of Sound and Vibration Research, University Of Southampton, Southampton, United Kingdom

Acoustic Black Holes in Curved Plates
Kristian Hook¹, Jordan Cheer¹, Stephen Daley¹
¹Institute of Sound and Vibration Research, University Of Southampton, Southampton, United Kingdom

Bayesian Parameter estimation of microphone positions, sound speed and dissipation for impedance tube measurements
Ziqi Chen¹, Cameron Fackler¹, Ning Xiang¹
¹Graduate Program in Architectural Acoustics, Rensselaer Polytechnic Institute, Troy, United States

The effect of the vibrissa shaped cylinder on the aeolian tone mitigation
Guanjiang Chen¹, Xiao Liu¹, Bin Zang¹, Mahdi Azarpeyvand¹
¹University of Bristol, City Of Bristol, UK

Method of high precision pointing control for spacecraft system based on the active-passive integrated orthogonal micro-vibration isolation platform
Zhizhou Chen¹, Li Feng¹, Hu Xueping¹, Ma Xiaolong¹, Ma Longyu¹, Shi Junwei¹
¹Shanghai Institute Of Aerospace System Engineering, Shanghai, China

Systematic Review of meta-analyses for noise
Yingxin Chen¹, Claire Blackmore¹, Katie Eminson¹, Xiangpu Gong¹, Anna Hansell¹
¹Centre for Environmental Health and Sustainability, University Of Leicester, Leicester, United Kingdom

Outlook for the ISO 22955 standard
Yoan Le-Muet, Patrick Chevret¹, Thomas Bonzom², Laurent Brocolini¹
¹Inrs, Vandoeuvre Les Nancy, France, ²Carsat Languedoc Roussillon, Aix en Provence, France

Modelling of wheel/rail squeal noise in curves from mono-harmonic vibratory limit cycles
Olivier Chiello¹, Rita Tufano², Martin Rissmann²
¹UMRAE, Univ Gustave Eiffel, IFSTTAR, CEREMA, Univ Lyon, F-69675, Lyon, France, ²Vibratec, Railway Business Unit, 28 chemin du petit bois, 69131 Ecully, France

Duration dependence of night-time noise effect for passively cooled residential bedrooms.
Anthony Chilton¹, Peter Leonard
¹Max Fordham LLP, London, United Kingdom

Finite Element modeling of force amplification at the spindle due to a tire’s cavity mode: experimental verification
Won Hong Choi¹, J. Stuart Bolton¹, Kyosung Choo¹, Matthew Black²
¹Purdue University, West Lafayette, United States, ²Ford Motor Company, Dearborn, United States
A Feasibility Study of Riblet for Aeroacoustics Applications

Chioma Muhammad¹, Tze Pei Chong¹
²Brunel University London, Uxbridge, United Kingdom

Distinct influence of everyday noise on cardiovascular stress

Jeppe Christensen¹, Klaudia Andersson²,³, Tobias Neher²,³
²Eriikholm Research Centre, Snekkersten, Denmark, ³Institute of Clinical Research, University of Southern Denmark, Odense, Denmark, ⁴Research Unit for ORL – Head & Neck Surgery and Audiology, Odense University Hospital & University of Southern Denmark, Odense, Denmark

Psychoacoustic Analysis of Various Train Pass-by Noise Using

Youngbeen Chung¹
¹Department Of Mechanical Engineering, Hanyang University, Seoul, South Korea

Dilatation wave velocities estimated from the plateau in sound insulation of cross-laminated timber (CLT) plates

Claire Churchill¹, Bernd Nusser², Christian Lux²
¹TU Wien, Vienna, Austria, ²Holzforschung Austria, Vienna, Austria

A Boundary Element Method (BEM) Solver for Low Frequency Room Modes

Andrea Cicero¹,², Jonathan A. Hargreaves¹
¹Acoustics Research Group, Newton Building, University of Salford, Salford, M5 4WT, United Kingdom, ²AC Acustica - Acoustic Design, Ragusa, 97100, Italy

The influence of thermo-hygrometric conditions on metamaterials’ acoustic performance: an investigation on a 3D printed coiled-up resonator

Matteo Cingolani¹, Gioia Fusaro¹, Massimo Garai²
¹Applied Physics, Department of Industrial Engineering, University of Bologna, Bologna, Italy

Relationships between loudness and preference judgments for fan sounds as a function of the reference sound pressure level

Eike Claaßen¹, Stephan Töpken, Steven van de Par
¹Carl Von Ossietzky University, Acoustics Group, Department of Medical Physics and Acoustics, Oldenburg, Germany

Characterizing noise barriers: SOPRANOISE final report and outcomes

Jean-Pierre Clairbois¹, Massimo Garai², Paolo Guidorzi², Marco Conter³, Andreas Fuchs³, Wolfram Bartolomaeus⁴, Michael Chudalla⁴, Fabio Strigari⁴, Christophe Nicodeme⁵
¹A-Tech Acoustic Technologies, Brussels, Belgium, ²University of Bologna, DIN Department of Industrial Engineering, Bologna, Italy, ³AIt Austrian Institute of Technology, Vienna, Austria, ⁴BAST Federal Highway Research Institute, Bergisch Gladbach, Germany, ⁵ERF European Road Federation, Brussels, Belgium

The latest Environment Agency Guidance for Noise and Vibration Management of Environmental Permits

Tony Clayton¹, Jon Tofts¹, Gillian Brown¹, Julija Smyrnova¹
¹Environment Agency, United Kingdom

A 2.5D automatic FEM-SBM method for the evaluation of free-field vibrations induced by underground railway infrastructures

Hassan Liravi¹, Robert Arcos², Arnau Clot-Razquin²
¹Acoustical and Mechanical Engineering Laboratory (LEAM), Universitat Politècnica De Catalunya (UPC), C/ Colom 11, Terrassa 08222, Spain, ²Serra Húnter Fellow, Acoustical and Mechanical Engineering Laboratory (LEAM), Universitat Politècnica De Catalunya (UPC), C/ Colom 11, Terrassa 08222, Spain
Modelling and visualization of surround buckling in electrodynamic audio transducers
Mattia Cobianchi¹, Christopher Spear¹
¹Bowers & Wilkins / Sound United, Southwater, United Kingdom

Achieving Global Consensus on Acceptable Sound Levels for Overland Supersonic Flight
Peter Coen¹, Alexandra Loubeau¹, Jonathan Rathsam¹, Gautam Shah¹
²NASA, Hampton, United States

Experimental and Numerical Studies on the Hilbert Fractal Architecture as an Acoustic Metamaterial
Gianni Comandini¹, Valeska Ting², Mahdi Azarpeyvand³, Fabrizio Scarpa¹
¹Bristol Composite Institute (BCI), Department of Aerospace Engineering, Bristol, United Kingdom, ²Bristol Composite Institute (BCI), Department of Mechanical Engineering, Bristol, United Kingdom, ³Department of Aerospace Engineering, Bristol, United Kingdom

Improving the intelligibility of underground station public address / voice alarm systems using horizontal line array
Diego Cordes¹, Douglas Shearer²
¹Sustainable Acoustics, Winchester, United Kingdom, ²LSBU, London, United Kingdom

Sonic boom, more than two centuries of investigation!
François Coulouvrat¹
¹Institut Jean Le Rond d’Alembert - CNRS & Sorbonne Université, Paris, France

A new sustainable material for in-situ absorption in noise barrier walls
Andrew Cowsill¹
¹Sealed Air, Alsfeld, Germany

Predicting Speech Intelligibility for People with a Hearing Loss: The Clarity Challenges
Trevor Cox¹, Michael Akeroyd², Jon Barker³, John Culling⁴, Jennifer Firth¹, Simone Graetzer¹, Holly Griffiths², Lara Harris¹, Rhoddy Viveros Munoz³, Graham Naylor², Zuzanna Podwinska², Eszter Porter²
¹University Of Salford, Salford M5 4WT, United Kingdom, ²University of Nottingham, Nottingham, UK, ³University of Sheffield, UK, ⁴Cardiff University, Cardiff, UK, ⁵Universidad Austral de Chile, Chile

An asymptotic formula for sound radiation from plates
Stephen Creagh¹, Neekar Mohammed, Martin Richter
¹University Of Nottingham, Nottingham, United Kingdom

Basic study on voice evacuation guidance system using precedence effect in virtual space with wall reverberation
Takeru Daimon¹, Ayumu Osumi¹, Youichi Ito¹
¹Nihon University, Chiyoda-ku, Japan

The effect of loudness on spatial knowledge acquisition in a virtual outpatient polyclinic
donya Dalirnaghadeh¹, Semih Yilmazer
¹Bilkent University, Bilkent University, Faculty Of Art, Design And Architecture, Department Of Interior Architecture And Environmental Design, Bilkent, Ankara 06800, Turkey, Turkey

Feasibility Study for Otoacoustic Emission Hearing Assessment of Classical Music Students
Stephen Dance\textsuperscript{1}, Eric Ballester\textsuperscript{2}
\textsuperscript{1}London South Bank University, London, United Kingdom, \textsuperscript{2}University of Le Mans, Le Mans, France

**Analysis of Combustion Noise Sources Using Doak’s Momentum Potential Theory**

Raffaele D’Aniello\textsuperscript{1}, Karsten Knobloch\textsuperscript{1}, Carolin Kissner\textsuperscript{1}
\textsuperscript{1}German Aerospace Center (DLR), Institute of Propulsion Technology - Dep. Engine Acoustics, Berlin, Germany

**Synchronization in multi-sensor measurements: importance and methods**

Tyler Dare\textsuperscript{1}
\textsuperscript{1}The Pennsylvania State University, State College, United States

**Fine tuning topological waveguides using asymptotic analysis**

Bryn Davies\textsuperscript{1}
\textsuperscript{1}Imperial College London, London, United Kingdom

**Can acoustic design accommodate aural diversity?**

Bill Davies\textsuperscript{1}
\textsuperscript{1}Acoustics Research Centre, University Of Salford, Salford, United Kingdom

**The imaginary part of the diffuse field forced normalized radiation impedance of a rectangular panel**

John Davy\textsuperscript{1}
\textsuperscript{1}RMIT University and CSIRO, Melbourne, Australia

**EXPERIMENTAL INVESTIGATION ON A SIDE-BY-SIDE TWIN ROTOR SYSTEM IN PUSHER CONFIGURATION**

Elisa De Paola\textsuperscript{1}, Alessandro Di Marco\textsuperscript{1}, Luana Georgiana Stoica\textsuperscript{1}, Leonardo Falcini\textsuperscript{1}, Roberto Camussi\textsuperscript{1}
\textsuperscript{1}Università degli studi Roma Tre, Rome, Italy

**Clustering analyses to assess HVAC noise in real-world conditions**

Domenico De Salvio\textsuperscript{1}, Dario D’Orazio\textsuperscript{1}, Massimo Garai\textsuperscript{1}
\textsuperscript{1}University Of Bologna, Viale del Risorgimento, 2, Italy

**Assessing human activity noise in workspaces using machine learning and numerical models**

Domenico De Salvio\textsuperscript{2}, Giulia Fratoni\textsuperscript{1}, Dario D’Orazio\textsuperscript{1}, Massimo Garai\textsuperscript{1}
\textsuperscript{1}Department of Industrial Engineering, University Of Bologna, Viale del Risorgimento, 2, Italy

**Evaluation of the renovation of an urban highway viaduct using citizen science low-cost noise monitoring**

Luc Dekoninck\textsuperscript{1}
\textsuperscript{1}Ghent University, Technologiepark Zwijnaarde 126, Belgium

**Acoustic echo modeling of people in acoustic arrays using LIDAR**

Alberto Izquierdo\textsuperscript{1}, Lara Del Val\textsuperscript{1}, Juan J. Villacorta\textsuperscript{1}
\textsuperscript{1}University Of Valladolid, Valladolid, Spain

**Quantifying non-linear effects in acoustic source localization**

Samuel Deleu\textsuperscript{1}, Romain Gojon\textsuperscript{1}, Jérémie Gressier\textsuperscript{1}
\textsuperscript{1}ISAE-SUPAERO, 10 Avenue Edouard Belin, 31000, Toulouse, France

**Techniques to establish accurate background noise levels in areas affected by operational wind turbine noise**
Low frequency attenuation of acoustic waves using sound-soft scatterers

Alexander Dell¹, Anton Krynkin¹, Kirill Horoshenkov, Gavin Sailor¹

¹The University of Sheffield, Sheffield, United Kingdom

Acoustic and thermal performance evaluation of residence facades

Dilara Demir Tunca¹, Gülten Manioglu¹, Nese Yügrük Akdag²

¹ISTANBUL TECHNICAL UNIVERSITY, ISTANBUL, TURKEY, ²YILDIZ TECHNICAL UNIVERSITY, ISTANBUL, TURKEY

Radiation of a metaplate made of an acoustic black hole and local resonators

Jie Deng¹, Oriol Guasch², Laurent Maxit³, Nansha Gao¹

¹Northwestern Polytechnical University, Xi'an, China, ²GTM - Grup de Recerca en Tecnologies Mèdia, La Salle, Universitat Ramon Llull, C/Quatre Camins 30, 08022 Barcelona, Catalonia (Spain), ³INSA–Lyon, Laboratoire Vibrations-Acoustique (LVA), 25 bis, av. Jean Capelle, F-69621 Villeurbanne Cedex, France,

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Jie Deng¹, Oriol Gausch², Laurent Maxit³, Nansha Gao¹

²School of Marine Science and Technology, Northwestern Polytechnical University, Xi'an, China, Xi'an, China, ²GTM - Grup de Recerca en Tecnologies Mèdia, La Salle, Universitat Ramon Llull, C/Quatre Camins 30, 08022 Barcelona, Catalonia (Spain), ³INSA–Lyon, Laboratoire Vibrations-Acoustique (LVA), 25 bis, av. Jean Capelle, F-69621 Villeurbanne Cedex, France,

Bayesian Optimization Based Adaptive Control of Thermoacoustic Instabilities

Bayu Dharmaputra¹, Alain Williner¹, Bruno Schuermans¹, Nicolas Noiray¹

¹ETH Zurich, Zurich, Switzerland

Methods for product sound quality design: evaluation of a case study

Samantha Di Loreto¹

¹Università Politecnica Delle Marche, Via Brecce Bianche 12, Italy

Application of the SVM algorithm for the development of a model classification of the visual and sound landscape

Samantha Di Loreto, Fabio Serpilli, Valter Lori

¹Università Politecnica Delle Marche, villa rosa, Italia

Pressure-velocity measurements of a small automotive fan at different working conditions. A noise generation perspective.

Alessandro Di Marco¹, Elisa de Paola¹, Georgiana Stoica¹, Enrico Mollica²

¹University Roma Tre, Rome, Italy, ²SPAL Automotive, Reggio Emilia, Italy

Acoustic and aesthetics: The effect of paint on fabric backed by a sound absorber

Angela Marion Diaz Mena¹, Haydar Aygun¹

¹London South Bank University, London, United Kingdom

Prediction of noise from mechanical ventilation systems in dwellings: case studies

Arne Dijckmans¹

¹Belgian Building Reserach Institute, Brussels, Belgium
Physical Quantities Reconstruction in Reacting Flows with Deep Learning
Nilam Tathawadekar\textsuperscript{2}, Camilo Silva\textsuperscript{4}, Philip Sitte\textsuperscript{3}, Nguyen Anh Khoa Doan\textsuperscript{1}
\textsuperscript{1}Delft University Of Technology, Delft, Netherlands, \textsuperscript{2}Technical University of Munich, Munich, Germany, \textsuperscript{3}Siemens Mobility Austria GmbH, Vienna, Austria, \textsuperscript{4}Ansaldo Energia Switzerland, Baden, Switzerland

Spatial design outcomes of indoor soundscaping course as part of interior architecture education
Papatya Nur Dokmeci Yorukoglu\textsuperscript{1}
\textsuperscript{1}Cankaya University, Ankara, Turkey

IoT smart city framework using AI for urban sound classification
Simona Domazetovska\textsuperscript{1}, Damjan Pecioski\textsuperscript{1}, Viktor Gavriloski\textsuperscript{1}, Hristijan Mickoski\textsuperscript{1}
\textsuperscript{1}Faculty Of Mechanical Engineering In Skopje, Rugjer Boskovic Nn, Macedonia

Influence of several audio parameters in urban sound event classification
Simona Domazetovska\textsuperscript{1}, Viktor Gavriloski\textsuperscript{1}, Maja Anachkova\textsuperscript{1}
\textsuperscript{1}Faculty Of Mechanical Engineering In Skopje, Rugjer Boskovic Nn, Macedonia

Noise and Pavement Rehabilitation Using Chip Seal Surfaces
Paul Donavan\textsuperscript{1}, Carrie Janello, Dana Lodico
\textsuperscript{1}Illingworth & Rodkin, Inc, Cotati, United States

Investigation of vibration-based measurements of impact and airborne noise insulation
Wayland Dong\textsuperscript{1}, John LoVerde\textsuperscript{1}, Ben Shafer\textsuperscript{2}, Sunit Girdhar\textsuperscript{3}
\textsuperscript{1}Veneklasen Associates, Santa Monica, United States, \textsuperscript{2}PABCO Gypsum, Tacoma, United States, \textsuperscript{3}Michigan Technological University, Houghton, United States

Studying the association between noise exposure, stress and characteristics of green spaces: protocol and pilot study
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\textsuperscript{1}Empa Laboratory for Acoustics/Noise Control, Swiss Federal Laboratories for Materials Science and Technology, Dübendorf, Switzerland, \textsuperscript{2}Swiss Federal Institute for Forest, Snow and Landscape Research, Birmensdorf, Switzerland, \textsuperscript{3}Swiss Tropical and Public Health Institute, Basel, Switzerland, \textsuperscript{4}University of Basel, Basel, Switzerland, \textsuperscript{5}Federal Office for the Environment, Switzerland

Amplitude death and growth in a pair of nonidentical thermoacoustic oscillators interacting via time-delay and dissipative coupling
Mohammad Hossein Doranehgard\textsuperscript{1}, Vikrant Gupta\textsuperscript{2}, Larry K. B. Li\textsuperscript{1}
\textsuperscript{1}Hong Kong University of Science and Technology, Hong Kong, Hong Kong, \textsuperscript{2}Southern University of Science and Technology, Shenzhen, China

Numerical simulations of sonic boom propagation over urban areas
Didier Dragna\textsuperscript{1}, Ariane Emmanuelli\textsuperscript{1}, Sébastien Ollivier\textsuperscript{1}, Philippe Blanc-Benon\textsuperscript{1}
\textsuperscript{1}LMFA, Centrale Lyon, Ecully, France

Vehicle pass-by noise auralization in a virtual urban environment
Christian Dreier\textsuperscript{1}, Michael Vorländer\textsuperscript{1}
\textsuperscript{1}Institute For Hearing Technology and Acoustics (IHTA), RWTH Aachen University, Kopernikusstr.5, 52074 Aachen, Germany

Auraltypical acoustics? A critical review of key standards and practices
John Drever\textsuperscript{1}, Mattia Cobinachi, Carmen Rosas Pérez
Vibration Characteristics Optimization of a Rectangular Plate Embedded with Two-dimensional Acoustic Black Holes
Xiaofei Du¹, Qing Gu²
¹School of Mechanical Engineering, Nanjing Institute of Technology, Nanjing, China, ²Nanjing Institute of Technology, Nanjing, China

BS 4142:2019 – Methods for rating and assessing industrial and commercial sound – the past, the present and future developments – a history.
Philip Dunbavin¹
¹PDA Ltd, WARRINGTON, United Kingdom

Context and Representation: Data Gathering Methodology for Soundscape Contextual Factors
Albert Dwan¹
¹Arup Deutschland GmbH, Joachimsthaler Straße 41, Germany

Noise in restorative environments – Perceptions, positive and negative environmental components in Tyrolean children
Angel Dzhambov¹, Peter Lercher², Johannes Rüdisser³
¹Department of Hygiene, Faculty of Public Health, Medical University of Plovdiv, Plovdiv, Bulgaria, ²Institute for Highway Engineering and Transport Planning, Graz University of Technology, Graz, Austria, ³Department of Ecology, University of Innsbruck, Innsbruck, Austria

Objective and perceived acoustic environments during the COVID-19 lockdown: An overview of evidence
Angel Dzhambov¹
¹Medical University of Plovdiv, 15A Vassil Aprilov Blvd., Plovdiv 4002, Bulgaria

Design of virtual binaural manikins and auditorium acoustic system
Eusébio E.¹, Ines Conceição², Manuela J. Lúcio¹, João M. Gomes¹, Hazim Awbi³
¹University of Algarve (Vat Number: 505 387 271), Faro, Portugal, ²IST - Universidade de Lisboa, Lisboa, Portugal, ³University of Reading, Reading, Reino Unido

Application of a thermo-biomechanical virtual manikin used in transient systems
Eusébio E.¹, Ines Conceição², Manuela J. Lúcio¹, João M. Gomes¹, Hazim Awbi³
¹University of Algarve (Vat Number: 505 387 271), Faro, Portugal, ²IST - Universidade de Lisboa, Lisboa, Portugal, ³University of Reading, Reading, UK

A large-scale, long-term experimental campaign for the investigation of wind turbine noise fluctuations and amplitude modulation phenomena.
David Ecotiere¹, Benoit Gauvreau, Isabelle Schmich-Yamane, Albert Alarcon, Marie-Cécile Nessi, Fabrice Junker, Gwenael Guillaume, Vincent Gary, Laurent Brendel, Guillaume Litou, Regis Boittin, Lionel Segaud, Hubert Lefèvre
¹Cerema, 11 Rue Jean Mentelin 67210 Strasbourg, France

Towards Wayside Wheel Flat Detection and Classification Based on Psychoacoustic Quantities
Jonas Egeler¹, Melissa Forstreuter¹, Christine Huth¹, Manfred Liepert¹
¹Moehler + Partner Ingenieure AG, Augsburg, Germany

The impact of changing fleet makeup on airline noise emission
Karina Einicke¹, John Kennedy¹
Numerical and experimental analysis on helicopter’s main rotor transmission for predicting structure-borne noise (SBN) using CB-TPA methods  
Wafaa El Khatiri¹, Raef Cherif², Khalid El Bikri³, Noureddine Atalla¹  
¹University Of Sherbrooke, 2500 Boulevard de l’Université, Sherbrooke, QC, J1K 2R1, Canada, ²University of Quebec in Rimouski, 300 All. des Ursulines, Rimouski, QC G5L 3A1, Canada, ³Université de Mohammed V Rabat, Ensam, B.P. 6207 Av. of the Royal Armed Forces, Rabat 10100, Morocco

Active control of acoustic scattering from a passively optimised spherical shell  
Stephen Elliott¹, Mihai Orita, Erika Quaranta, Jordan Cheer  
¹ISVR University Of Southampton, Southampton, United Kingdom

Acoustic Comfort in Hybrid Learning Spaces: Students Perspective  
Hussein Elmehdi¹, Ania Tato²  
¹University Of Sharjah, PO Box 27272, United Arab Emirates, ²University of the Basque Country, Leioa, Spain

Assessing Acoustic Conditions in Hybrid Classrooms with COVID-19 Social Distancing at the University of Sharjah  
Hussein Elmehdi¹, Ania Tato²  
¹University Of Sharjah, PO Box 27272, United Arab Emirates, ²University of the Basque Country, Bilbao, Spain

Ray tracing in Galerkin Boundary Integral form  
Amal Emthyas¹, Jonathan Hargreaves¹  
¹Acoustics Research Group, Newton Building, University of Salford, Salford, MS 4WT, United Kingdom

Cabin noise analysis of an H120 B helicopter for ANC applications  
Florian Ernst¹, Delf Sachau¹  
¹Helmut-Schmidt-Universität - University of the Federal Armed Forces Hamburg, Hamburg, Germany

Assessment of The Acoustic Scattering Matrix of a Heat Exchanger Using ssCFD-LNSE Simulation  
Hamed F. Ganji¹, Viktor Kornilov¹, Jeroen van Oijen¹, Philip de Goey¹, Ines Lopez Arteaga¹²  
¹Eindhoven University Of Technology, Eindhoven, Netherlands, ²KTH Royal Institute Of Technology, Stockholm, Sweden

Characterization and Identification of Thermoacoustic behaviour of flames anchored on burner decks with multiple perforation; Transfer Function (de)composition approach  
Hamed F. Ganji¹, Viktor Kornilov¹, Philip de Goey¹, Ines Lopez Arteaga¹, Jeroen van Oijen¹  
¹Eindhoven University Of Technology, Eindhoven, Netherlands

Equivalent Circuit Method Based Double Layer Micro-perforated Panel (MPP) Design to Widen the Sound Absorption Bandwidth  
Ela Fasllija¹, Semiha Yilmazer², Cengiz Yilmazer³  
¹Department of Interior Architecture and Environmental Design, Bilkent University, Ankara, Turkey, ²Ray W. Herrick Laboratories, Purdue University, West Lafayette, U.S.A, ³CSY R&D and Architecture Engineering, Ankara, Turkey

On the decay of entropic-compositional sources of indirect noise in combustors  
Abolfazl Fattahi, Ebrahim Rahmani, Nader Karimi, S. Mostafa Hosseinalipour  
¹University Of Kashan, Ghotbe Ravandi Blvd, Kashan, Iran

Noise mapping from above  
Endre Fay¹
A comparative study of semi-empirical noise emission models based on the PANAM and sonAIR aircraft noise simulation tools
Gil Felix Greco¹, Felix Wienke², Lothar Bertsch², Christoph Zellmann³, Beat Schäffer³, Tobias P. Ring¹, Sabine C. Langer¹
¹Herman Otto Institute Nonprofit Ltd., Budapest, Hungary

An update to the WHO 2018 Environmental Noise Guidelines exposure response relationships for annoyance from road and railway noise
Benjamin Fenech¹, Georgia Rodgers¹, Sierra Clark¹
¹Noise and Public Health Team, Radiation Chemical and Environmental Hazards, Science Group, UK Health Security Agency, London, United Kingdom

A Multiple Target Data Association Method for TDOA Passive Localization
Miao Feng¹, Zhaoqing Gu¹, Shiliang Fang¹
¹Key Laboratory of Underwater Acoustic Signal Pro, Nanjing, China

Sound.Wood.Austria - selected measurement results of building components for multi-storey timber construction in Austria
Heinz Ferk¹, Selina Vavrik-Kirchsteiger¹, Leh Christopher¹, Markus Mosing¹, Bernd Nusser²
¹Graz University of Technology, Graz, Austria, ²Holz Forschung Austria, Wien, Austria

Engine Order Cancelation in a supersports car cabin
Cesare Lupo Ferrari¹, Jordan Cheer²
¹Department of Mechanical Engineering, Politecnico di Milano, Milano, 20156, Italy, ²Institute of Sound and Vibration Research, University of Southampton, Southampton, SO17 1BJ, UK

Psychoacoustic properties of tire-road noise and the relation to noise annoyance
Andre Fiebig¹, Christoph Jakobs¹
¹Technische Universität Berlin, Berlin, Germany

Experimental design of an active vibration control device used to protect cultural heritage objects
Loïc Forma¹,²,³, Nicolas Wilkie-Chancellor¹, Sandie LeConté², Henri Boutin³, Marguerite Jossic⁴,⁵
¹Systèmes et Applications des Technologies de l’Information et de l’Energie (SATIE), CY Cergy-Paris Université, 5 mail Gay Lussac, 95000 Neuville-sur-Oise, France, ²Institut National du Patrimoine (INP), 124 Rue Henri Barbusse, Aubervilliers, France, ³Sciences et Technologies de la Musique et du Son (UMR9912), Sorbonne Université, Ircam, (CNRS) Centre National de la Recherche Scientifique, 1 place Igor Stravinsky, Paris, France, ⁴Équipe Conservation Recherche, Musée de la Musique, Cité de la Musique, Philharmonie de Paris, 221 Avenue Jean Jaurès, Paris, France, ⁵Centre de Recherche sur la Conservation, CNRS-USR3224, Muséum National d’Histoire Naturelle, Ministère de la Culture, 36 rue Geoffroy Saint-Hilaire, Paris, France

Effect of urban morphology and greening on noise and air pollution – case studies including disease burden estimates
Jens Forsssén¹, Marie Haeger-Eugensson²,³, Meta Berghauser Pont¹, Andreas Gustafson¹, Christine Achberger², Niklas Rosholm⁴
¹Chalmers University of Technology, Göteborg, Sweden, ²COWI AB, Sweden, ³Gothenburg University, Department of Earth Sciences, Sweden, ⁴City of Gothenburg, Environmental Office, Sweden
Using Non-wave based modelling to explore how much acoustic diffusion is too much in a concert hall.
Michael Fort

Characterisation Testing of Floating Floor systems under Impact Conditions
Adam Fox, Doug Valerio

Informing sound art design in public space through soundscape simulation
Valérian Fraisse, Nadine Schütz, Catherine Guastavino, Marcelo Wanderley, Nicolas Misdariis

Mixing materials in false ceilings to increase sound diffusion in education spaces
Giulia Fratoni, Dario D’Orazio, Luca Barbaresi, Massimo Garai, Luca Cappellini

Acoustic source localization in ports with different beamforming algorithms
Luca Fredianelli, Marco Bernardini, Lara Ginevra Del Pizzo, Francesca Tonetti, Francesco Fidecaro, Gaetano Licitra

Effect of neighbours sounds in wooden residential buildings on restorative EEG rhythm (Alpha waves)
Alessia Frescura, Pyoung-Jik Lee, Jeong-Ho Jeong, Yoshiharu Soeta

Overview of the acoustic quality of dwellings in Ukraine and CIS countries
Eugen Fridlib

Broadband potential optimisation of a full scale acoustic metawindow performance.
Gioia Fusaro, Massimo Garai, Jian Kang

Differences in acoustic characteristics of hitting sounds in baseball games
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Using data-driven techniques to provide feedback during material characterisation
Mathieu Gaborit, Luc Jaouen

Vibrational damping properties of finite microperforated plates
Lucie Gallerand, Mathias Legrand, Thomas Dupont, Philippe Leclaire
Acoustical Effects of Surgical and N95 Masks on Speech Perception in Open-Plan Offices
Pooja Ganatra
1École De Technologie Supérieure, Montréal, Canada, 2McGill University, Montréal, Canada, 3Université de Bourgogne, Nevers, France

High frequency modelling of electric motor vibration in the presence of adhesive bonded components
Boyang Gao1, Dan O’boy1, Georgios Mavros1
1Loughborough University, Epinal Way, Loughborough, UK LE11 3TU, United Kingdom

Influence of Environmental Sensitivity on Soundscape Evaluation in Urban Open Public Spaces
Weifu Gao2, Jian Kang2, Hui Ma1
2School of Architecture, Tianjin University, Tianjin, China, 2Institute for Environmental Design and Engineering, University College London, London, UK

Thermoacoustic stability prediction using Deep Learning
Renaud Gaudron1, Aimee S. Morgans1
1Imperial College London, London, United Kingdom

Impact of railroad switches on rail noise exposure near stations
Anders Genell1, Mikael Ögren2, Erik Nyberg1, Andreas Gustafson4, Tomas Jerson3
1Swedish National Road And Transport Research Institute, Gothenburg, Sweden, 2Department of Occupational and Environmental Medicine | School of Public Health and Community Medicine Institute of Medicine, Sahlgrenska Academy, University of Gothenburg, Gothenburg, Sweden, 3ELTON Acoustics Consultant, Höviksnäs, Sweden, 4Gärdhagen Akustik AB, Gothenburg, Sverige

Inverse Design of Linear and Nonlinear Cylindrical Metamaterial Rod
Pravinkumar Ghodake1
1Indian Institute of Technology Bombay, Mumbai, India

Topology optimization of single and double panels for improved sound insulation in specific frequency bands
Daniele Giannini1, Mattias Schevenels2, Edwin Reynders1
1Department of Civil Engineering - Structural Mechanics Section, KU Leuven, Leuven, Belgium, 2Department of Architecture - Architectural Engineering Research Group, KU Leuven, Leuven, Belgium

Measuring the impact force from the ISO impact ball and comparison with the tapping machine and alternate input method
Sunit Girdhar1, Jason Blough1, Andrew Barnard2, John LoVerde3, Wayland Dong3
1Michigan Technological University, Hancock, United States, 2Pennsylvania State University, State College, United States, 3Veneklasen Associates Inc., Santa Monica, United States

A method to quantify the noise annoyance in an airport community
Truls Gjestland1, Idar L N Granøien
1Sintef, Trondheim, Norway

The Sonic Identity Model: one interdisciplinary approach for qualitative urban soundscape analysis, management and design
Sophie Gleeson1
1Arup; RMIT University, Melbourne, Australia
The Effects of User Experience on the Questionnaire to Detection of the Soundscape of Historical Areas - Example of Eskisehir Factories Region
Özlem Gök Tokgöz
1Chair Of Acoustics And Haptics, TU Dresden, Dresden, Germany

Soundscape Research in Multicultural Market Areas- Example of Berlin Kreuzberg
Özlem Gök Tokgöz, André Fiebig
1Chair Of Acoustics And Haptic Engineering, Institute of Acoustics And Speech Communication, TU Dresden, Dresden, Germany, 2Department of Engineering Acoustics, Institute of Fluid Dynamics and Technical Acoustics, TU Berlin, Berlin, Germany

Further application of the 1/3 oct band heavy/hard impact prediction method
Matthew Golden, Tim Patzke
1Pliteq, 131 Royal Group Crescent Vaughan, Canada

An ocean acoustical ray-tracing tool based on Fermat's least time principle in real a environment
João Duarte Gonçalves
1Escola Naval, Lisboa, Portugal

Large Eddy Simulation of compositional indirect noises generated in a non-isentropic nozzle
Yu Gong, William Jones, Fred Marquis
1Imperial College London, London, United Kingdom

Association between aircraft noise levels and deprivation
Xiangpu Gong, Nicole Itzkowitz, Kathryn Adams, Calvin Jephcote, Marta Blangiardo, John Gulliver, Anna Hansell
1Centre for Environmental Health and Sustainability, University of Leicester, Leicester, United Kingdom, 2National Institute for Health Protection Research Unit in Environmental Exposures and Health at the University of Leicester, Leicester, United Kingdom, 3Department of Epidemiology and Biostatistics, Imperial College London, London, United Kingdom

An Approach to Designing and Specifying Audibility Requirements of Train Activated Warning Systems
Christabel Goode, Seckin Basturk, James Block, Alex Southern
1Aecom, United Kingdom

State of the art about solutions for tram noise reduction in the framework of the Life SNEAK project
Lapo Governi, Monica Carfagni, Francesco Borchi, Luca Puggelli, Francesco Buonamici
1University of Florence - Department of Industrial Engineering of Florence, Via Di Santa Marta, 50139, Firenze, Italy

A new procedure to carry out noise and vibration measurements oriented to support an annoyance evaluation in the framework of the Life SNEAK project
Lapo Governi, Andrea Bracciali, Gianluca Megna, Matteo Bernardini, Chiara Bartalucci, Raffaella Bellominì, Gianfrancesco Colucci, Sergio Luzzi
1University of Florence - Department of Industrial Engineering, Firenze, Italy, 2Vie en.ro.se. Ingegneria, Firenze, Italy

Assessment of the Noise Reduction Impact from Application Restrictions on Rail Dampers
Christoph Gramowski, Roxana Donner
1Schrey & Veit GmbH, Sprendlingen, Germany, 2Acouplan GmbH, Berlin, Germany
Classroom acoustics design beyond BB93 - refurbishment of a hearing impaired unit in a mainstream primary school
Emma Greenland
\textsuperscript{1}Anderson Acoustics, 1 Trafalgar Mews 15-16 Trafalgar Street, United Kingdom

Verification of Railways Noise Mapping Using CNOSSOS-EU: Case Study on Freight Trains
Alvaro Grilo Bensusan\textsuperscript{1}, Javier Mitjavila\textsuperscript{1}
\textsuperscript{1}Inerco Acústica, Calle Tomas Alba Edison, 2 41092 Seville, Spain

Acoustics for a Sustainable Future
Richard Grove
\textsuperscript{1}Inhabit, London, United Kingdom

Incoherent Integration of Hyperbolic Frequency Modulated Pulses by the Radon Transform
Zhaoning Gu\textsuperscript{1}, Chuanqi Zhu\textsuperscript{1}, Shiliang Fang\textsuperscript{1}
\textsuperscript{1}Key Laboratory of Underwater Acoustic Signal Processing, Ministry of Education, Southeast University, Nanjing, China

Experimental study on electromechanical performance decoupling and vibration suppression of crystal oscillator
Zhangqi Gu\textsuperscript{1}, Qingqing Yu\textsuperscript{1}, Xuelin Peng\textsuperscript{1}
\textsuperscript{1}Nanjing Research Institute Of Electronics Technology, Nanjing, China

Chimera states in a can-annular combustion system
Yu Guan\textsuperscript{1}, Kihun Moon\textsuperscript{1}, Kyu Tae Kim\textsuperscript{1}, Larry K. B. Li\textsuperscript{1,3}
\textsuperscript{1}Department of Mechanical and Aerospace Engineering, The Hong Kong University of Science and Technology, Hong Kong, China, \textsuperscript{2}Department of Aerospace Engineering, Korea Advanced Institute of Science and Technology, Daejeon, Republic of Korea, \textsuperscript{3}Guangdong–Hong Kong–Macao Joint Laboratory for Data-Driven Fluid Mechanics and Engineering Applications, The Hong Kong University of Science and Technology, Hong Kong, China

Sound Radiation Estimate from Vibration Measurements With Multiple Cameras
Gianluca Guernieri\textsuperscript{1}, Paolo Gardonio\textsuperscript{1}, Roberto Rinaldo\textsuperscript{1}, Andrea Fusiello\textsuperscript{1}, Emanuele Turco\textsuperscript{1}
\textsuperscript{1}Università Degli Studi Di Udine, Udine, Italy

Apparent wood elements and acoustic performance – Feedback from Adivbois CLT building mockup
Catherine Guigou Carter\textsuperscript{1}, Nicolas Balanant\textsuperscript{2}, Jean-Luc Kouyoumjii\textsuperscript{3}
\textsuperscript{1}CSTB, Saint Martin d’Hères, France, \textsuperscript{2}CERQUAL Qualitel Certification, Paris, France, \textsuperscript{3}FCBA, Bordeaux, France

Building acoustic performance prediction – Feedback from Adivbois CLT building mockup
Catherine Guigou Carter\textsuperscript{1}, Nicolas Balanant\textsuperscript{2}, Jean-Luc Kouyoumjii\textsuperscript{3}
\textsuperscript{1}CSTB, Saint Martin d’Hères, France, \textsuperscript{2}CERQUAL Qualitel Certification, Paris, France, \textsuperscript{3}FCBA, Bordeaux, France

Sound generation by entropy waves accelerated by blades
Juan Guzman-Inigo\textsuperscript{1}, Aimee Morgans\textsuperscript{1}
\textsuperscript{1}Imperial College London, London, United Kingdom

The tyre/road noise comparison of SMA 11 and cobblestone pavement
Blanka Hablovičová\textsuperscript{1}, Petra Marková\textsuperscript{1}, Vítězslav Křivánek\textsuperscript{1}
\textsuperscript{1}Transport Research Centre CDV, Liščínská 33a, 636 00 Brno, Czech Republic

Testing the active minimization of the total radiated sound power of a vibrating plate
Mehran Hajilou\textsuperscript{1}, Delf Sachau
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Practical Tutorial on cylindrical structure vibro-acoustics Part 1 – Vibrations
Stephen Hambric

Systematic review and meta-analyses of association between transportation noise and Ischaemic heart disease based on studies published between 1994 – 2022
Sophie Hamilton1, Benjamin Fenech1,2, Xiangpu Gong2, Danielle Vienneau3,4, Anna Hansell2,5
1Noise and Public Health Team, Radiation Chemical and Environmental Hazards, Science Group, UK Health Security Agency, UK, 2Centre for Environmental Health and Sustainability, University of Leicester, Leicester, UK, 3Swiss Tropical and Public Health Institute, Allschwil, Switzerland, 4University of Basel, Switzerland, 5National Institute of Health Research (NIHR) Health Protection Research Unit (HPRU) in Environmental Exposures and Health at the University of Leicester,

Resonance mode analysis of finite plate strip with acoustic black holes: the gap between bandgap and attenuation band
Bing Han1, Hongli Ji1, Jinhao Qiu1, Li Cheng2
1Nanjing University of Aeronautics and Astronautics, Nanjing, China, 2Hong Kong Polytechnic University, Hong Kong

The effect of main stage flow velocity on thermoacoustic instability of stratified swirl burner
Meng Han1, Xiao Han1, Jianchen Wang1, Yuzhen Lin1
1Beihang University, Beijing, China

Analysis of community departure noise exposure variation using airport noise monitor networks and operational ADS-B data
R John Hansman1, Jacqueline Huynh2, R. John Hansman3
1MIT International Center For Air Transportation, Cambridge, United States, 2UC Irvine Department of Mechanical and Aerospace Engineering, Irvine, United States, 3MIT International Center for Air Transportation, Cambridge, United States

Acoustic Shielding and Scattering Effects of a Propeller Mounted Above a Flat Plate
Liam Hanson1, Kabilan Baskaran1, Bin Zang1, Mahdi Azarpeyvand1
1University Of Bristol, Queen’s Building, University Walk, Bristol, BS8 1TR, United Kingdom

Challenges in delivering effective noise management at gas compressor stations
Carl Christian HANTSCHK1, Marco GEISLER1
1Müller-BBM, 82152 PLANEGG, Germany

Subjective evaluation for sharp sound image construction based on reverberation control with surround sound system using parametric and electro-dynamic loudspeakers
Yuna Harada1, Yuting Geng1, Kenta Iwai2, Masato Nakayama3, Takanobu Nishiura2
1Graduate School of Information Science and Engineering, Ritsumeikan University, Kusatsu, Japan, 2College of Information Science and Engineering, Ritsumeikan University, Kusatsu, Japan, 3Faculty of Design Technology, Osaka Sangyo University, Daito, Japan

A comparison between the high-frequency Boundary Element Method and Surface-Based Geometrical Acoustics
Jonathan Hargreaves1
1University of Salford, Salford, United Kingdom

Analysis and Control of Acoustic Modes in Cylindrical Cavities with application to Direct Field Acoustic Noise (DFAN) Testing.
The three methods of calculating population exposure according to CNOSSOS-EU
Erwin Hartog Van Banda
1DGMR Software, The Hague, Netherlands

Acoustic measurement around the pinna in very high frequency region using a dummy head
Koki Harusawa
1Kanagawa Institute of Technology, 1030 Shimo-ogino, Atsugi City, Kanagawa, 243-0292 Japan, Japan

A new Building Regulation for overheating: practical considerations for the acoustic constraints
Jack Harvie-Clark1, Nick Conlan1, Nicholas Dobinson1, Rupert Kazlauciunas2
1Apex Acoustics Ltd, Gateshead, United Kingdom, 2Zehnder Group UK Ltd, Camberley, United Kingdom

Confidence in Room Acoustic Design: an Empirical Approach for Classrooms
Weigang Wei1, Jack Harvie-Clark1
1Apex Acoustics Ltd, Design Works, William St, Gateshead, NE10 0jp, United Kingdom

Perception of tire-pattern noise
Takeo Hashimoto1, Shigeko Hatano1
1Seikei University, Tokyo, Japan

Railway Noise Reduction at the Source only. Is this possible or mandatory?
Markus Hecht1
1TU Berlin, Berlin, Germany

Impact Sound Insulation of thermally insulated Balconies
Lucas Heidemann1, Jochen Scheck1,2, Berndt Zeitler1
1University of Applied Sciences Stuttgart, Stuttgart, Germany, 2STEP GmbH, Winnenden, Germany

Simplification of ISO 3744 – Making the Most Important Standard for Determination of Sound Power Levels Easier to Use
Fabian Heisterkamp1, Jeff Schmitt2, Joey Hook2
1BAuA, Dortmund, Germany, 2Viacoustics, Austin, USA

Interdisciplinary collaboration to identify challenges and opportunities in urban sound planning
Josh Hernandez1, Marion Burgess2, Deo Prasad1
1University of New South Wales, Sydney, Australia, 2University of New South Wales, Canberra, Australia

Full Multiphysics Electro-Vibroacoustic Analysis of a Balanced Armature Transducer
Mads Herring Jensen1
1COMSOL, Kgs. Lyngby, Denmark

Runway determination using two-point time difference method
Taichi Higashioka1, Yoshih Tadahira1, Manabu Sugii1, Tsushi Fujita1, Osamu Kohashi1
1Nihon Onkyo Engineering Co., Ltd., 1-21-10 Midori Sumida-ku, Japan

Subjective studies on floor impact sound using headphone
Susumu Hirakawa1, Hayato Sato2, Manabu Chikai3, Atsuo Hiramitsu1, Hiroshi Sato3, Jeffrey Mahn4, Markus Mueller-Trapet4, Iara Batista da Cunha4
Effect of concrete topping on floor impact sound insulation performance of CLT floor
Atsuo Hiramitsu¹, Susumu Hirakawa²
¹National Institute For Land And Infrastructure Management, Tsukuba, Japan, ²Building Research Institute, Tsukuba, Japan

Distance control of virtual sound source based on switching electro-dynamic and parametric loudspeaker arrays
Ayano Hirose¹, Haonan Wang¹, Masato Nakayama², Takanobu Nishiura¹
¹College of Information Science and Engineering, Ritsumeikan University, Kusatsu, Japan, ²Faculty of Design Technology, Osaka Sangyo University, Daito, Japan

Extension of frequency range of the sixteen-microphone method in normal-incidence sound transmission loss measurement.
NAKAGAWA HIROSHI¹, Akira Sanada²
¹Nihon Onkyo Engineering Co., Ltd., 1-21-10 Midori Sumida-ku, Tokyo, Japan, ²Industrial Technology Center of Okayama Prefecture, 5301 Haga, Kita-ku, Okayama, Japan

Main flow oriented vorticity noise experiments
Lionel Hirschberg¹, Friedrich Bake¹, Karsten Knobloch¹, Steven Hulshoff¹
¹Imperial College London, Imperial College London, South Kensington Campus, London SW7 2AZ, United Kingdom

Effects of noise presence and noise position on interpersonal distance in a triadic conversation.
Lubos Hladek¹, Bernhard Seeber¹
¹Technical University of Munich, Munich, Germany

Sheet Pile Tuned Mass Damper for Construction Noise Control
Wilson Ho¹, Wylog Wong¹, Eric Chu¹
¹Acoustics Innovation Limited, Unit 106, Block A, Shatin Industrial Centre, Sha Tin, N.T, Hong Kong

Lightweight Retractable Noise Barrier in Hong Kong
Wilson Ho¹, Wylog Wong¹, Eric Chu¹
¹Acoustics Innovation Limited, Unit 106, Block A, Shatin Industrial Centre, Sha Tin, N.T, Hong Kong

Railway Ground Borne Noise (GBN) Reduction by Rail Dampers
Wilson Ho¹, Ron Wong¹
¹Jabez Innovation Limited, Unit 106, Block A, Shatin Industrial Centre, Sha Tin, N.T, Hong Kong

Track Decay Rate (TDR) Measurement Method for Reactive Damping by Tuned Mass Damper (TMD)
Wilson Ho¹, Marco Ip¹
¹Jabez Innovation Limited, Unit 106, Block A, Shatin Industrial Centre, Sha Tin, N.T, Hong Kong

Five Years’ Monitoring Data on Rail Damper Performance
Wilson Ho¹, Max YIU¹, Qian SHA¹, Ron Wong¹
¹Wilson Ho and Associates Limited, Unit 601, Block A, Shatin Industrial Centre, Sha Tin, N.T, Hong Kong

Factors influencing tyre/road noise under torque
Carsten Hoever¹, Achillefs Tsotras¹, Marie-Agnès Pallas², Julien Cesbron³
Combination of Acoustic Black Holes with point masses

Steffen Hoffmann\textsuperscript{1}, Sebastian Rothe\textsuperscript{1}, Sabine Christine Langer\textsuperscript{1}
\textsuperscript{1}Technische Universität Braunschweig, Braunschweig, Germany

Multi-directional active vibration control of 1D smart structure inspired by automotive engine mounting system

Moon Hojoon\textsuperscript{1}, Yang Qiu\textsuperscript{1}, Kim Byeongil\textsuperscript{1}
\textsuperscript{1}Yeungnam University, 280 Daehak-ro, Gyeongsan, Gyeongbuk 38541, South Korea

Comparison of the direct sound insulation for wooden joist, CLT and timber hollow box floors

Anders Homb\textsuperscript{1}, Simone Conta\textsuperscript{1}
\textsuperscript{1}SINTEF Community, 7465 Trondheim, Norway

Validation of target tracking performance through signal feature extraction method based on 1D convolutional neural network

Dongwoo Hong\textsuperscript{1}, Junhee Kwon\textsuperscript{1}, Byeongil Kim\textsuperscript{1}
\textsuperscript{1}Yeungnam University, 280 Daehak-ro, Gyeongsan, Gyeongbuk 38541, South Korea

Interlaboratory comparison of testing the level reduction of booths and furniture ensembles by ISO 23351-1

Valtteri Hongisto\textsuperscript{1}, Jukka Keränen\textsuperscript{1}
\textsuperscript{1}Turku University Of Applied Sciences, Joukahaisenkatu 3-5, FI-20520 Turku, Finland

Acoustic properties of commercial thermal insulators

Valtteri Hongisto\textsuperscript{1}, Pekka Saarinen\textsuperscript{1}, Jarkko Hakala\textsuperscript{1}, Reijo Alakoivu\textsuperscript{1}
\textsuperscript{1}Turku University Of Applied Sciences, Joukahaisenkatu 3-5, FI-20520 Turku, Finland

Health effects of environmental noise in a wind power area

Valtteri Hongisto\textsuperscript{1}, Jenni Radun\textsuperscript{1}, Henna Maula\textsuperscript{1}, Pekka Saarinen\textsuperscript{1}, Jukka Keränen\textsuperscript{1}, Reijo Alakoivu\textsuperscript{1}
\textsuperscript{1}Turku University Of Applied Sciences, Joukahaisenkatu 3-5, FI-20520 Turku, Finland

Prediction of combustion noise for a swirling flame with low order network model

Zhu Hongzhi\textsuperscript{1}, Zhu Min\textsuperscript{1}
\textsuperscript{1}Department Of Energy And Power Engineering, Tsinghua University, Beijing, China

A key physical mechanism that controls the sound absorption of aerogel powders

Kirill Horoshenko, Y Xue, S. Bolton, K.V. Horoshenkov
\textsuperscript{1}University Of Sheffield, Sheffield, United Kingdom, \textsuperscript{2}Midea Corporate Research Center, Foshan, Guangdong, China, \textsuperscript{3}Herrick Laboratories, Purdue University, West Lafayette, Indiana, USA

Estimation of insertion loss for noise barrier with multichannel sound reproduction technology

Satoshi Hoshika\textsuperscript{1}, Tetsuya Doi\textsuperscript{1}, Masaaki Hiroe\textsuperscript{1}, Takahiro Iwami\textsuperscript{2}
\textsuperscript{1}Kobayasi Institute of Physical Research, Tokyo, Japan, \textsuperscript{2}Kyushu University, Fukuoka, Japan

The effects of workstation arrangements on the acoustical performance of the architecture design studios.

Hany Hossam Eldien\textsuperscript{1}, Umaru M. Bongwirnso\textsuperscript{1}, Seraj Alzaher\textsuperscript{1}
\textsuperscript{1}Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia
Impact of Mihrab geometry on the acoustics of the mosque
Hany Hossam Eldien1, Umaru M. Bongwirnso1, Emad Hammad2
1Department of Building Engineering, College of Architecture and Planning, Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia, 2Department of Interior Architecture, College of Architecture and Planning, Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia

Unlock the myth of low-frequency footstep thumping noise in lightweight wood floors
Lin Hu1, Anes Omeranovic1, Fabrice Roussiere1, Christian Christian1, Sylvain Gagnon5
1FPinnovations, Quebec city, Canada

Aural Diversity: noise control and a sustainable future.
Andrew Hugill1
1University Of Leicester, Leicester, United Kingdom

Two-step optimization design of a periodic beam with acoustic black holes
Sheng Hui1, Hui Sheng1
1Tianjin University, 92 Weijin Road, Tianjin 300072, China

Green transition and noise transition – Europe’s first Living Lab on traffic noise
Karolina Huss1, Sif Enevold1
1Gate 21, Liljens Kvarter 2, Albertslund, Denmark

Speech perception and deaf and hard of hearing children in the classroom: A multidisciplinary effort in the United States to bring data and standards to architects, school districts, and into building codes
Frank Iglehart1
1Educational Audiology Assoc. Classroom Acoustics Coalition, Leverett, United States

Research on Sound Power Levels of Structure-Borne Noise of Viaducts Roads
Kimikazu Ikeya1, Tatsuaki Mori, Tomoyuki Itiki, Akinori Fukushima1
1Nexco Research Institute Japan, Tokyo Matida City, Japan

Parameter extraction of 3D acoustic images using a nonlinear optimization technique
Lara Del Val1, Alberto Izquierdo1, Juan J. Villacorta1
1University Of Valladolid, Valladolid, Spain

New aircraft noise monitoring system introduced at the three airports in the Osaka area
Junshi Izumi1, Yoshio Nishino1, Kenji Matsubara1, Jyunshi Izumi1, Etsushi Fujita2, Taichi Higashioka2
1Kansai Airports, 1 Senshu-ku Kita, Izumisanoshi, Japan, 2Nihon Onkyo Engineering Co., Ltd., 1-21-10 Midori Sumida-ku, Japan

High sensitivity of indirect noise predictions in non-isentropic nozzles
Animesh Jain1, Luca Magni2,1
1University Of Cambridge, Cambridge, United Kingdom, 2Imperial College London, London, United Kingdom

Sound Insulation Performance of Composites Developed using Waste Carbonaceous Materials
Sunali Jaish1, Jonty Mago1, Ashutosh Negi1,2,3, S. Fatima1
1Automotive Health Monitoring Laboratory, Centre for Automotive Research &Tribology, Indian Institute of Technology Delhi, India, 2Renewable Energy and Chemicals Laboratory, Department of Chemical Engineering, Indian Institute of Technology Delhi, India, 3School of Interdisciplinary Research, Indian Institute of Technology Delhi, India

Experimental Noise Characterisation of Different Pitch Propellers in Static and Forward Flight.
An investigation of classroom sound levels as a function of class size
Adrian James¹
¹Adrian James Acoustics, Norwich, United Kingdom

Recent Technological Advances in Spatial Active Noise Control Systems
Ehsan Javahersaz, Samira Mohamady, Rooollah Javahersaz¹
¹Lancaster University, Lancaster, United Kingdom

The Attenuation and Speech Intelligibility of the Gecko Helmet Used by the Royal National Lifeboat Institution
Stephen Jay¹²
¹London South Bank University, London, United Kingdom, ²Environment Agency, United Kingdom

Sub-band attention CNN with feature evaluation for chatter detection
Kwanghun Jeong¹, Jonghoon Jeon¹, Junhong Park¹
¹Hanyang University, Seoul, South Korea

Measuring low noise level in dwellings
Birger Jessen¹
¹Danish Technological Institute, Hoeje Taastrup, Denmark

Study of the comfort aircraft norms
Sarah Jibodh-jiaouan¹², Study of the comfort aircraft norms Etienne Parizet¹, Study of the comfort aircraft norms Guillaume Osmond²
¹Insa, Villeurbanne, France, ²Airbus, Toulouse, France

Prediction of rattle noise in steering gear system and analysis of contributing factors through neural networks using design and manufacturing data
Hyeon-Cheol Jo¹, Jae-Yong Seo¹, Kyung-Hwan Park¹
²Applied NVH Technology cell, Hyundai Mobis, Yongin, South Korea

Elastic hangers for suspended ceilings – are they really needed?
Bengt Johansson¹
¹Efterklang, Stockholm, Sweden

Aircraft Approach Noise Trials
Anders Johansson¹
¹KTH-Center for Sustainable Aviation, 100 44 Stockholm, Sweden

Data-driven reconstruction of rough surfaces from acoustic scattering
Michael-David Johnson¹, Anton Krynkin¹, Giulio Dolcetti¹, Mansour Alkmim², Jacques Cuenca², Laurent De Ryck³, Yue Li²
¹University Of Sheffield, Sheffield, United Kingdom, ²Siemens Industry Software NV, Leuven, Belgium

Numerical investigation of sound transmission through single and double walls with periodic arrays of resonators
Milica Jovanoska¹, Todorka Samardzioska¹
²Faculty of Civil Engineering, UKIM, Skopje, Macedonia
A Study on Improving the Robustness of Virtual Sensing Methods in ANC Systems
Yoshinobu Kajikawa¹, Yoshinobu Kajikawa²
¹Kansai University, 3–35 Yamate-cho Suita-shi, Japan

Development of ventilation and sound-absorbing materials using specimens generated by the multi-objective optimization method (Part 1: The multi-objective optimization method to generate 3D model based on fluid potential flow analysis)
Keigo Kajitani¹
¹Shimane University, Matsue-shi, Japan

Prediction methodology and assessment of low frequency noise break-in for a science building
Christos Karatsovis¹, Erika Quaranta¹
¹ISVR, University of Southampton, Southampton, United Kingdom

Annoyance of railway curve squeal
Christian Kasess¹, Thomas Maly², Christian Kirisits³, Piotr Majdak¹, Holger Waubke¹
¹Acoustics Research Institute, Austrian Academy Of Sciences, Vienna, Austria, ²Institute of Transportation, TU Wien, Vienna, Austria, ³Kirisits, Chartered Engineering Consultants, Pinkafeld, Austria, ⁴Medical University of Vienna, Vienna, Austria

Comparing Tank Measurements Using A Calibration Panel
Scott Kasprzak¹, Matthew Craun¹, Stephen Robinson¹
¹Naval Surface Warfare Center, Carderock Division, Bethesda, United States, ²National Physical Laboratory, Teddington, United Kingdom

A field experiment on the effect of sound absorption installed to a highly reverberant preschool classroom
Keiji Kawai¹, Midori Ishizawa¹, Yuuki Matsufuji¹
¹Kumamoto University, Kumamoto, Japan

Modelling the uncertainties of wind farm noise predictions
David Ecotière¹, Benoit Gauvreau¹, Bill Kayser¹
¹Cerema, Université Gustave Eiffel, UMRAE, Bouguenais, France

Noise mitigation of UAV operations through a Complex Networks approach
Harun Siljak, John Kennedy², Stephen Byrne, Karina Einicke
¹Trinity College Dublin, Dublin, Ireland

The influence of helmets on sound localisation in motorcyclists
John Kennedy¹, Seán Byrne¹
¹Trinity College Dublin, Dublin, Ireland

Precision of room acoustic modelling in open-plan offices
Juukka Keränen¹, Pekka Saarinen¹, Valtteri Hongisto¹
¹Turku University Of Applied Sciences, Turku, Finland

Measured effect of resilient edge joints on airborne sound insulation of heavyweight wall
Juukka Keränen¹, Jarkko Hakala¹, Valtteri Hongisto¹
¹Turku University Of Applied Sciences, Turku, Finland

Modified Acoustic Black Hole Profile for Improved Fatigue Performance
Archie Keys¹, Jordan Cheer¹
¹University Of Southampton, Southampton, United Kingdom

Impact of road traffic noise on annoyance and preventable mortality in European cities: a health impact assessment.
Sasha Khomenko¹,²,³, Marta Cirach¹,²,³, Jose Barrera-Gómez¹,²,³, MPH Evelise Pereira-Barboza¹,²,³, MPH Tamara Jungman¹,²,³, Natalie Mueller¹,²,³, Maria Foraster¹,²,³,⁴, Cathryn Tonne¹,²,³, Meelan Thondoo¹,²,³, Calvin Jephcote⁵, John Gulliver⁶, James Woodcock⁶, Mark Nieuwenhuijsen¹,²,³
¹Barcelona Institute For Global Health (ISGlobal), Barcelona, Spain, ²Department of Experimental and Health Sciences, Universitat Pompeu Fabra (UPF), Barcelona, Spain, ³CIBER Epidemiología y Salud Pública (CIBERESP), Madrid, Spain, ⁴PHAGEX Research Group, Blanquerna School of Health Science, Universitat Ramon Llull (URL), Barcelona, Spain, ⁵Centre for Environmental Health and Sustainability (CEHS), University of Leicester, Leicester, United Kingdom, ⁶MRC Epidemiology unit, University of Cambridge School of Clinical Medicine, Cambridge, United Kingdom

Clustering the residential noise in apartment house based on spectral and temporal analysis
Jeonghun Kim¹, Songmi Lee¹, Suhong Kim¹, Eunsung Song¹, Dokyeong Kim¹, Chunwon Eom¹, Jongkwan Ryu¹
¹Chonnam National University, Gwangju, South Korea

Sound fields characteristics of a box-type CLT building for heavy-weight impact sources
Yong Hee Kim¹, Dae-gwan Won¹, Gyu-in Oh¹, Bon-su Koo¹, Jang-won Lee¹, Sejong Kim²
¹Y'sU Youngsan University, Junamro 288, Yangsan, South Korea, ²National Institute of Forest Science, 57 Hoegiro, Dongdaemun-gu, South Korea

Methods of Mode Generation Inside Hollow Core Photonic Crystal Fibers
Peter Seigo Kincaid¹, Alessandro Porcelli¹, Ennio Arimondo¹,², Antonio Alvaro Ranha Neves³, Andrea Camposeo³, Dario Pisignano¹,³, Donatella Ciampini¹,²
¹Dipartimento di Fisica “E. Fermi”, Università di Pisa, Pisa, Italy, ²INO-CNR, Pisa, Italy, ³NEST, Istituto Nanoscienze-CNR and Scuola Normale Superiore, Pisa, Italy, ⁴Universidade Federal do ABC, Santo André, Brazil

A review of a proposed noise quota system for Dublin Airport
Eoin King¹
¹NUI Galway, Galway, Ireland

Advancements in autonomous detection of high noise emitters in road traffic
Nikolas Kirchhoff¹, Maximilian Ertsey-Bayer¹, Manuel Männel¹
¹Müller-BBM GmbH, 82152 Planegg, Deutschland

Study on sound source localization inside a structure using a domain transfer model for real-world adaption of a trained model
Šunsuke Kita¹,², Yoshinobu Kajikawa²
¹Osaka Research Institute Of Industrial Science And Technology, Izumi, Japan, ²Kansai University, Suita, Japan

Numerical study of sonic boom propagation through atmospheric turbulence using open data of weather research and forecasting
Šinya Koganezawa¹, Yusuke Naka¹, Hiroaki Ishikawa¹, Ryo Shimada²
¹Japan Aerospace Exploration Agency, Mitaka, Japan, ²ASIRI inc., Chiyoda, Japan

Intrinsic thermo-acoustic instability criteria based on frequency response of flame transfer function
Mohammad Kojourimanesh¹, Viktor Kornilov¹, Ines Lopez Arteaga¹,², Philip de Goey¹
¹Eindhoven University of Technology, Netherlands, ²KTH Royal Institute of Technology, Sweden
Leq levels of yelling audience at live shows
Marcel Kok¹, Adam Hill, Jon Burton, Jos Mulder
¹dBcontrol, De Corantijn 27-J Zwaag, Netherlands

Enhancing the Dutch engineering calculation method.
Arnaud Kok¹
¹National Institute For Public Health And The Environment, Bilthoven, Netherlands

Towards the placement of actuators and sensors for an active control of structure-borne sound in a stiffened rectangular plate
Alexander Kokott¹, Hans Peter Monner
¹German Aerospace Center, Braunschweig, Germany

Control and broadening of multiple noise frequencies using an assembly of sub-metamaterials connected by membranes for aircraft noise mitigation.
Tenon Charly Kone¹, Sebastian Ghinet, Pr. Raymond Panneton, Zacharie Laly, Pr. Christopher Mechefske, Anant Grewal
¹National Research Council Canada, Flight Research Laboratory, 1200 Montreal Road, Ottawa, On, K1A 0R6, Canada

Subwoofer array design for optimal performance and minimal noise pollution in the Roman theatre of Italica, Spain
Claus Köpplin Orrán¹, Luis Gomez-Agustina¹, Alvaro Grilo Bensusan²
¹London South Bank University, London, United Kingdom, ²INERCO Acústica S.L., Seville, Spain

Results from The Quiet Project - UK Acoustic Community’s response to Covid-19
Henry Kowalik¹, Stephen Dance¹, Lindsay McInyre
¹London South Bank University, London, United Kingdom

The dependence of transformer sound power measurement accuracy on microphone configurations in the anechoic chamber.
Michal Kozupa¹, Filip Kamiński¹, Robert Baranski², Tadeusz Wszolek², Pawel Pawlik²
¹Hitachi Energy Research, Krakow, Poland, ²AGH University of Science and Technology, Krakow, Poland

Acoustic behaviour of CLT structures: influence of decoupling bearing stripes, floor assembly and connectors under storey-like loads
Anton Kraler¹, Paola Brugnara²
¹University Of Innsbruck, Technikerstraße 13, 6020 Innsbruck, Austria, ²Rotho Blaas srl, Via Dell'Adige 2/1, 39040 Cortaccia, Italy

DEVELOPEMENT OF LOW-COST NOISE MONITORING TERMINALS (NMT) BASED ON MEMS MICROPHONES
Jacek Kuczyński¹
¹SVANTEK SP. Z O.O., Strzygłowska 81, Poland

Reproduction of acoustic evanescent waves using wave field synthesis by controlling phase differences between monopole secondary sources
Akash Kumar¹, Amrita Puri¹
¹Department of Mechanical Engineering, Indian Institute of Technology Jodhpur, Jodhpur, India

A study of different tapering windowing functions and referencing curve for the improvement of sound field using wave-field synthesis
Amrita Puri¹, Akash Kumar¹
Experimental and numerical investigations of rain fall induced noise from roofing sheets
AKARSH S1, AKSHAY C C1, ABHINAV K V1, ABHILASH P1, SUDHEESH KUMAR C P1
1Department of Mechanical Engineering, Indian Institute of Technology Jodhpur, Jodhpur, India

Spatial audio for interactive hearing research
Matthieu Kuntz1, Bernhard U. Seeber1
1Audio Information Processing, Technical University Of Munich, Arcisstrasse 21, 80333 München, Germany

Interaction between annoyance, indoor noise levels and acoustic classification of buildings
Selma Kurra, Ayca Sentop
1Istanbul Technical University (rtd), consultant To Dbkes Engineering., Krizantem Sk No 70 Levent Istanbul 34330, Turkey

Aeroacoustic shape optimization using adjoint sensitivity analysis based on lattice Boltzmann method for bluff bodies
Kazuya Kusano1
1Kyushu University, Fukuoka, Japan

Modal Decomposition Analysis of Bluff-Body Stabilized Lean Premixed CH4/H2/air Flames Based on LES Data
Halit Kutkan1, Alberto Amato2, Giovanni Campa2, Luis Tay-Wo-Chong3
1University Of Genoa, Genoa, Italy, 2Ansaldo Energia S.p.A, Genoa, Italy, 3Ansaldo Energia Switzerland AG, Baden, Switzerland

Modeling, analysis, and control of shaft transverse vibration from rotating systems through active bearing concept
Junhee Kwon1, Dongwoo Hong1, Byeongil Kim1
1Yeungnam University, 280 Daehak-Ro, Gyeongsan, Gyeongbuk 38541, South Korea

Association between hearing threshold and low-frequency walking sounds on concrete floors
Mikko Kylliäinen1, Jesse Lietzén1
1Tampere University, Tampere, Finland

Robust estimation of open aperture active control systems using virtual sensing
Chung Kwan Lai1, Chung Kwan Lai1, Jing Sheng Tey1, Dongyuan Shi1, Woon-Seng Gan1
1School of Electrical and Electronic Engineering, Nanyang Technological University, Singapore, Singapore

Numerical design of Helmholtz resonators with multiple necks for multi-tonal noise control
Zacharie Laly1, Christopher Mechefske2, Sebastian Ghinet1, Charly T. Kone3, Noureddine Atalla1
1CRASH, Centre de Recherche Acoustique-Signal-Humain, Université de Sherbrooke, 2500 Boulevard de l’Université, Sherbrooke, J1K 2R1, Canada, 2Department of Mechanical and Materials Engineering, Queen’s University, Kingston, K7L 3N6, Canada, 3National Research Council Canada, Aerospace, 1200 Montreal Road, Ottawa, K1A 0R6, Canada

Modelling of acoustic metamaterial sound insulator using a transfer matrix method for aircraft cabin applications
Zacharie Laly1, Christopher Mechefske2, Sebastian Ghinet1, Charly T. Kone3, Noureddine Atalla1
1CRASH, Centre de Recherche Acoustique-Signal-Humain, Université de Sherbrooke, 2500 Boulevard de l’Université, Sherbrooke, J1K 2R1, Canada, 2Department of Mechanical and Materials Engineering, Queen’s University, Kingston, K7L 3N6, Canada, 3National Research Council Canada, Aerospace, 1200 Montreal Road, Ottawa, K1A 0R6, Canada
Numerical modelling of acoustic metamaterial made of periodic Helmholtz resonator containing a damping material in the cavity
Zacharie Laly\textsuperscript{1,2}, Christopher Mechefske\textsuperscript{2}, Sebastian Ghinet\textsuperscript{3}, Charly T. Kone\textsuperscript{3}, Noureddine Atalla\textsuperscript{1}
\textsuperscript{1}CRASH, Centre de Recherche Acoustique-Signal-Humain, Université de Sherbrooke, 2500 Boulevard de l’Université, Sherbrooke, J1K 2R1, Canada, \textsuperscript{2}Department of Mechanical and Materials Engineering, Queen's University, Kingston, Canada, \textsuperscript{3}National Research Council Canada, Aerospace, 1200 Montreal Road, Ottawa, Canada

Ideas for improving diversity and inclusion in acoustics
Angela Lamacraft\textsuperscript{1}, Susan Witterick\textsuperscript{1}
\textsuperscript{1}dBx Acoustics Ltd, Bramley, United Kingdom

A Preliminary Investigation of an Active Membrane-type Acoustic Metamaterial
Felix Langfeldt\textsuperscript{1}, Jordan Cheer\textsuperscript{1}
\textsuperscript{1}University of Southampton, Southampton, United Kingdom

SEA based statistical approaches for the mid and high frequency vibro-acoustic analysis of complex systems
Robin Langley\textsuperscript{1}
\textsuperscript{1}University Of Cambridge, Cambridge, United Kingdom

Evaluation of the restorative potential of church buildings
Josée Laplace\textsuperscript{1,2,3}, Catherine Guastavino\textsuperscript{1,2,3}
\textsuperscript{1}McGill University, Montreal, Canada, \textsuperscript{2}Centre for Interdisciplinary Research in Music Media and Technology (CIRMMT), Montreal, Canada, \textsuperscript{3}Sounds in the City partnership, Montreal, Canada

Shore power connection for offshore vessels - Measured noise reduction in port and dock
Bernt Mikal Larsen\textsuperscript{1}
\textsuperscript{1}Multiconsult Norway, Fjellgata 6, 4612 Kristiansand, Norway

Whole glass facade in office building - Measured noise level and requirement for facade
Bernt Mikal Larsen\textsuperscript{1}
\textsuperscript{1}Multiconsult Norway, Fjellgata 6, 4612 Kristiansand, Norway

Description of sound absorption by a flat resonator stacking metamaterial with double porosity model
Daniel Craig Brooke\textsuperscript{1}, Olga Umnova\textsuperscript{1}, Philippe Leclaire\textsuperscript{2}, Thomas Dupont\textsuperscript{3}
\textsuperscript{1}University of Salford, Manchester, England, UK, Manchester, England, \textsuperscript{2}DRIVE EA1859, Univ. Bourgogne Franche Comté, F58000, Nevers France, Nevers, France, \textsuperscript{3}Ecole de Technologie Supérieure (ETS) – Université du Québec, Montréal, Canada

Sound masking depending on spectral and temporal characteristics of residential noise and natural sound
Songmi Lee\textsuperscript{1}, Chunwon Eom\textsuperscript{1}, Jeonghun Kim\textsuperscript{1}, Suhong Kim\textsuperscript{1}, Eunsung Song\textsuperscript{1}, Dokyeong Kim\textsuperscript{1}, Jongkwan Ryu\textsuperscript{1}
\textsuperscript{1}Chonnam National University, Gwangju, South Korea

Aerodynamic noise due to complex internal flow through cordless vacuum cleaner and suction tower station
Kwongi Lee\textsuperscript{1}, Cheolung Cheong\textsuperscript{1}, Kyeonghun Park\textsuperscript{2}, Jinman Jang\textsuperscript{2}
\textsuperscript{1}Pusan National University, Pusan, South Korea, \textsuperscript{2}LG Electronics, Changwon-si, South Korea

Application of active noise control based on neural network to vehicle’s engine sound
Donghyeon Lee\textsuperscript{1}, Narae Kim\textsuperscript{1}, Junhong Park\textsuperscript{1}
\textsuperscript{1}Hanyang University, Seoul, South Korea
Investigation of vibrational and acoustic characteristics of compressor discharge duct using CFD and FE-BE method
Sangheon Lee¹, Chulung Cheong¹, Jinhyung Park²
¹Department of Mechanical Engineering, Pusan National University, Pusan, South Korea, ²LG electronics, Changwon, South Korea

Inter-channel Conv-TasNet for source-agnostic multichannel audio enhancement
Dongheon Lee¹, Jung-Woo Choi¹
¹Korea Advanced Institute of Science and Technology (KAIST), Yuseong-gu, South Korea

Flyover noise evaluation of low-noise technologies applied to a blended wing body aircraft
Ingrid Legriffon¹, Lothar Bertsch², Francesco Centracchio³, Daniel Weintraub⁴
¹Office National d’Études et de Recherches Aérospatiales (ONERA) – Paris Saclay University, Châtillon, France, ²German Aerospace Center (DLR), Göttingen, Germany, ³Università degli Studi Roma Tre, Dipartimento di Ingegneria, Rome, Italy, ⁴RWTH Aachen University, Institute of Jet Propulsion and Turbomachinery, Aachen, Germany

A Prediction Method for Indoor Vibration in the Metro Depot Throat Area Based on the Coupled Vibration Response of the Turnout
He Lei¹, Ruixiang Song¹, Yubin Wu¹, Yanan Wu¹
¹Institute Of Urban Safety And Environmental Science, Beijing Academy Of Science And Technology, Beijing, China

Noise and Deprivation in Scotland’s Four Largest Cities: Glasgow, Edinburgh, Aberdeen and Dundee
Ashley Leiper¹, Andrew Hood
¹SSE Renewables, Glasgow, United Kingdom

Effects of binaural classroom noise scenarios on primary school children’s speech perception and listening comprehension
Larissa Leist¹, Carolin Reimers², Stephan Fremerey³, Janina Fels², Alexander Raake³, Maria Klatte¹
¹TU Kaiserslautern, Kaiserslautern, Germany, ²RWTH Aachen University, Aachen, Germany, ³Technische Universität Ilmenau, Ilmenau, Germany

Public address and sound emission by an active noise control system in ventilation duct networks
Stephane Lesoinne¹
¹Bbri, Limelette, Belgium

Nonlinear response of laminar premixed flames to dual-input harmonic disturbances
Xiaozhen Jiang¹, Jingxuan Li¹,², Lijun Yang¹,²
¹School of Astronautics, Beihang University, Beijing, China, ²Aircraft and Propulsion Laboratory, Ningbo Institute of Technology, Beihang University, Ningbo, China

Modeling and analysis for the deployment dynamic behavior of the large flexible solar array
Ning Li¹, Ma Xiaolong¹, Zhang Chongfeng¹, Zou Huaiwu¹, Liu Jinglong¹, Yang Wenhao¹
¹Shanghai Institute Of Aerospace System Engineering, Shanghai, China

A benchmark study on room acoustic simulations with various material input complexities
Yue Li¹, Julie Meyer², Tapio Lokki³, Jacques Cuenca¹, Onur Atak¹, Wim Desmet³
²Siemens Digital Industries Software, Leuven, Belgium, ³Aalto University, Espoo, Finland, ⁴KU Leuven, Leuven, Belgium

A 2D low-order thermoacoustic network model of annular combustor with baffles in the plenum
Liang Ji¹, Yuanqi Fang³, Jingxuan Li¹,², Gaofeng Wang³, Lijun Yang¹,²
Four-element planar arrays focus a point-like source based on the artificial iterative phase conjugated processing
Ting Li¹, Yi Zhang¹, Liufang Fu¹
¹Department Of Underwater Weaponry And Chemical Defense, Dalian Naval Academy, Dalian, China

Focal spot enhanced by artificial iterative phase conjugated twin-line planar array
Ting Li¹, Zhu Kou¹, Jiajing Wang¹
¹Department Of Underwater Weaponry And Chemical Defense, Dalian Naval Academy, Dalian, China

Piezoelectric vibration suppression of a flexible mounting link for precise space robot operating
Feng Li¹, Lanqing Hu², Huaiwu Zou¹
¹Shanghai Institute of Aerospace System Engineering, Shanghai, China, ²Shanghai Aerospace Equipment Manufacturer Limited Company, Shanghai, China

Design method of asphalt mixture with balanced noise reduction and mechanical properties
Mingliang Li¹, Yingtao Li², Jun Li³, Wei Zhou², Yaqun Zu²
¹Research Institute Of Highway Ministry Of Transport, Beijing, China, ²Jiangsu Expressway Maintenance Engineering Technology Co., Ltd., Nanjing, China

Study on the scoping prediction of railway-induced environmental vibration based on transfer learning
Ruihua Liang¹, Weifeng Liu¹
¹Key Laboratory of Urban Underground Engineering of Ministry of Education, Beijing Jiaotong University, Beijing, China

A review of techniques and challenges in outdoor sound field control
Pierangelo Libianchi¹, Finn Agerkvist², Elena Shabalina¹, Jonas Brunskog²
¹d&b audiotechnik, Backnang, Germany, ²DTU, Kgs. Lyngby, Denmark

Efficacy evaluation of low-emission asphalts in port areas using the CPX and SPB method
Gaetano Licitra¹, Luca Fredianelli², Lara Ginevra Del Pizzo³, Antonino Moro³, Francesco Bianco³, Francesco Fidecaro⁴
¹Arpat, Via Vittorio Veneto 27, Pisa, Italy, ²Italian National Research Council, Pisa, Italy, ³IPOOL S.r.l., Pisa, Italy, ⁴University of Pisa, Physics Dpt., Pisa, Italy

Quantifying the annoyance caused by flat tops on the wheels of railway vehicles
Manfred Liepert¹, Christine Huth, Melissa Forstreuter
¹Möhler + Partner Ingenieure AG, Prinzstraße 49, Germany

Masking effect of HVAC noise on walking sounds on concrete floors
Jesse Lietzén¹, Mikko Kylliäinen¹, Ville Kovalainen²
¹Tampere University, Tampere, Finland, ²AINS Group, Turku, Finland

Validation of a potential-based active sound control methodology
Hyun Lim¹, Luis Gomez-Agustina¹
¹London South Bank University, London, United Kingdom

Glass cover with high acoustic performance and specification challenges
Milena Lima¹
¹Atenua Som, São Paulo, Brazil
Modeling the impact of traffic noise: analysis of lightning geometry and its contribution to direct, specular and diffuse path propagation.
Dayane Cristina Lima Estercio¹, Paulo Fernando Soares²
¹State University Of Campinas (UNICAMP), Campinas, Brazil, ²State University of Maringa (UEM), Maringá, Brazil

Active Vibration Control of a Rotating Mechanical System with a Rigid Coupling using Active Disturbance Rejection Control
Tingyu Lin¹, Dunant Halim¹, Liaooyuan Ran¹, Zhuang Xu¹, Chung Ket Thein³
¹Department of Mechanical, Materials and Manufacturing Engineering, University of Nottingham Ningbo China, Ningbo, China, ²Department of Electrical and Electronic Engineering, Ningbo, China, ³School of Aerospace, Ningbo, China

Active Control of an Unbalanced Rotor System using Active Bearings and the Generalized Disturbance Estimation
Liaoyuan Ran¹, Dunant Halim¹, Tingyu Lin¹, Chung Ket Thein², Michael Galea³
¹Department of Mechanical, Materials and Manufacturing Engineering, University of Nottingham Ningbo China, Ningbo, China, ²School of Aerospace, Ningbo, China, ³Department of Industrial Electrical Power Conversion, Msida, Malta

Fluctuations by atmospheric turbulence in aircraft flyover auralisation
Dorothea Lincke¹, Reto Pieren¹
¹Empa Materials Science And Technology, Überlandstrasse 129, 8600 Dübendorf, Switzerland

Occupational exposure to noise and myocardial infarction risk one year later in Sweden
Claudia Lissåker¹, Maria Albin¹, Theo Bodin¹, Mattias Sjöström¹, Jenny Selander¹
¹Karolinska Institutet, Stockholm, Sweden, ²Centre for Occupational and Environmental Medicine, Stockholm, Sweden

Sound isolation via temporal modulation material based on piezoelectric elements
Xiang Liu¹, Chunqi Wang¹, Yumin Zhang¹, Keming Wu¹, Lixi Huang¹
¹The University of Hong Kong, Hong Kong, Hong Kong

Experimental study on vibration response of wooden house façade to low-frequency outdoor sound
Jinyu Liu¹, Naohisa Inoue², Tetsuya Sakuma¹
¹The University of Tokyo, Bunkyo-ku, Japan, ²Maebashi Institute of Technology, Maebashi-shi, Japan

The time-frequency characteristics analysis and prediction of ground vibration near a subway station
Bideng Liu¹, Yubin Wu¹, Ruixiang Song¹, Lei He¹, Qiong Wu¹
¹Institute Of Urban Safety And Environmental Science, Beijing Academy Of Science And Technology, Beijing, China

An exponentially convergent adaptive robust based space manipulator noise control method
Jinglong Liu¹, Ning Li¹, Xiaolong Ma¹, Feng Li¹
¹Shanghai Institute Of Aerospace System Engineering, Shanghai, China, ²Shanghai Key Laboratory of Spacecraft Mechanism, Shanghai, China

Speech privacy through dynamic fundamental frequency matching
Charlene Lo¹, C. T. Justine Hui, Yusuke Hioka
¹Acoustic Research Centre University Of Auckland, Auckland, New Zealand

Assessing the environmental burden of disease due to road traffic noise in Hesse, Germany
Matthias Lochmann, Janice Hegewald, Melanie Schubert, Andreas Seidler
1HLNUG (Hessian Agency for Nature Conservation, Environment and Geology), Wiesbaden, Germany

Field Validation of Octave Band Sound Modeling for Wind Turbines
Dana Lodico
1RSG, Denver, United States, 2RSG, White River Junction, United States

Local authorities in The Netherlands supported by new software tooling in delivering European strategic noise maps
Dorien Lolkema, Danny Greefhorst, Jan Skornsek
1National Institute for Public Health and the Environment, Bilthoven, Netherlands

The city of Ravello and its hundreds clerical buildings. Acoustic discoveries of the St Mary Gradillo’s church
Ilaria Lombardi, Rosaria Parente, Silvana Sukaj
1University of Campania Luigi Vanvitelli, Avessa, Italy, 2Benecon University Consortium, Napoli, Italy, 3European University of Tirana, Tirana, Albania

Witches Valley acoustics
Ilaria Lombardi, Antonella Bevilacqua, Cobi van Tonder
1University of Campania Luigi Vanvitelli, Avessa, Italy, 2University of Parma, Parma, Italy, 3University of York, York, UK

Effects of noise and vibration on operatives with machine interaction in manufacturing environments
Mario Buono, Antonella Bevilacqua, Sonia Capece, Ilaria Lombardi
1University of Campania Luigi Vanvitelli, Avessa, Italy, 2University of Parma, Parma, Italy

From sport to science: the acoustics of a pool transformed into an auditorium
Umberto Berardi, Antonella Bevilacqua, Ilaria Lombardi, Gino Iannace, Amelia Trematerra
1University of Campania Luigi Vanvitelli, Avessa, Italy, 2Ryerson University, Toronto, Canada, 3University of Parma, Parma, Italy

A mass-spring analogy for modeling the acoustic behaviour of a metamaterial
Maël Lopez, Thomas Dupont, Raymond Panneton
1École de Technologie Supérieure de Montréal, Montréal, Canada, 2Université de Sherbrooke, Sherbrooke, Canada

New ASTM ratings for impact noise insulation
Wayland Dong, John LoVerde
1Veneklasen Associates, Santa Monica, United States

In situ measurements for sound levels near facades in low-rise courtyards with different geometries exposed to aircraft noise
Martijn Lugten
1TU Delft, Julianalaan 134, 2628BL, Delft, Netherlands

Deep Neural Networks for Selective Fixed-filter Active Noise Control
Zhengding Luo, Dongyuan Shi, Woon-Seng Gan, Qirui Huang, Libin Zhang
1Nanyang Technological University, Singapore, Singapore, 2Huawei International Pte Ltd, Singapore, Singapore

Subjective evaluation of the acoustic annoyance in a large passenger aircraft cabin
Bingcong Lv, Yu Huang, Weikang Jiang
1Shanghai Jiao Tong University, Shanghai, China
Numerical investigation of thermo-acoustic instability in a model afterburner with a simplified model for observed lock-in Phenomena
Muthaiah M, Ragul Senthilkumar, Varunkumar S
1Department of Mechanical Engineering, Indian Institute Of Technology - Madras, Chennai, India

Study on the correlation between noise perception and annoyance level of residents in residential areas along the tracks
Jinglun Ma, Yue Wu, Qi Meng
1School of Architecture, Key Laboratory of Cold Region Urban and Rural Human Settlement Environment Science and Technology, Ministry of Industry and Information Technology, Harbin Institute of Technology, No. 66 West Dazhi Street, Harbin, China

Accelerating knowledge transfer from research to sound aware practice
Arnthrudur Gisladottir, Trond Maag
1Aarhus University, Department of Civil and Architectural Engineering, Aarhus, Denmark, 2FOEN, Federal Office for the Environment, Switzerland

Sensing of aircraft position through IoT camera system installed with a fisheye lens.
Takashi Maeyama, Takumi Asakura, Junichi Mori, Makoto Morinaga, Kentaro Nishino, Shigenori Yokoshima, Ippei Yamamoto
1Tokyo University of Science, Noda, Japan, 2Kanagawa University, Yokohama, Japan, 3Kanagawa Environment Research Center, Hiratsuka, Japan, 4Defense Structure Improvement Foundation, Shinjuku, Japan

Sound Insulation Property of Waste Jute Fiber/Recycled High-Density Polyethene Composites
Jonty Mago, Sunali, Ashutosh Negi, S. Fatima
1Automotive Health Monitoring Laboratory, Centre for Automotive Research & Tribology, Indian Institute of Technology Delhi, Hauz Khas, New Delhi-110016, India, New Delhi, India, 2Renewable Energy and Chemicals Laboratory, Department of Chemical Engineering, Indian Institute of Technology Delhi, New Delhi-110016, India, New Delhi, India, 3School of Interdisciplinary Research, Indian Institute of Technology Delhi, Hauz Khas, New Delhi-110016, India, New Delhi, India

Modeling the Influence of Under-Sleeper Pads on the Vibration Emissions from Railway Traffic
Nils Mahlert, Sascha Hermann
1DB Systemtechnik GmbH, Völckerstraße 5, 80939 Munich, Germany

The Vibration Reduction Index of Typical Canadian CLT Junctions
Jeffrey Mahn, Markus Müller-Trapet, Iara Cunha
1National Research Council Canada, Ottawa, Canada

Sound source directivity considering source movement
Yusuke Makino, Yasushi Takano
1Kyoto University, Graduate School of Engineering, Kyoto-City, Japan

Analysing changes in physiological response to different soundscape scenarios.
Manish Manohare, Elangovan Rajasekar, Tin Oberman, Francesco Aletta, Jian Kang, Manoranjan Parida
1Indian Institute of Technology, Roorkee, Roorkee, India, 2UCL Institute for Environmental Design and Engineering, The Bartlett University College London, London, United Kingdom

An Heuristic Prediction Method for Managing Environmental Blast Noise Impacts
Gethin Manuel, David Waddington
1Acoustics Research Centre, University Of Salford, Salford M5 4WT, United Kingdom
The Status of International Guidance and Standards for Environmental Noise Assessment
Douglas Manvell
2
DMdB, Charlottenlund, Denmark

Combining mobile measurements on noise and soundscape evaluation in a University Campus after a
renovation plan.
Efstathios Margaritis1, Ferry van Kann2
1University of Groningen, Groningen, Netherlands, 2University of Groningen, Groningen, Netherlands

Noise-related challenges in combined commercial and military operations at an airport
Jan Anders Marheim1, Michael Newman1
1Avinor AS, Gardermoen, Norway

Perceptual acoustic space of tire noise
Thibaut Marin-cudraz1, Juan J. García2, Etienne Parizet1
1Laboratoire Vibration Acoustique - INSA Lyon, Villeurbanne, France, 2Applus+ IDIDA, Santa Oliva, Spain

Experimental investigation of a phase-cancelling slow-sound metamaterial with mean flow
Richard Martin1, Bruno Schuermans1, Nicolas Noiray1
1CAPS Laboratory, Department of Mechanical and Process Engineering, ETH Zürich, Zürich 8092, Switzerland

Relationship between vortex shedding noise and remotely-sensed surface pressure fluctuations of a
structured porous-coated cylinder
Reza Maryami1, Elias J. G. Arcondoulis1, Chenghao Yang1, Yu Liu1
1Southern University Of Science And Technology, Shenzhen,, China

Wind turbine noise modeling including aeroacoustic sources and propagation effects: comparison against
field measurements
David Mascarenhas1, Benjamin Cotté1, Olivier Doaré1, David Ecotière2, Gwenaël Guillaume2, Benoit
Gauvreau2, Isabelle Schmicl-Yamane3, Fabrice Junker4
1IMSIA, ENSTA Paris, CNRS, CEA, EDF, IP Paris, Paris, France, 2Univ. Gustave Eiffel, Cerema, UMRAE, Lyon, France, 3EDF
HYDRO-DTG, France, 4EDF Renewables, France

The effects of different sound environments on physiological stress recovery and perceived restorativeness.
Massimiliano Masullo1, Roxana Adina Toma1, Juan Miguel Navarro Ruiz2, Jorge Hernandez Bellot2, Luigi
Maffe11
1Università degli Studi della Campania "Luigi Vanvitelli", Aversa (CE), Italy, 2UCAM Universidad Católica de Murcia,
Murcia, Spain

Spatial Interpolation of Early Room Impulse Responses Using Equivalent Source method based on Grouped
Image Sources
Haruka Matsuhashi1, Izumi Tsunokuni1, Yusuke Ikeda1
1Tokyo Denki University, 5 Senju-Asahi-Cho, Adachi-ku, Japan

Causal-based acoustic optimization of micro-perforated structures with rigid backing
Teresa Bravo1, Cédric Maury2
1CSIC, Madrid, Spain, 2Ecole Centrale Marseille, Marseille, France

Vibroacoustic simulations with non-homogeneous TBL excitations: Synthesis of wall pressure fields with the
Continuously-varying Uncorrelated Wall Plane Waves approach
Corentin Guillon1, Emmanuel Redon1, Laurent Maxit1
Accurate reconstruction of point and transfer mobilities using the round-trip method
Ramin McGee\textsuperscript{1}, Joshua Meggitt\textsuperscript{1}, John Smith\textsuperscript{1}, Andrew Elliott\textsuperscript{1}
\textsuperscript{1}University Of Salford, Manchester, United Kingdom

Prediction of impact noise from gym sources on resilient matting
Nikhilesh Patil\textsuperscript{1}, Martin Mcnulty\textsuperscript{1}
\textsuperscript{1}Hoare Lea Vibration, Manchester, United Kingdom

Appraising the performance of floating floors using dynamic sub-structuring methods
Martin Mcnulty\textsuperscript{1}, Nikhilesh Patil\textsuperscript{1}
\textsuperscript{1}Hoare Lea Vibration, Manchester, United Kingdom

Noise and soundscape in Welsh planning policy
Martin McVay\textsuperscript{1}
\textsuperscript{1}Welsh Government, Cardiff, United Kingdom

The eventful environment that characterises Indonesia's urban soundscape
Christina E Mediastika\textsuperscript{2}, Anugrah S Sudarsono, Sentagi S Utami, Isnen Fitri, Rizka Drastiani, MI Ririk Winandari, Akbar Rahman, Asniawaty Kusno, NW Meidayanti Mustika, Yuliana B Mberu, Ressy J Yanti, Zulfi A Rachman
\textsuperscript{1}Petra Christian University, Jalan Siwalankerto 121-131 Surabaya 60236, Indonesia, \textsuperscript{2}Ciputra University

Validation of three inherently different aircraft noise calculation programs
Jonas Meister\textsuperscript{1}, Stefan Schalcher\textsuperscript{1}, Jean-Marc Wunderli\textsuperscript{2}, Beat Schäffer\textsuperscript{1}
\textsuperscript{1}Empa, Dübendorf, Switzerland

On homogenized ribbed-panel model for SEA analysis
Abderrazak Mejdi\textsuperscript{1}, Luca Alimonti\textsuperscript{1}, Bryce Gardner\textsuperscript{1}
\textsuperscript{1}Esi-north America, San Diego, United States

Audio-frequency surface waves over multiple width and depth grooves
Steve Mellish\textsuperscript{1}, Shahram Taherzadeh, Keith Attenborough
\textsuperscript{1}The Open University, Milton Keynes, United Kingdom

Deployment of an autonomous system for noise monitoring based on digital MEMS microphones
Felipe Ramos de Mello\textsuperscript{1}, William D'Andrea Fonseca\textsuperscript{1}
\textsuperscript{1}Federal University Of Santa Maria, Santa Maria, Brazil

Acoustic comfort at Kyiv metro stations
Illia Melnyk\textsuperscript{1}, Yevhen Fridlib, Artem Maksymenko, Hanna Kliushnichenko
\textsuperscript{1}Acoustic Group, Kyiv, Ukraine

Acoustic performance of a heat exchange silencer for marine diesel engine
Lianghu Meng\textsuperscript{1,2}
\textsuperscript{1}Harbin Engineering University, Harbin, China, \textsuperscript{2}Henan Diesel Engine Industry Co., Ltd, Luoyang, China

A simulation study on the influence of aircraft panel thickness on the cabin sound quality
Zhenjing Miao\textsuperscript{1}, Yu Huang\textsuperscript{1}
\textsuperscript{1}Shanghai Jiao Tong University, Shanghai, China
Application of the transfer path analysis to vehicle doors
Thomas Michaelis¹, Steffen Marburg², Stefanie Retka¹
¹University of Applied Sciences Würzburg-Schweinfurt, Ignaz-Schön-Strasse 11, 97421 Schweinfurt, Germany, ²Technical University of Munich, Chair of Vibroacoustics of Vehicles and Machines, Boltzmannstrasse 15, 85748 Garching b. München, Germany

Active Sound Power Attenuation with a Ring of Harmonic Acoustic Pneumatic Sources fOr Destructive Interference (RHAPSODI) and near field in-duct microphones
Philippe Micheau¹, Julien Drant¹, Alain Berry¹
¹CRASH-UdeS, Université De Sherbrooke, 2500 Blvd de l’universite, Canada

Effects of differences in speaker performance on sports performance -Behavior analysis using OpenPose-Satoshi Miharu¹
¹Kanagawa Institute of Technology, 1030 Shimo-ogino, Atsugi City, Kanagawa, 243-0292 Japan, Japan

Study on Sound and Vibration Propagation Caused by External Flow Affecting Interior Noise of Railway Vehicles
Gaku Minorikawa¹, Kousuke Hotta², Noboru Yamano¹
¹Hosei University, Koganei, Japan, ²Nippon Sharyo Co., Ltd., Nagoya, Japan

Tyre/road noise measurements on ISO tracks using the modified CPX method
Piotr Mioduszewski¹, Truls Berge²
¹Gdansk University Of Technology, Gdansk, Poland, ²SINTEF AS, Trondheim, Norway

Assessment of a Statistical Energy Analysis model to perform automotive acoustic comfort subjective evaluation
Valentin Miqueau, Etienne Parizet¹, Sylvain Germes²
¹Laboratory of Vibration and Acoustic, Lyon, France, ²Saint-Gobain Research Compiègne, Thourotte, France

Modelling of piano string vibration using coupled mobilities and a state-space approach
Pablo Miranda¹, Giacomo Squicciarini², David. J Thompson¹
¹University of Southampton, Southampton, United Kingdom

Influential Factors on Recognition of Sound Emitting Direction Using in Evacuation Guidance System
Tetsuya Miyoshi¹
¹Hannan University, Matsubara, Japan

Numerical prediction method for vibration characteristics of steel-framed ALC floor structure
Haruki Mizunuma¹, Takumi Asakura¹, Yasuhiro Ishiwatari¹, Takayuki Shiraishi¹, Fumiaki Satoh²
¹Tokyo University of Science, 2641 Yamazaki, Noda-shi, Chiba Prefecture 278-8510, Japan, ²Chiba Institute of Technology, 2-1-1 Shibazono,Narashino, Chiba 275-0023, Japan, ³CEL Corporation, 3-7-1 Kyobashi, Chuo, Tokyo 104-0031, Japan

Nonlinear characterization of azimuthal combustion instability exhibiting flame transient phenomena
Balasundaram Mohan¹, Sathesh Mariappan¹
¹Indian Institute of Technology Kanpur, Kanpur, India

RENAULT Smart Cocoon Technology CAE
Philippe Mordillat¹
¹Renault Group, 1 Avenue Du Golf 78288 Guyancourt Cedex, France
Experimental tests of a multichannel active noise control system with single and multiple reference signals applied to the cabin of a tractor
Francesco Mori1, Paolo Bonfiglio2, Patrizio Fausti1, Francesco Pompoli1, Andrea Santoni1
1University of Ferrara, Engineering Department, Ferrara, Italy, 2Materiacustica s.r.l., Ferrara, Italy

Study on Power-level Measuring Method of Structure-Borne Noise of Viaduct Road
Tatsuaki Mori, Kimikazu Ikeya, Tomoyuki Itiki, Akinori Fukushima
1NEXCO Research Institute Japan, Tadao 1-4-1, Machida City, Japan

Study on the objective assessment of sleep disturbance due to environmental noise by wearable devices
Makoto Morinaga1, Chikashi Takara2, Yosiaki Sasazawa3, Hiroshi Nakamura2
1Kanagawa University, Yokohama, Japan, 2Nakamura Clinic, Urasoe, Japan, 3University of Ryukyus, Nishihara, Japan

A laboratory investigation into the threshold of the oppressive or vibratory feeling to low-frequency pure-tone
Makoto Morinaga1, Shigenori Yokoshima2, Tomohiro Kobayashi3, Sakae Yokoyama3, Koichi Makino3, Tetsuya Doi3
1Kanagawa University, Yokohama, Japan, 2Kanagawa Environment Research Center, Hiratsuka, Japan, 3Kobayasi Institute of Physical Research, Kokubunji, Japan

Flow and surface loading induced by a supersonic jet over an aft deck
Philip Morris1, Darryl Douglas1
1Penn State University, State College, United States

Use of Sound “PHONONS’ in the modelling and Optimisation of automotive acoustic systems in 3D
Rodney Morris-kirby1
1Adler Pelzer Group, 33 Barrys Lane, Padstow, Cornwall, United Kingdom

Costing the benefit of low noise surfacing
Matthew Muirhead1
1AECOM, Basingstoke, United Kingdom

Virtual work experience in acoustics
Matthew Muirhead1, Vicky Wills2
1AECOM, Basingstoke, United Kingdom, 2Atkins, Epsom, United Kingdom

A fully-coupled vibro-acoustic model of an electronic stethoscope
Snehashis Mukherjee1, Anoop Akkoorath Mana2
1Department of Mechanical Engineering, Indian Institute of Technology Palakkad, India

Acoustic wave propagation through panels that are made of used tea bags
Stefano Mundula1, Haydar Aygun
1London South Bank University School of the Built Environment and Architecture, London, United Kingdom

Fan Noise Reduction by Acoustic Liners Combined with Fine-Perforated-Film: Noise Tests by a Small Turbofan Engine DGEN 380
Yo Murata1, Tatsuya Ishii2, Shunji Enomoto2, Hideshi Oinuma2, Kenichiro Nagai2, Junichi Nagai2, Hirofumi Daiguji1
1Department of Mechanical Engineering, The University of Tokyo, Tokyo, Japan, 2Aviation Environmental Sustainability Innovation Hub, Aviation Technology Directorate, Japan Aerospace Exploration Agency, Tokyo, Japan
Using burden of disease or harmful effect assessments for quantifying health impacts from environmental noise?
Enda Murphy¹, Jon-Paul Faulkner¹
¹University College Dublin, Dublin, Ireland

A quantitative approach to density-based clustering of flight trajectories for efficient air traffic noise simulations
Shreyas Mysore Guruprasad¹, Gil Felix Greco¹, Tobias P. Ring¹, Sabine C. Langer¹
¹Technische Universität Braunschweig, Institut für Akustik, Braunschweig, Germany

A slug length calculation for a contraction with mean flow between two half cylinders
Wei Na¹, Dong Yang², Aswathy Surendran³, Susann Boij⁴, Aimee Morgans⁵, Huadong Yao¹
¹Department of Mechanics and Maritime Sciences, Chalmers University Of Technology, SE-412 96 Gothenberg, Sweden, ²Department of Mechanics and Aerospace Engineering, Southern University of Science and Technology, 518055 Shenzhen, PR China, ³Department of Engineering Physics and Computation, Technical University of Munich, 85747 Garching, Germany, ⁴KTH Royal Institute of Technology, Marcus Wallenberg laboratory for Sound and Vibration Research, Dept. of Engineering Mechanics, Stockholm, Sweden, ⁵ Department of Mechanical Engineering, Imperial College London, SW72AZ London, United Kingdom

Re-examining the perceived affective quality attributed to soundscapes
Koji Nagahata¹
¹Fukushima University, Kanayagawa 1, Fukushima, 960-1296, Japan

Experimental Results of Double Near-filed Holography method for a commercial Product
Masao Nagamatsu¹
¹Hokkaido University Of Science, Sapporo, Japan

Method for estimating aircraft noise corresponding to changes in thrust and speed during start of takeoff roll
Toshiyasu Nakazawa¹, Naoaki Shinhara¹, Kazuyuki Hanaka²
¹Organization Of Airport Facilitation, 1-3-1-5F, Shiba-koen, Minato-ku, Japan, ²Narita International Airport Promotion Foundation, Japan

Instrumentation Techniques for the Measurement of Gunfire
Anthony Nash¹
¹Charles M. Salter Associates, San Francisco, United States

Sketching sound in architectural design using Virtual Reality
Kristin Nedlich¹, Arne Nykänen, Björn Hellström
¹Luleå University of Technology, Ludvika, Sweden

Localization of higher order exceptional points from finite element model and their applications to duct acoustics.
Benoit Nennig¹, Emmanuel Perrey-Debain², Martin Ghienne¹
¹Institut supérieur de mécanique de Paris (ISAE-Supmeca) - Laboratoire Quartz EA 7393, Saint-Ouen, France, ²Université de Technologie de Compiègne - Laboratoire Roberval, UMR CNRS 7337, Compiègne, France

Acoustic classification with the descriptor of the weighted standardized level difference DnT,w with use of the weighted apparent sound reduction index R’w
Reinhard Neubauer¹
¹IBN Bauphysik GmbH & Co. KG, Ingolstadt, Germany
Construction details affecting flanking transmission in cross laminated timber structures for multi-story housing
Maximilian Neusser1, Thomas Bednar1
1TU Wien - Institute of Material Technology, Building Physics, and Building Ecology, Karlsplatz 13, 1030 Vienna, Austria

A Practical Method to Increase the Low Frequency Sound Insulation of Timber Frame Constructions
Michael Newman1, Arild Brekke2, Ståle Ellingsen2, Frode Eikeland2
1Avinor, Oslo, Norway, 2Brekke & Strand Akustikk, Oslo, Norway

The development of sustainable policies to manage noise around airports in Vietnam
Thi Thanh Vu1, Thulan Nguyen2, Masaharu Ohya3, Keishi Sakoda3, Ichiro Yamada5
1Department of Science, Technology and Environment, The Civil Aviation Authority of Vietnam, Hanoi, Vietnam, 2Department of Architectural Design, Shimane University, Matsue, Japan, 3RION Co., Ltd., Tokyo, Japan

New guidance manual for the monitoring and evaluation of aircraft noise in Vietnam with an experimental application to the aircraft noise monitoring at Noi Bai International Airport
Thulan Nguyen1, Thi Thanh Vu2, Naoaki Shinohara3, Koichi Makino4, Keishi Sakoda5, Ichiro Yamada5
1Department of Architectural Design, Shimane University, Matsue, Japan, 2Department of Science, Technology and Environment, The Civil Aviation Authority of Vietnam, Hanoi, Vietnam, 3Organization of Airport Facilitation, Tokyo, Japan, 4Kobayasi Institute of Physical Research, Japan, 5RION Co., Ltd., Tokyo, Japan

Assessment of Drone Noise Within Urban Soundscapes
Rory Nicholls1, Antonio J Torija2
1University of Salford, Salford, United Kingdom

Effect of Bearing Direction and Mounting Techniques on Cross-Laminated Timber Elements in the Field
Erik Nilsson1, 2Sylvain Ménard1, Delphine Bard Hagberg2, Klas Hagberg3
1University of Québec at Chicoutimi, Department of Applied Sciences, Chicoutimi (Québec), Canada, 2Lund University, Engineering Acoustics, Lund, Sweden, 3Acouwood AB, Malmö, Sweden

Calculation of Drive-Related Structure-Borne Sound in Electric Driven Trains using Elastic Multi-Body Simulation
Sascha Noack1, Michael Beitel Schmidt1
1TU Dresden, Dresden, Germany

The meaning of sound environment for children with special needs: Action research on room acoustics in the child development support center
Saki Noguchi1, 2Minami Arai2, Kanako Ueno2, Hisao Funaba1, 3Tomoko Matsumoto4, Ryoko Watanabe4, 5Nearai Gakuen, Japan, 3Yokohama National University, Japan, 4Nearai Gakuen, Japan, 5Hamamatsu Gakuin University, Japan

Experiments on the aeroacoustic whistling of a cylindrical cavity
Abel Faure Beaulieu1, Tiemo Pedergnana3, Yuan Xiong2, Nicolas Noiray1
1ETH Zürich - CAPS Laboratory, Sonneggstrasse 3, MI J13.1, 8092, ZÜRICH, Switzerland, 2Beihang University, Beijing, China

Vibration Isolation in Plates Using Flexural Cloaking
Aidin Nojavan1, Sabine Christine Langer1
1Institute for Acoustics, TU Braunschweig, Braunschweig, Germany
Bias-aware thermoacoustic data assimilation
Andrea Novoa1, Alberto Racca1, Luca Magri1,2,3,4
1University of Cambridge, Cambridge, United Kingdom, 2Imperial College, London, United Kingdom, 3The Alan Turing Institute, London, United Kingdom, 4Institute for Advanced Study. Technical University of Munich, Garching, Germany

Inverse scheme for sound source identification in a vehicle trailer
Jonathan Nowak1, Reinhard Wehr1,2,3, Manfred Haider2, Manfred Kaltenbacher2
1TU Wien, Vienna, Austria, 2TU Graz, Austria, 3AIT, Austria

Sound absorption of porous composites with heated impervious inclusions
Gabriel Ignacio Núñez Gómez1, Rodolfo Venegas1, Claude Boutin2
1University Austral Of Chile, Institute Of Acoustics, P.o. Box 567, Valdivia, Chile, 2Université de Lyon—Ecole Nationale des Travaux Publics de l'Etat, LGCB/LTDS UMR-CNRS 5513/CeLyA, Rue Maurice Audin, Vaulx-en-Velin, France

Bringing the Tranquillity Rating Prediction Tool (TRAPT) Indoors – A Case Study at The Warren, Hull
James Oatley1,2, Mark Swale1,2
1Cirrus Research Plc, Filey, United Kingdom, 2The Warren, Hull, United Kingdom

Collecting and mapping soundscape data across the 15 UK national parks
Tin Oberman1, Peter Stollery2, Francesco Aletta1, Jian Kang1
1University College London, London, United Kingdom, 2University of Aberdeen, Aberdeen, United Kingdom

Hybrid space filling curve metamaterials for transmissive flow in Jet Engine inlets
Jennifer Glover1, Dan O’Boy1
1Loughborough University, Loughborough, United Kingdom

Basic investigation of sound field inside and outside ear canal under ultrasound irradiation
Yuya Ogawa1, Ayumu Osumi1, Youichi Ito1
2Nihon University, Mitaka-shi, Japan

Sound power level properties of hovering UAVs (drones) in a semi-anechoic room
Gyu-in Oh1, Yonghee Kim1, Jang-won Lee1, Bon-su Koo1, Dae-gwan Won1, Seung-soo Lee2, Sang-ho Kim3
1Y’su Youngsan University, Junamro 288, Yangsan, South Korea, 2Korea Conformity Laboratories, Nambusunhwonro 319-gil 7, Seocho, South Korea, 3Konkuk University, Neungdongro 120, Kwangjin, South Korea

Machine-learning-based estimation of absorption coefficients from transfer functions modeled by equivalent sources
Yukiko Okawa1, Haruka Matsuhashi, Izumi Tsunokuni, Yusuke Ikeda, Yasuhiro Oikawa
2Tokyo Denki University, 5, Senju-Asahi-Cho, Adachi-ku, Japan

Examining the Difference Between Laboratory Measurements and Calculation Results in Impact Sound Insulation
Mehmet Okay1, Mehmet Nuri İlgürel2, Rahmi Güçlü3
1Yıldız Technical University, Istanbul/Besiktas, Turkey, 2Yıldız Technical University, Istanbul/Besiktas, Turkey, 3Yıldız Technical University, Istanbul/Besiktas, Turkey

Sound perception of the space inhabited during COVID-19 pandemic in Brazil: relations with demographic data
Poliana Oliveira1, Erasmo Felipe Vergara, Gildean Almeida, Maria Lúcia Oiticica, Jordana Silva, Elisabeth Gonçalves
1University of Santa Catarina, Florianópolis, Brasil
A high-order stabilized finite-element model for the Linearized Navier-Stokes equations
Simone Olto¹,², Hadrien Bériot¹, Sophie Le Bras¹, Hervé Denayer²
¹Siemens Industry Software NV, Leuven, Belgium, ²KU Leuven, Leuven, Belgium

Application of taguchi method for investigating the acoustical properties of synthetic foam composite structure
Nursah Oner¹, Sinem Ozturk¹, Sevinc Aycan Yetim¹, Ugur Tatlier¹
¹Istanbul Technical University, Istanbul, Turkey

Modelling of Train Floor Sound Transmission using Coupled FE-SEA analysis
Ulf Orrenius¹, Mark Teschner², Torsten Kohrs³
¹Akustikdoktorn Sweden, Stockholm, Sweden, ²Dassault Systems, Hamburg, Germany, ³Alstom, Hennigsdorf, Germany

In-situ measurements at gymnasiums for sound absorption characteristics of building materials using the ensemble averaging technique
Toru Otsuru¹, Reiji Tomiku¹, Noriko Okamoto¹
¹Faculty of Science and Technology, Oita University, Oita, Japan

Investigation of the applicability of recurrent neural networks for structural health monitoring in the frequency domain
Lukas Outzen¹, Tobias P. Ring¹, Sabine C. Langer¹
¹Technische Universität Braunschweig, Braunschweig, Germany

Physics-aware learning of nonlinear limit cycles and adjoint limit cycles
Defne Ege Ozan¹, Luca Magri¹,²
¹Department of Aeronautics, Imperial College London, United Kingdom, ²The Alan Turing Institute, United Kingdom

A Study on Multimodal Behaviour of Plate Absorbers
Mehmet Sait Özer¹, Friedrich Beyer¹, Sebastian Merchel¹, Ercan Altınsoy¹
¹Chair of Acoustics and Haptics, TU Dresden, Dresden, Germany

The Sound Characteristics Of The Baglama With Respect To Different Chest Shapes
Sinem OZTURK¹, Filiz Gurer Yucel², Ozay Onal²
¹Istanbul Technical University, Istanbul, Turkey, ²Music and Fine Arts University, Ankara, Turkey

Investigation of electric vehicle noise sources on low-noise road surfaces
Marie-agnès Pallas¹, Simon Bianchetti¹, Adrien Le Bellec³, Julien Cesbron²
¹UMRAE, Univ Gustave Eiffel, IFSTTAR, CEREMA, Univ Lyon, F-69675 Bron, France, ²UMRAE, Univ Gustave Eiffel, IFSTTAR, CEREMA, F-44344 Bouguenais, France

Assessment of annoyance and cognitive fatigue of open-plan office occupants subjected to noise from two different activities
Lucas Lenne¹, Etienne Parizet¹, Patrick Chevret²
¹Lva - Insa Lyon, Villeurbanne, France, ²INRS, Vandoeuvre les Nancy, France

Contribution analysis of road noise with transfer path analysis based on neural network
Uyeup Park¹, Yeon June Kang¹
¹Department of Mechanical Engineering, Seoul National University, Seoul, Republic of Korea
The impact of the COVID-19 pandemic on community noise
Sang Hee Park¹, Hye-Kyung Shin¹, Kyoung-Woo Kim¹
¹Korea Institute Of Civil Engineering And Building Technology (KICT), Goyang, South Korea

Health & whole life cost benefits of highways noise barriers
Giles Parker¹
¹Sound Barrier Solutions Ltd, Coventry, United Kingdom

“Eyes don’t say it all” – Communication challenges while wearing facemasks in class
Katarina Paunovic¹,², Danka Vukašinović¹,², Katarina Đurđević¹,², Ana Jovanović¹,², Maja Miloradović¹,²
¹Faculty of Medicine, University of Belgrade, Belgrade, Serbia, ²Institute of Hygiene and Medical Ecology, Belgrade, Serbia

New soundscape after the Covid-19 lockdown
Katarina Paunovic¹,², Branko Jakovljevic¹,², Radmila Mircić¹, Dragan Pajić³, Milan Konatarević³
¹Faculty of Medicine, University of Belgrade, Belgrade, Serbia, ²Institute of Hygiene and Medical Ecology, Belgrade, Serbia, ³City Institute for Public Health, Belgrade, Serbia

Design, construction and commissioning of a reverberation room
John Pearse¹, Aaron Healey
¹University Of Canterbury, Christchurch, New Zealand

Unified low-order modeling approach to can-annular combustors
Tiemo Pedergnana¹, Nicolas Noiray¹
¹ETH Zürich, Zürich, Switzerland

Noise limits and indicators for intermittent indoor low frequency noise
Frank Pedersen¹
¹The Danish Environmental Protection Agency, Tolderlundsvej 5, 5000 Odense C, Denmark

Classification of noisy vehicles from unsupervised measurements
Bert Peeters¹, Ard Kuijpers¹
¹M+P, Vught, Netherlands

Investigation of potential benefits and functionality of a vibroacoustic camera by combining results of a common beamforming and nearfield holography acoustic camera and a highspeed camera, allowing to visualize structural vibration (optical flow tracking).
Johannes Pehe², Dirk Döbler², Daniel Herfert², Christof Puhle²
²gfai tech Gmbh, Berlin Adlershof, Germany, ²Gesellschaft zur Förderung angewandter Informatik e.V., Berlin Adlershof, Germany

Noise mapping and acoustic evaluation of different pavements in the city of Fortaleza, northeast Brazil.
Nara Gabriela de Mesquita Peixoto¹, Carla Marília Cavalcante Alecrim², Gleidson Martins Pinheiro³, Verônica Teixeira Franco Castelo Branco², Paulo Henrique Trombeta Zannin⁴
¹Faculty of Architecture and Urbanism, University of São Paulo, São Paulo, Brazil, ²Department of Transportation engineering, Federal University of Ceará, Fortaleza, Brazil, ³Department of Mechanical engineering, Federal University of Santa Catarina, Florianópolis, Brazil, ⁴Department of Mechanical engineering, Federal University of Paraná, Curitiba, Brazil

Finite element modelling of airborne sound insulation in single and double cross laminated timber panels
MARIA Pettersson, Fredrik Ljunggren
¹Luleå University Of Technology, 97187 Luleå, Sweden
Sonic Boom over land avoidance and the impact on economic feasibility
Holger Pfaender
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1Georgia Institute Of Technology, 270 Ferst Dr, Atlanta, GA, 30126, United States

Towards high frequency boundary element methods for multiple scattering
Simon Chandler-wilde1, Stephen Langdon2, Oliver Phillips1
1University of Reading, Reading, United Kingdom, 2Brunel University, Uxbridge, United Kingdom

Using clustering methods to detect quality data in a smartphone-based crowd-sourced database for environmental noise assessment
Ayoub Boumchich1, Judicaël Picaut1, Erwan Bocher2
1UMRAE, Univ Gustave Eiffel, IFSTTAR, CEREMA, Bouguenais, France, 2CNRS, Lab-STICC, UMR 6285, Université Bretagne Sud, Vannes, France

Auralisation of combined mitigation measures in railway pass-by noise
Reto Pieren1, Fotis Georgiou1, Giacomo Squicciarini2, David J. Thompson2
1Empa, Dübendorf, Switzerland, 2ISVR, University of Southampton, Southampton, UK

Limitations of FxLMS in Feedforward Active Vibration Control of a Nonlinear Two-Degree-of-Freedom System
Xander Pike1, Jordan Cheer1
1ISVR - University of Southampton, Southampton, United Kingdom

Virtual sound source perception challenges of binaural audio systems with head-tracking
Vedran Planinec1, Kristian Jambrošić1, Petar Franček1, Marko Horvat1
1University Of Zagreb Faculty Of EE And Computing, Zagreb, Croatia

Assessment of wind turbine noise in laboratory conditions
Dariusz Pleban1, Grzegorz Szczepanski1, Agnieszka Wludarczyk1, Adrian Alikowski3, Krzysztof Lada1
2Central Institute for Labour Protection - National Research Institute, Warsaw, Poland

Creating a new research community on detection and classification of acoustic scenes and events: Lessons from the first ten years of DCASE challenges and workshops
Mark Plumbley1, Tuomas Virtanen2
1University of Surrey, Guildford, United Kingdom, 2Tampere University, Tampere, Finland

Audio augmentation of car journeys to improve occupants’ well-being
Zuzanna Podwinska1, Lara Harris2, Andrew Jackson2, Connor Welham1, Andrew Elliott1
1University of Salford, Manchester, United Kingdom, 2Bentley Motors Limited, Crewe, United Kingdom

Respite from aircraft noise: consolidation of current understanding in relation to airspace design
Richard Norman2, Nicole Porter3, Andy Knowles1, Robin Monaghan1
1Anderson Acoustics Ltd, 3, Trafalgar Mews, 15-16 Trafalgar St, Brighton BN1 4EZ, United Kingdom, 2Heathrow Airport Ltd, United Kingdom

Low-noise friction courses containing treated and un-treated crumb rubber to mitigate tyre/road noise in urban contexts
Filippo G. Pratico1, Filippo G. Praticò1
1University Mediterranea Of Reggio Calabria, Via Graziella - Feo di Vito, Reggio Calabria, Italy
Numerical investigation of the effects of model and operator uncertainties on component-based transfer path analysis methods with substructuring applied to aircraft-like components
Simon Prenant¹, Thomas Padois¹, Thomas Dupont¹, Olivier Doutres¹
¹Éts, 1100 Rue Notre-dame Ouest, Canada

Noise emission and noise exposure – an approach to improve the link
Wolfgang Probst¹
²Datakustik GmbH, Gilching, Germany

Effect of presence of furnishings on designed and measured reverberation time in school spaces
Elena Prokofieva¹
¹Edinburgh Napier University, Unit 1, 7 Hills Business Park, Edinburgh, United Kingdom

Narrowing the knowledge gap - solving the problems that occur when teaching the theory of acoustics in a higher education course
Elena Prokofieva¹
¹Lecturer, acoustic consultant, Edinburgh Napier University, Unit 1, 7 Hills Business Park, Edinburgh, United Kingdom

Prediction of combustion instabilities based on the Green’s function in a three-dimensional annular combustor with multiple flames
Lei Qin, Xiaoyu Wang, Guangyu Zhang, Xiaofeng Sun
²Research Institute of Aero-engine, Beihang, Beijing, China, ³Research Institute of Aero-engine, Beihang, Beijing, China
³School of Energy and Power Engineering, Beihang, Beijing, China

Effects of aircraft noise on psychophysiological feedback in under-route open spaces
Fei Qu¹, Qi Xie¹
¹Shenzhen University, Shenzhen, China

The influence of the modes of surrounding buildings on the ground vibration from railways
Xiangyu Qu¹, David Thompson¹, Evangelos Ntotsios¹, Giacomo Squicciarini¹
¹Institute of Sound and Vibration Research, University of Southampton, Southampton, United Kingdom

Valve noise at high pressure ratios
Erika Quaranta¹, Malcolm Smith¹
²ISVR Consulting, University of Southampton, Southampton, United Kingdom

Influence of contact parameters on the radiated noise from an automotive drum brake
Ananthapadmanabhan Ramesh¹, Aditya Rangamani¹, Sriram Sundar¹
²Indian Institute of Technology Tirupati, India

On the Optimization of Sonic Crystal Acoustic Noise Barriers
David Ramírez-Solana¹, Javier Redondo², Maria Pia Fanti¹, Agostino Marcello Mangini¹, Jaime Galiana-Nieves²
¹Department of Electrical and Information Engineering, Politecnico Di Bari, Via Edoardo Orabona, 4, 70126 Bari, Italy,
²Instituto de Investigación para la Gestión Integrada de Zonas Costeras, Universitat Politècnica de València, Paranimf 1, Grao de Gandía, 46730, Spain

Structural design optimization of a high-speed rotor system for mechanical vibration mitigation
Liaoyuan Ran¹, Dunant Halim¹, Chung Ket Thein², Michael Galea³
³Department of Electrical and Information Engineering, Politecnico Di Bari, Via Edoardo Orabona, 4, 70126 Bari, Italy,
²Instituto de Investigación para la Gestión Integrada de Zonas Costeras, Universitat Politècnica de València, Paranimf 1, Grao de Gandía, 46730, Spain
An in-plane flexible ring model for the analysis of the free and forced response of a rolling tyre
Luca Rapino1, Ivano La Paglia1, Francesco Ripamonti1, Roberto Corradi1, Simone Baro2
1Politecnico Di Milano, Via La Masa 1, 20156, Milano, Italy, 2Pirelli Tyre S.p.A., Viale Piero e Alberto Pirelli 25, 20126, Milano, Italy

Combined acoustic testing of home appliances: a case study
Luca Rapino1, Ivano La Paglia1, Francesco Ripamonti1, Roberto Corradi1, Antonio Acri2
1Politecnico Di Milano, Via La Masa 1, 20156, Milano, Italy, 2Haier Europe, Via Privata Eden Fumagalli, 20861, Brugherio, Italy

Noise from ventilation systems in dwellings – Regulations and field test procedures in selected countries in Europe
Birgit Rasmussen1, Teresa Carrascal García
1BUILD, Department of the Built Environment, Aalborg University, Copenhagen, Denmark

Wavenumber spectrum determination for aeroacoustic applications using FISTA
Hans-Georg Raumer1, Carsten Spehr1
1German Aerospace Center (DLR), Göttingen, Germany

Structureborne noise transmission from sports court
Wayland Dong1, Samantha Rawlings1, John LoVerde1
1Veneklasen Associates, Santa Monica, United States

Characterisation of time-varying structure-borne sound sources using a reception plate to predict maximum Fast time-weighted levels in buildings
Steffi Reinhold1,2, Carl Hopkins1
1University of Liverpool, Liverpool, UK, 2Hochschule für Technik Stuttgart, Stuttgart, Germany

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William Renel2
1Royal College Of Art, London, United Kingdom, 2Touretteshero CIC, London, United Kingdom

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1Universidad de Extremadura, Cáceres, Spain, 2Universidad Politécnica de Madrid, Madrid, Spain, 3Unité de Mixte de Recherche en Acoustique Environnementale (UMRAE) - Université Gustave Eiffel, Nantes, France

A methodological proposal to measure rolling noise under real road use conditions
Pedro Atanasio Moraga1, Manuel Sánchez Fernández1, Guillermo Rey Gozalo1, David Montes González1, Rosendo Vilchez-Gómez1, Alicia Bachiller León1, Juan Miguel Barrigón Morillas1
1Universidad de Extremadura, Cáceres, Spain

Assessing the coupling strength between subsystems in (hybrid deterministic-)statistical energy analysis
Edwin Reynders1, Cédric Van hoorickx1
1Université Catholique de Louvain, Louvain-la-Neuve, Belgium.
Environmental quality or behavioural cognitions? Identifying variables that can be used to classify intended civic engagement against transportation noise exposure
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1University of Münster, Münster, Germany

Exploring the relationship between acoustic environmental quality and civic engagement against environmental noise: Outline of a study design from an equity perspective
Natalie Riedel
1University Of Münster, Münster, Germany

Unsteady FW-H Simulation of the Aerodynamic Noise of a High Speed Train Bogie
Martin Rissmann, Romain Leneveu, Claire Chaufour, Alexandre Clauzet, Fabrice Aubin
1Vibratec SA, Écully, France, 2SNCF VOYAGEURS - SNCF MATÉRIEL INGÉNIEURIE DU MATÉRIEL – CENTRE D’INGÉNIEURIE DU MATÉRIEL, Le Mans, France

Laboratory measurements on replaceable jack-up systems
Marina Rodrigues
1Cdm Stravitec Nv, Reutenbeek 9-11 B - 3090 Overijse, Belgium

Constrained layer damping concept used on isolated gym floors. Better than Concrete?
Marina Rodrigues
1Cdm Stravitec Nv, Reutenbeek 9-11 B - 3090 Overijse, Belgium

Self-tuning vibration control using piezoelectric patches and RL shunts set to maximise electric power absorption
Gabriel Rodrigues, Paolo Gardonio, Loris Dal Bo, Emanuele Turco
1Università degli Studi di Udine, Udine, Italy

Acoustic satisfaction for residents despite entertainment sound impact: can a soundscape approach reveal the positive strength of non-acoustic factors?
Peter Rogers, J Harvie-Clark, R Hinton, J Hill, D Cordes
1Sustainable Acoustics Ltd., Winchester, United Kingdom, 2Apex Acoustics Ltd, Newcastle upon Tyne, United Kingdom

The evolution of a lexicon for Sustainable Acoustics
Peter Rogers
1Sustainable Acoustics Ltd., Winchester, United Kingdom, 2FIOA,

Gym Acoustics Guidance - the standardised UK approach
Peter Rogers, Sebastian Woodhams
1Sustainable Acoustics Ltd., Winchester, United Kingdom, 2FIOA,

Citizen Science and Soundscape Perception during Covid restrictions in the UK
Peter Rogers, Jim Smith, Ben Ward
1Sustainable Acoustics Ltd., Winchester, United Kingdom, 2Winchester Science Centre, Winchester, United Kingdom

The new buildings acoustic classification scheme in Spain: the standard UNE 74201
Amelia Romero Fernández, María Teresa Carrascal García, María Belén Casla Herguedas
1IETcc-CSIC. Eduardo Torroja Institute For Construction Science. Spanish National Research Council, Madrid, Spain
Reflections on burden of disease and health impact assessment methods for noise
Martin Röösli1, Danielle Vienneau1
1Swiss Tropical and Public Health Institute, Kreuzstrasse 2, CH-4123 Allschwil, Switzerland

Human diversity in acoustics. Towards a more inclusive sound environment.
Carmen Rosas-Pérez1, Laurent Galbrun1
1Heriot-Watt University, Edinburgh, United Kingdom

Can you really put a price on a good night’s sleep?
Lukáš Zelem1, Arnon Vandenberghhe3, Andrea Vargová1, Vojtech Chmelik1, Monika Rychtáriková2
1STU in Bratislava, Radlinského 2766/11, 810 05, Slovakia, 2KU Leuven, Hoogstraat 51, 9000 Gent/Paleizenstraat 65, B1030 Brussel, Belgium, 3KU Leuven, Kasteelpark Arenberg 1 box 2200, B-3001, Heverlee, Belgium

Explaining inconsistent uncertainty quantification in neural network models of nonlinear flame response.
Marcin Rywik1, David da Cruz1, Wolfgang Polifke1
1Technical University Munich, Munich, Germany

Validation of calculation method of road traffic noise behind building complex in ASJ RTN-Model 2018 by field measurements
Shinichi Sakamoto1, Wenrui Xu2, Taiki Fukuda2, Miki Yonemura1
1Institute of Industrial Science, The University of Tokyo, 4-6-1, Komaba, Meguro, Japan, 2Graduate School of Engineering, The University of Tokyo, 7-3-1, Hongo, Bunkyo, Japan

Characteristics of powders that cause sound absorption in the low frequency range due to longitudinal vibration in lightweight and fine powders
Shuichi Sakamoto1, Ren Saito1, Keisuke Jindai1, Koki Ikeda1
1Niigata University, Niigata, Japan

Enhanced 3D (three dimensional) acoustic scene analysis based on sound arrival direction for automatic airport noise monitoring.
Keishi Sakoda1, Ichiro Yamada
1Rion Co., Ltd., Kokubunjishi, Japan

Investigation of nonlinear propagation effects on sound from supersonic bullets
Erik Salomons1, Frits van der Eerden1, Frank van den Berg1
1TNO, The Hague, Netherlands

Towards bridging nano- and macroscale acoustics of porous solids
Alan Sam1, Marina Barbagero1, Rodolfo Venegas2, Benoit Coasne1
1Laboratoire Interdisciplinaire de Physique (LIPhy), Université Grenoble Alpes, Grenoble, 38402, France, 2University Austral of Chile, Valdivia, Chile

Reduced basis methods with parameterized boundary conditions for room acoustics
Hermes Sampedro Llopis1,2, Allan P. Engsig-Karup3, Cheol Ho Jeong3, Finnur Pind4, Jan S. Hesthaven5
1Rambøll, Copenhagen, Denmark, 2Acoustic Technology, Department of Electrical Engineering, Technical University of Denmark, Lyngby, Denmark, 3Department of Applied Mathematics and Computer Science, Technical University of Denmark, Lyngby, Denmark, 4Treble Technologies, Reykjavik, Iceland, 5Chair of Computational Mathematics and Simulation Science, Ecole polytechnique federale de Lausanne, Lausanne, Switzerland
Acoustic effects of elevated platforms for standing audiences in an indoor music venue
Rebeca Sánchez¹, Luis Gomez-Agustina²
¹London South Bank University, London, United Kingdom, ²London South Bank University, London, United Kingdom

The EU Tyre Noise Label: The problem with measuring the noise level of only a few of all tyre variants
Ulf Sandberg¹, Piotr Mioduszewski²
¹Swedish National Road and Transport Research Institute (VTI), Linkoping, Sweden, ²Gdansk University of Technology, Gdansk, Poland

The effect of corrugations on the crackle noise in under-expanded impinging jets
Debivarati Sarangi¹, Karthik R², Srinivasan K³
¹IIT Madras, Chennai, India, ²IIT Madras, Chennai, India, ³IIT Madras, Chennai, India

Evaluation of flyover auralisations of today's and future long-range aircraft concepts
Beat Schäffer¹, Lothar Bertsch², Ingrid Le Griffon³, Axel Heusser¹, Catherine Lavandier⁴, Reto Pieren¹
¹Empa, Swiss Federal Laboratories for Materials Science and Technology, Dübendorf, Switzerland, ²German Aerospace Center (DLR), Göttingen, Germany, ³Office National d’Études et de Recherches Aérospatiales (ONERA)—Paris Saclay University, Châtillon Cedex, France, ⁴ETIS laboratory, CY Cergy Paris University, ENSEA, CNRS, UMR8051, Cergy, France

Calculation of annual aircraft noise exposure for Geneva and Zurich airports with the next-generation program sonAIR—first results
Stefan Schalcher¹, Christoph Zellmann¹,², Jonas Meister¹, Jean-Marc Wunderli¹, Beat Schäffer¹
¹Empa - Swiss Federal Laboratories for Materials Science and Technology, Dübendorf, Switzerland, ²n-Sphere AG, Zürich, Switzerland

Uncertainty of structure-borne sound source quantities and the installed power from interlaboratory test results according to EN 15657
Jochen Scheck¹, Volker Wittstock, Michel Villot
¹HFT Stuttgart, Stuttgart, Germany

Annoyance of rotorcraft sounds in urban background noise
Josef Schlittenlacher¹, Karine Wales¹
¹University Of Manchester, Manchester, United Kingdom

Experiences with source characterization methods within and beyond the scope of EN 15657
Fabian Schöpfer¹, Tobias Kruse¹, Johanna Weinzierl¹, Andreas Mayr¹, Ulrich Schanda¹
¹Rosenheim Technical University Of Applied Sciences, Hochschulstr. 1, 83024 Rosenheim, Germany

The role of sound emergence for aircraft noise annoyance
Dirk Schreckenberg¹, Christin Belke¹, Jördis Wothge², Rainer Gusk³
¹ZEUS GmbH, Hagen, Germany, ²Germen Environmental Agency, Dessau-Roßlau, Germany, ³Ruhr-University Bochum, Bochum, Germany

Acoustical properties of alternative sleepers: experimental testing
Wout Schwanen¹, Nils Yntema²
¹M+P, Vught, Netherlands, ²ProRail, Utrecht, Netherlands

Application of sound absorption measurements according to EN 1793-5 on gabion walls
Wout Schwanen¹, Willem Jan van Vliet²
¹M+P, Vught, Netherlands, ²Rijkswaterstaat Grote Projecten en Onderhoud, Utrecht, Netherlands
Role of stretch on the flame dynamics of laminar premixed flames
Edoardo Scoletta¹, Wolfgang Polifke¹
¹Technical University of Munich, Garching, Germany

Objective and subjective analysis of the acoustic performance of a ZEB test-building
Chiara Scrosati¹, Fabio Scamoni, Michele Depalma, Ludovico Danza
²ITC CNR, viale Lombardia 49, San Giuliano Milanese (MI), Italy

Resolving clashes between net-zero energy and acoustics engineering specifications, to enhance low-carbon building performance, regulatory compliance and future skills. Laws and standards comparison between Italy and UK
Ludovico Danza¹, Chiara Scrosati¹, Lorenzo Belussi¹, Fabio Scamoni², John Currie³, Sean Smith²
¹Itc Cnr, Via Lombardia 49, Italy, ²University of Edinburgh, Edinburgh, Uk, ³Edinburgh Napier University, Edinburgh, UK

Development of Room Acoustic Prediction and Evaluation Tools for Designers
Yukiko Seike¹, Daisaku Miura², Takashi Ishizuka¹, Kanaya Kitajima¹, Ayame Kato¹, Toru Miyajima¹
¹Institute of Technology, Shimizu Corporation, Koto-ku, Japan, ²Building Construction Headquarters, Shimizu Corporation, Chuo-ku, Japan

Serial recall performance under different room acoustic conditions
Jan Selzer¹, Florian Schelle¹, André Fiebig²
¹Institute for Occupational Safety and Health (IFA der DGUV), Sankt Augustin, Germany, ²Technische Universität Berlin, Berlin, Germany

Modal analysis of Free Vibration of an Extremely Lightweight Panel Model for Bridge Bearing Applications
Pasakorn Sengsri¹, Sakdirat Kaewunruen¹
¹Laboratory for Track Engineering and Operations for Future Uncertainties (TOFU Lab), School of Engineer- ing, The University of Birmingham, Edgbaston, Birmingham B15 2TT, UK, United Kingdom

Periodic flank modifications for optimal excitation behavior of practical gear geometries
Sebastian Sepp¹
¹Technical University Of Munich - Gear Research Center (FZG), 85748 Garching (Munich), Germany

Study On the Effect of Operating Conditions on Acoustic Three-Port Measurements of Perforates in presence of Grazing Flow
Shail Shah¹, Hans Bodén¹, Susann Boij¹
¹KTH Royal Institute of Technology, Stockholm, Sweden

Flow Acoustic Interaction In A Rectangular T-Junction With Mounted Perforate Using Acoustic Three-Port Measurements
Shail Shah¹, Hans Bodén¹, Susann Boij¹
¹KTH Royal Institute of Technology, Stockholm, Sweden

The impact of covid-19 restrictions on complaints of noise made to a local authority in Northern Ireland - a case study.
Lindsay Shaw¹, Paul McCullough
¹Ulster University, Belfast, United Kingdom

Noise reduction by perforated cascades in annular ducts
Zihan Shen¹, Xiaoyu Wang², Xiaofeng Sun¹
Implementations of wireless active noise control in the headrest
Xiaoyi Shen, Dongyuan Shi, Santi Peksi, Woon-Seng Gan
1School of Energy and Power Engineering, Beihang University, Beijing, China, 2Research Institute of Aero-Engine, Beihang University, Beijing, China

Low-frequency vibration of a timber joist floor section connected by metal screws: experimental validation of FEM models
Xiaoxue Shen, Carl Hopkins
1University Of Liverpool, Liverpool, United Kingdom

Diesel Engine Noise Source Visualization by Using Compressive Sensing Algorithms
Tongyang Shi, J. Stuart Bolton, Frank Eberhardt
13M Company, Woodbury, United States, 2Purdue University, West Lafayette, United States, 3Cummins Inc., Columbus, United States

Applying the remote microphone method in the filtered error least mean squares algorithm
Yujie Fu, Chunyu Liu, Chuang Shi
1University of Electronic Science and Technology of China, Chengdu, China

Determining CNOSSOS-EU Meteorological correction factors in Ireland
Simon Shilton, Joshua Nunn
1Acustica Limited, Manchester, United Kingdom, 2Noise Consultants Limited, Warrington, United Kingdom

Implementing the CNOSSOS-EU correction near traffic light junctions and roundabouts
Simon Shilton, RafDouglas C. Tommasi
1Acustica Limited, Manchester, United Kingdom, 2Tommasi and Tommasi, Udine, Italy

Five Levels of Soundscape Design
Gary Siebein
1Siebein Associates, Inc., Gainesville, United States

Reconstruction of acoustic fields via physics-informed neural networks
Camilo Fernando Silva Garzon, Philip Bonnaire, Nguyen Anh Khoa Doan, Camilo Fernando Silva
1Technical University of Munich, Munich, Germany, 2Delft University of Technology, Delft, Netherlands

Noise characterization and mitigation of a shrouded propeller for vertical lift vehicles
Frank Simon, Noah H. Schiller, Nicole Pettingill, Nicolas Zawodny, Matt Galles
1Onera, Toulouse Cedex, France, 2NASA Langley Research Center, Hampton, USA

A repeated-measurements study: Annoyance and sleep disturbance due to vibrations from trains
Sendrick Simon, Elise van Kempen, Arnaud Kock, Nick Mabjaia, Irene van Kamp
1RIVM, Antonie van Leeuwenhoeklaan 9, Netherlands

Flat Fresnel-spiral acoustic metamaterials composed of several arms ventilated metamaterials for simultaneous broadband sound absorption and air circulation
Sanjeev Kumar Singh, Shantanu Bhattacharya
1Indian Institute Of Technology Kanpur, Kanpur, India
Development of a relation between traffic variables and environmental noise descriptors for four-lane National Highways
Ashish Singh¹, Elangovan Rajsekar², Manoranjan Parida³
¹Indian Institute of Technology Roorkee, India, ²Indian Institute of Technology Roorkee, India, ³Indian Institute of Technology Roorkee, India

The application of wavy geometries for the reduction of trailing edge instability noise
Tom Smith¹, Yiannis Ventikos
¹University College London, London, United Kingdom

Role of community engagement in soundscape design of rural areas
Julija Smyrnova¹, Gillian Brown¹
¹Environment Agency, United Kingdom

Applicability of ISO 16283-3 for field measurement of sound insulation of partially open windows
Lars Sommer Søndergaard¹, Birgit Rasmussen², Rune Egedal¹, Rasmus Stahlfest Holck Skov³
¹FORCE Technology, Aarhus, Denmark, ²BUILD, Aalborg University, Copenhagen, Denmark, ³FORCE Technology, Hørsholm, Denmark

Listening Difficulty of Public Announcement at Subway Platform with Long Reverberation Time
Eun Sung Song¹, Su Hong Kim¹, Jeong Hun Kim¹, Song Mi Lee¹, Do Kyung Kim¹, Chun Won Eom¹, Jong Kwan Ryu¹
¹Chonnam National University, buk-gu Yong Bong-ro 77, South Korea

A general stable approach to modeling and coupling multilayered systems with various types of layers
Guochenhao Song¹, Zhuang Mo¹, J. Stuart Bolton¹
¹Ray W. Herrick Labs, Purdue University, West Lafayette, United States

Effect of the microstructure on the acoustic performance of porous material liner in the duct
Xiang Song¹, Jingjian Xu¹, Tianyue Yuan¹, Dan Sui¹, Heye Xiao², Jie Zhou¹
¹School of Aeronautics, Northwestern Polytechnical University, Xi’an, China, ²Unmanned System Research Institute, Northwestern Polytechnical University, Xi’an, China

A traffic big data analysis on relationships between urban planning and traffic noise level——taking Dongguan Demonstration Area, China as an example
Jiaxun Song¹, Qi Meng¹, Jian Kang²
¹Key Laboratory of Cold Region Urban and Rural Human Settlement Environment Science and Technology, Ministry of Industry and Information Technology, School of Architecture, Harbin Institute of Technology, 66 West Dazhi Street, Nan Gang District, Harbin, 150001, China, ²UCL Institute for Environmental Design and Engineering, The Bartlett, University College London, Central House, 14 Upper Woburn Place, London WC1H 0NN, United Kingdom

A time delay estimation approach with low computational complexity for speaker localization
Bangguo Song¹, Hongsen He¹, Tao Yang²
¹Southwest University of Science and Technology, No. 59, Middle Qingdong Road, Mianyang, China

An example of a digital engagement platform for large scale community engagement using auralization
Alex Southern¹, Brian Bulnes¹, Alan Oldfield¹
¹Aecom, Glasgow, United Kingdom
Traffic noise and children’s health: New insights from a machine learning algorithm?
Jan Spilski¹, Christoph Giehl¹, Hendriek Boshuizen², Albert Wong², Kirstin Bergström¹, Thomas Lachmann³, Maria Klatte¹
¹University of Kaiserslautern, Center for Cognitive Science, Kaiserslautern, Germany, ²RVIM, Rijksinstituut voor Volksgezondheid en Milieu, Bilthoven, Netherland, ³Facultad de Lenguas y Educación, Universidad Nebrija, Madrid, Spain

Prediction of turnout support deterioration through dynamic train-track interactions integrated with artificial intelligence
Jessada Sresakoolchai¹, Mehmet Hamarat¹, Sakdirat Kaewunruen¹
¹University of Birmingham, Edgbaston, Birmingham, B15 2TT, United Kingdom

Prediction of vibration transmission across finite double wall junctions using a hybrid diffuse-deterministic approach.
Wannes Stalmans¹, Cédric Van hoorickx, Edwin Reynders
²Ku Leuven, Kasteelpark Arenberg 40 Heverlee, Belgium

Influencing companies to purchase lower noise tool consumables?
Chris Steel¹, Antonia Hawker¹
¹HSE, Edinburgh, United Kingdom

Passive amplification of acoustic signals using surfaces with periodic roughness.
Alex Stronach¹
²RSK Acoustics, Manchester, United Kingdom

Acoustic Measurements and Psychoacoustic Analyses of Ventilation Diffusers
Lara Stürenburg¹, Philipp Ostmann², Lukas Aspöck¹, Dirk Müller², Janina Fels¹
¹Institute For Hearing Technology And Acoustics, RWTH Aachen University, Kopernikusstr. 5, 52074 Aachen, Germany, ²RWTH Aachen University, E.ON Energy Research Center, Institute for Energy Efficient Buildings and Indoor Climate, Mathieustraße 10, 52074 Aachen, Germany

A study on normal incident sound absorption characteristics of Japanese traditional cedar board, yakisugi
Akiko Sugahara¹, Kentaro Okamura¹, Yasuhiro Hiraguri¹, Noboru Yasui², Chihiro Kaku²
¹Kindai University, Higashiosaka, Japan, ²TEAM SAKURA, Shibuya, Japan

Subjective assessments of interference during cognitive tasks in noisy and silent working conditions
Helga Sukowski¹
¹Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (BAuA), Dortmund, Germany

Nanofluidic Attenuation of Metal-Organic Frameworks
Heting Xiao¹, Hebin Jiang¹, Haixia Yin¹, Yueting Sun¹
¹University of Birmingham, Birmingham, United Kingdom, ²Central South University, Changsha, P. R. China

Experimental vibro-acoustics transfer functions for the system with impact
Kumar Milind Rewanand Shripad³, Sriram Sundar³, Saurabh Sanjayrao Suryawanshi¹
¹Indian Institute Of Technology Tirupati, Tirupati, Andhrapradesh, India, Yerpedu, India

Enhancing the noise reduction capability of serrations using low-profile vortex generators
Shivam Sundeevol¹, Peng Zhou¹, Chuntai Zheng¹, Hanbo Jiang¹, Siyang Zhong¹, Xin Zhang¹,²
¹The Hong Kong University of Science and Technology, Clear Water Bay, Kowloon,, China, ²HKUST-Shenzhen Research Institute, Shenzhen, 518057, China
Low order modelling of thermoacoustic instabilities in aero-propulsion engines
Aswathy Surendran¹, Charles Boakes², Dong Yang³, Aimee Morgans⁴
¹Technical University of Munich, Garching, Germany, ²Imperial College London, London, United Kingdom, ³Southern University of Science and Technology, Shenzhen, China

Adapting a slit model to determine the aeroacoustic response of tube rows
Aswathy Surendran¹, Wei Na⁵, Charles Boakes³, Dong Yang⁴, Aimee Morgans⁴, Susann Boij⁵
¹Technical University of Munich, Garching, Germany, ²Chalmers University of Technology, Gothenburg, Sweden, ³Imperial College London, London, United Kingdom, ⁴Southern University of Science and Technology, Shenzhen, China, ⁵KTH Royal Institute of Technology, Stockholm, Sweden

Sound field reproduction based on Pressure Matching with transfer functions modeled by equivalent sources and image sources
Yukika Suzuki¹, Haruka Matsuhashi¹, Izumi Tsunokuni¹, Yusuke Ikeda¹
¹Tokyo Denki University, 5 senju-asahi-cho, adachi-ku, Japan

Modeling sound transmission through apertures with diffraction
Peter Svensson¹, Shahin Sohrabi
¹Acoustics group, Dept. of Electronic Systems, NTNU, NO-7491 Trondheim, Norway

Self-Determined Hearing Through Artificial Intelligence (AI)
Peggy Sylopp¹
¹pexlab.space, Berlin, Germany

The study of the acoustical properties of a 3D printed noise barrier
Grzegorz Szczepański¹, Marlena Podlesna¹, Krzysztof Lada¹
¹Central Institute For Labour Protection - National Research Institute, Czerniakowska, Poland

Basic study on the estimation method of burrows on the seafloor using ultrasound
Hajime Tachiki¹, Haruki Hirasawa¹, Takumi Asakura¹, Katsunori Mizuno², Koji Seike³
¹Tokyo University Of Science, 2641 Yamazaki, Noda-shi, Chiba Prefecture 278-8510, Japan, ²The University of Tokyo, 5-1-5 Kashiwa no ha, Kashiwa city, Chiba 277-8563, Japan, ³National Institute of Advanced Industrial Science and Technology (AIST), 1-1-1 Umezono, Tsukuba, Ibaraki 305-8560, Japan

Improved acoustics for semi-enclosed spaces in the proximity of residential buildings
Armin Taghipour¹, Arnthrudur Gisladottir², Francesco Aletta³, Matthias Bürgin³, Mohadeseh Rezaei¹, Ulrike Sturm⁴
¹Lucerne School Of Engineering And Architecture, The Lucerne University of Applied Sciences and Arts, Horw, Switzerland, ²Department of Civil and Architectural Engineering, Aarhus University, Aarhus, Denmark, ³UCL Institute for Environmental Design and Engineering, The Bartlett, University College London, London, UK, ⁴Lucerne School of Social Work, The Lucerne University of Applied Sciences and Arts, Lucerne, Switzerland

Parametric design of a modular acoustic panel for sound recording space versatility
Stavros Tagios¹, Luis Gomez - Agustina¹
¹London South Bank University, London, UK

Wake-adapted ducted propeller for full-scale generic underwater vehicle: parametric study on blade skew for unsteady propeller thrust
Kenshiro Takahashi¹, Chris Gargan-Shingles²
¹Naval Systems Research Centre, Acquisition, Technology &Logistics Agency, Meguro-ku, Japan, ²Maritime Division, Defence Science and Technology Group, Melbourne, Australia
Practical calibration method of airborne ultrasound measurement system by using acoustic calibrators
Hironobu Takahashi\(^1\), Koto Hirano\(^1\), Keisuke Yamada\(^1\)
\(^1\)National Institute of Advanced Industrial Science and Technology, Tsukuba, Ibaraki, Japan

Automating the assessment of sound power levels of running vehicles using information extracted from a static video camera
Marjorie Takai\(^1\), Miki Yonemura\(^1\), Hyojin Lee\(^2\), Shinichi Sakamoto\(^1\)
\(^1\)The University Of Tokyo, Tokyo, Japan, \(^2\)Seoul National University, Seoul, South Korea

Effect of spatial masking release on perception of vehicle’s approaching sound in headphone music listening
Reika Takakura\(^1\), Masanobu Miura\(^2\)
\(^1\)Graduate School of Music, Kunitachi College of Music, Kashiwa-cho 5-5-1, Tachikawa-shi, 190-8520, Japan, \(^2\)Faculty of Music, Kunitachi College of Music, Kashiwa-cho 5-5-1, Tachikawa-shi, 190-8520, Japan

The soundscape approach for people with dementia; using psychoacoustic parameters to select suitable sounds
Arezoo Talebzadeh\(^1\), Timothy Van Renterghem\(^1\), Pieter Thomas\(^1\), Paul Devos\(^1\), Dick Botteldooren\(^1\)
\(^1\)Ghent University, Ghent, Belgium

ERP components analysis of selective attention to auditory signals in meaningful or meaningless noise using adaptive correlation filter.
Takahiro Tamesue\(^1\)
\(^1\)Yamaguchi University, Ube, Japan

Active nonreciprocal structural control on a flexible plate
Joe Tan\(^1\), Jordan Cheer\(^1\), Steve Daley\(^1\)
\(^1\)ISVR, University of Southampton, Southampton, United Kingdom

Optimizing the performance of a side-branch array duct muffler
Shiu Tang\(^1\), Ho Yu\(^2\)
\(^1\)The University Of Hull, Hull, United Kingdom, \(^2\)The Hong Kong Polytechnic University, Hong Kong, China

High-speed optical imaging and spatio-temporal analysis of sound sources of edge tone phenomena
Risako Tanigawa\(^1\), Kohei Yatabe\(^2\), Yasuhiro Oikawa\(^2\)
\(^1\)Panasonic Corporation, 1006, Oaza Kadoma, Kadoma-shi, Japan, \(^2\)Department of Intermedia Art and Science, Waseda University, 3-4-1 Ohkubo, Shinjuku-ku, Japan

EXPERIMENTAL AND NUMERICAL MODAL ANALYSIS OF THE TURKISH TRADITIONAL INSTRUMENT ‘BENDIR’
Ugur Tatlier\(^1\), Sinem Ozturk\(^1\), Nursah Oner\(^1\), Sevinc Aycan Yetim\(^1\)
\(^1\)Istanbul Technical University, Istanbul, Turkey

Quantification of coin falling sound quality of coin processing machine
Motoki Terada\(^1\)
\(^1\)Osaka Institute Of Technology, #501 Westpoint 1-7-16 Akagawa Asahi-ku, Osaka-shi, Osaka-fu, Japan

Construction of motional phase maps for granular dampers
Furkan Terzioglu\(^1\), Jem A. Rongong\(^2\), Charles E. Lord\(^1\)
\(^1\)The University of Sheffield, Department of Mechanical Engineering, Sheffield, United Kingdom

The WHO Environmental Noise Guidelines and noise policy in Denmark
Jens Schultz Thers\(^1\)
\(^1\)
Developing a holistic tranquillity assessment method from a soundscape design approach
Adam Thomas1, David Owen1, Sarah Drysdale1
1Arup, London, United Kingdom

The influence of model assumptions in a hybrid prediction tool for railway induced vibration
David Thompson1, Evangelos Ntotsios1, Pascal Bouvet2, Brice Nélain2, Andreas Nuber3, Bernd Fröhling3, Fakhreddin Seyfaddini4, Geertreui Herremans4, Pieter Reumers4, Geert Lombaert4, Geert Degrande4
1ISVR, University Of Southampton, Southampton, United Kingdom, 2Vibratec, Ecully, France, 3Wölfel Engineering, Höchberg, Germany, 4KU Leuven, Department of Civil Engineering, Leuven, Belgium

Study on railway curve squeal using a rigid-flexible coupling model of vehicle and track
Qiuyong Tian1, Yichang Zhou1, Thilo Hanisch1, Markus Hecht1
1Technische Universität Berlin, Chair of Rail Vehicles, Berlin, Germany

Speech enhancement for helicopter headsets with an integrated ANC-system for FPGA-platforms
Johannes Timmermann1, Florian Ernst1, Delf Sachau1
1Helmut-Schmidt-University / University of the Federal Armed Forces Hamburg, Hamburg, Germany

ERROR AND UNCERTAINTY IN NEAR-FIELD SOUND POWER ASSESSMENTS OF INDUSTRIAL SOURCES
Jon Tofts1
1Environment Agency (England), Taunton, United Kingdom

Reduction of transmitted impact sound of dry-type floating floor due to differences in impact force characteristics
Ryuta Tomita1
1Nihon University, Chiyoda-ku, Japan

Generation and Analysis of Artificial Warning Sounds for Electric Scooters
Antonio J Torija Martinez1, Andrew Elliott, Lara Harris, Zuzanna Podwinska, Connor Welham
1Acoustics Research Centre, University Of Salford, Manchester, United Kingdom

Evaluating the Specific Sound Level from Plant and Machinery in High Residual Sound Environments
Matt Torjussen1
1ANV Measurement Systems Ltd, Milton Keynes, United Kingdom

“You are on mute”: the impact of indoor soundscape on sexual well-being during the COVID-19 lockdown
Simone Torresin1,2, Eleanor Ratcliffe3, Francesco Aletta4, Rossano Albatici1, Francesco Babich2, Tin Oberman4, Jian Kang4
1Department of Civil Environmental and Mechanical Engineering, University of Trento, Trento, Italy, 2Institute for Renewable Energy, Eurac Research, Bolzano Bozen, Italy, 3School of Psychology, Faculty of Health and Medical Sciences, University of Surrey, Guildford, UK, 4UCL Institute for Environmental Design and Engineering, The Bartlett, University College London, London, UK

A recent feedback of wooden multi-storey buildings in France
Thomas Toulemonde1, Bertrand De Bastiani1
1ACOUSTB, Saint Martin d’Hères, France

Sound propagation and audibility of train horns
Martin Toward1, Mike Lower1, Marcus Wiseman1, David Thompson1, Paul Ferraby2
Why listening matters
David Trevor-jones1, Peter Rogers2
1Sustainable Acoustics, Basingstoke, United Kingdom, 2Sustainable Acoustics, Ovington, Alresford, United Kingdom

Protection of art gallery and museum collections from vibration
David Trevor-jones1, Martin McNulty2
1Sustainable Acoustics, Basingstoke, United Kingdom, 2Hoare Lea, Manchester, United Kingdom

Sensitivity of Input Parameter on CNOSSOS-EU Railway Emission Levels
Jonathan Phillips1, James Trow1, Simon Shilton2
1Noise Consultants Limited, Warrington, United Kingdom, 2Acustica Limited, Manchester, United Kingdom

Determining and quantifying effects of Favourable Propagation on CNOSSOS-EU Calculated Noise Levels
Davide Vinci1, Joshua Nunn1, James Trow1, Simon Shilton2
1Noise Consultants Limited, 6 Bankside, United Kingdom, 2Acustica Limited, Manchester, United Kingdom

Impact of Ground Cover Dataset Selection on CNOSSOS-EU Calculated Levels
Chris Youdale1, Simon Shilton2, James Trow1
1Noise Consultants Limited, Warrington, United Kingdom, 2Acustica Limited, Manchester, United Kingdom

Sensitivity of Input Parameter on CNOSSOS-EU Road Emission Levels
Jonathan Phillips1, Simon Shilton2, James Trow1
1Noise Consultants Limited, Warrington, United Kingdom, 2Acustica Limited, Manchester, United Kingdom

Automation of a National Noise Model
James Trow1, Magdalena Wilczek2, Katarzyna Fedyk3, Simon Shilton3, Hartmut Stapelfeldt4, Raymond Wong5
1Noise Consultants Limited, Warrington, United Kingdom, 2Mott MacDonald, Bristol, United Kingdom, 3Acustica Limited, Manchester, United Kingdom, 4Stapelfeldt Ingenieuresgesellschaft mbH, Dortmund, Germany, 5NGIS, Hong Kong, China

Simulating Changes in Aircraft Noise at Heathrow Airport during the 2020 Covid-19 Lockdown
James Trow1, Jonathan Phillips1, Davide Vinci2
1Noise Consultants Limited, Warrington, United Kingdom

Quantifying Carbon in Airspace Noise Management Measures
Pierangelo Di Stefano1, James Trow1, Davide Vinci2
1Noise Consultants Limited, Warrington, United Kingdom

Measurement of acoustic source data of taxiing aircraft for noise modelling
George Gibbs1
1Noise Consultants Limited, Warrington, United Kingdom

Study on an evaluation method of virus exposure risk by droplets focusing on a sound environment
Sohei Tsujimura1
1Graduate School of Science and Engineering, Ibaraki University, 4-12-1 Nakanarusawa, Hitachi, 316-8511, Japan

Environmental Noise Monitoring and Assessment of Petrochemical Plants
Scott Tunnah1
1Robin Mackenzie Partnership, Edinburgh Napier University, Edinburgh, United Kingdom
Noise Policy in a More Sustainable Future
Stephen Turner
1ST Acoustics, Ashtead, United Kingdom

Mixed Reality Visualization System for the 3D sound intensity using PAGE method and spatial interpolation
Ayame Uchida1, Yukiko Okawa1, Yusuke Ikeda1, Yasuhiro Oikawa2
1Tokyo Denki University, 5 Senju-Asahi-Cho, Adachi-ku, Japan, 2Waseda University, 3 Okubo, Shinjuku-ku, Japan

Sound source distribution of high-speed trains and reduction of aerodynamic bogie noise
Toki Uda1, Mariko Akutsu2
1Railway Technical Research Institute, 2-8-38, Kokubunji-shi, Japan, 2Railway Technical Research Institute, 2-8-38, Kokubunji-shi, Japan

An inter-laboratory study to quantify the repeatability, reproducibility, and bias of sound power measurement methods
Samuel Underwood1, Lily Wang1
1University Of Nebraska - Lincoln, United States

Development of a Reference Energy Mean Emission Level Traffic Noise Models for Bituminous Pavement for Mid-Sized Cities in India.
Saurabh Upadhyay1, Manoranjan Parida1, Brind Kumar2
1Indian Institute of Technology Roorkee, Roorkee, Haridwar, India, 2Indian Institute of Technology (BHU) Varanasi, Varanasi, India

Factor analysis of power seat noise using blocked force
Ryohei Usui1, Junji Yoshida, Yasuo Inose
1Osaka Institute of Technology, Osaka, Japan

Effect of Pitch Ratio of Tube Banks on Passive Acoustic Properties
Charitha Vaddamani1, Susann Boji1, Hans Boden1, Mikael Karlsson1
1KTH Royal Institute Of Technology, Stockholm, Sweden

Sound propagation for a low height impulsive source over an absorbing ground
Frits Van Der Eerden1, Frank Van Den Berg2, Ad Van Heijningen1
1TNO, The Hague, Netherlands

A new approach to generate diffuse sound pressure fields
Cédric Van hoorickx1, Edwin Reynders1
1KU Leuven, Leuven, Belgium

Frequency response function statistics of diffuse systems
Cédric Van hoorickx1, Edwin Reynders1
1KU Leuven, Leuven, Belgium

Energy transition related noise issues and its health consequences
Irene Van Kamp
1RIVM, Bilthoven, Netherlands
Annoyance and sleep disturbance due to vibrations from trains in the Netherlands: results from the second study “Living Alongside Railway Tracks”
Elise Van Kempen, Sendrick Simon, Harm van Wijnen, Arnaud Kok, Nick Mabjaia, Irene Van Kamp
1National Institute for Public Health and the Environment (RIVM), Antonie Van Leeuwenhoeklaan 9, Bilthoven, The Netherlands

A reduced-order cutFEM approach to model complex moving sound sources
Sjoerd van Ophem1,2, Wim Desmet1,2
1KU Leuven, Leuven, Belgium, 2Flanders Make, Leuven, Belgium

Turbulent scattering in upwardly refracting atmospheres: towards a practical approach
Timothy Van Renterghem1, Kirill Horoshenkov
1Ghent University, iGent building, Technologiepark 126, 9052 Zwijnaarde, Belgium

Urban advanced noise indicator mapping relying on street categorization and measurements
Timothy Van Renterghem1, Wout Van Hauwermeiren, Valentin Le Bescond, Luc Dekoninck, Dick Botteldooren
1Ghent University, iGent, Technologiepark 126, 9052 Zwijnaarde, Belgium

Nonlinear dynamical features of vortex-acoustic lock-on in a backward-facing step combustor
Joel Vasanth1, Satyanarayanan Chakravarthy1
1Indian Institute Of Technology Madras, Chennai, India

Experimental and numerical investigation of the narrow-band impact sound insulation of layered floors
Jasper Vastiau1, Cédric Van hoorickx1, Edwin Reynders1
1Ku Leuven, Kasteelpark Arenberg 40, box 2448, B-3001 Leuven, Belgium

Effect of Face Masks on Speech Intelligibility
Ruben Vazquez Amos1, James Green1, Stephen Dance1, Jerrin Thomas1, Havni Gohil1, Jacob Telford1, Peter Mapp1
1London South Bank University, London, United Kingdom

Emission and propagation of sound waves in porous media with active inner heat sources
Rodolfo Venegas1, Claude Boutin2, Gabriel Núñez1
1University Austral of Chile, Institute of Acoustics, Valdivia, Chile, 2ENTPE - Université de Lyon, Vaulx-en-Velin 69518, France

Optimizing noise exposure in the Vehicle Routing Problem: A case study of last-mile freight deliveries in Stockholm
Siddharth Venkataraman1,2, Sacha Baclet1,2, Romain Rumpler1,2
1KTH Royal Institute Of Technology, Stockholm, Sweden, 2The Centre for ECO2 Vehicle Design, Stockholm, Sweden

Acousto-optic sensing for near-field acoustic holography
Samuel A. Verburg1, Efren Fernandez-Grance2, Earl G. Williams2
1Technical University Of Denmark (DTU), Lyngby, Denmark, 2United States Naval Research Laboratory, Washington, DC, USA

LOWNOISEPAD: Low-cost noise control by optimized rail pad: Feasibility study on the use of rail pad as noise mitigation measure
Eduard Verhelst1, Pinar Yilmazer2, Jakob Oertl2, Guenter Dinhobi4
1SD&M, La Borderie, 87120 Domps, France, 2SBB, Bern, Switzerland, 3UIC, Paris, France, 4ÖBB, Austria
Environmental noise and densification of cities – a paradox?
Ivonne Verstappen¹, Kjersti Espeland²
¹Norconsult AS, Vestfjordgaten 4, 1338 Sandvika, Norway, ²Statens vegvesen, Nygårdsgaten 112, 5008 Bergen, Norway

Long-term exposure to transportation noise and diabetes mortality: a national cohort study
Danielle Vienneau¹², Benedikt Wicki¹², Benjamin Flückiger¹², Beat Schäffer³, Jean-Marc Wunderli³, Martin Röösli¹²
¹Swiss Tropical and Public Health Institute, Basel, Switzerland, ²University of Basel, Basel, Switzerland, ³Empa, Swiss Federal Laboratories for Materials Science and Technology, Dübendorf, Switzerland

Why noise control must be considered in the context of sustainable development
Monica Waaranperä¹
¹Chalmers University of Technology, Gothenburg, Sweden

Habitats: Managing the Ecological Impacts of Noise on Wildlife Habitats for Sustainable Development
David Waddington¹, Mike Wood¹, Bill Davies¹, Rob Young¹
¹University Of Salford, Salford, M5 4WT, United Kingdom

Accelerometer Intensity Vector Sensor (AIVS) network for environmental noise monitoring with source location
Jim Waite¹
¹Nanotok LLC, Eastsound, United States

A Prewhitening Technique for Adaptive Active Noise Control Applications using Polynomial Matrix Spectral Factorization
yiming wang¹, Yongjie Zhuang², Yangfan Liu²
¹Ancsonic, Beijing, China, ²Ray W. Herrick Laboratories, School of Mechanical Engineering, Purdue University, West Lafayette, United States

A theoretical study on the interplay of thermoacoustic modes with Helmholtz dampers in a longitudinal combustor
Yichen Wang¹, Dong Yang², Min Zhu¹
¹Department of Energy and Power Engineering, Tsinghua University, Beijing, China, ²Department of Mechanics and Aerospace Engineering, Southern University of Science and Technology, Shenzhen, China

Tactics Implemented at the University of Nebraska – Lincoln for Growing Inclusive Excellence in Engineering
Lily Wang¹
¹University of Nebraska - Lincoln, Omaha, United States

Relationships between Acoustics, Thermal, Indoor Air Quality, and Lighting Conditions on Student Achievement in K-12 Classrooms
Lily Wang¹
¹University Of Nebraska - Lincoln, Omaha, United States

Experimental study of the Sound Absorption of Nylon Woven Fabric
Fang Wang¹, Zenong Cai¹, Xianhui Li¹, Xiaoling Gai¹, Tuo Xing¹
¹Beijing Key Laboratory of Environment Noise and Vibration, Institute of Urban Safety and Environmental Science, Beijing Academy of Science and Technology, Xicheng District, China
Monitoring of combustion oscillation by cascade extended state observer
Zhaohui Wang
1 Tsinghua University, Beijing, China

The use of a parametric array source and nearfield scanning in the characterisation of panel materials for underwater acoustics
Lian Wang1, Lian Wang1, Victor Humphrey1
1 NPL, Teddington, United Kingdom

Numerical analysis of acoustic noise from an electronic cooling fan at flow disturbed by an external obstacle
Sahan Wasala1, Lon Stevens2, Raye Sosseh3, Tim Persoons1
1 Trinity College Dublin, Dublin 2, Ireland, 2Seagate Technology, Longmont, USA, 3Seagate Technology, Minneapolis, USA

A Method for Separating Knocking Sounds from Engine Radiation Noise by Deep Learning
Hikaru Watabe1, Taro Kasahara1
1 Ono Sokki Co., Ltd., 3-9-3 Shin-yokohama, Kohoku-ku, Yokohama, 222-8507, Japan

Performance and acceptability of the TfL Urban Bus Sound (AVAS)
Eduardo Manzano1, Grant Waters1, Thomasin Stuart1
2 Anderson Acoustics, London, United Kingdom

Acoustic measures of biodiversity and human disturbance – a study in the UK Yorkshire Dales National Park
Greg Watts1
1 Centre for Sustainable Environments, University of Bradford, Bradford, United Kingdom

Usage of the 2.5D Boundary Element Method for the Detection of Moving Noise Sources
Holger Waubke1
1 Acoustics Research Institute, Austrian Academy of Sciences, Wohllebengasse 12-14, 1040 Vienna, Austria

Scaling of the simulated pass-by measurement based on the vehicle's acoustic centre
Yannik Weber1, Albert Albers1
1 Institute of Product Engineering at the Karlsruhe Institute of Technology, Karlsruhe, Deutschland

Optimization of a thermoacoustic system with adjoint-based sensitivity analysis
Jiasen Wei1, Jan Oscar Pralits1, Alessandro Bottaro1
1 University of Genoa, Department Of Civil, Chemical And Environmental Engineering (DICCA), Via Montallegro, 1, 16145 Genoa, Italy

MEMs Based Low-Cost Urban Noise Monitoring: Tests and Case Study
Paola Weitbrecht1, Carolina Monteiro1, Leonardo Jacomussi1, Marcel Borin1, Cecilia Jardim1
2 Harmonia, Avenida Mofarej 1200, Brazil

Low Frequency Noise – An inventory of literature and of the situation in the Netherlands
Kim White1, Anja Versteeg1, Arnaud Kok1, Ric van Poll1, Annelike Dusseldorp1
1 RIVM, Antonie van Leeuwenhoeklaan 9, 3721 MA, Bilthoven, Netherlands

New Zealand is actively improving school acoustics with government-led initiatives
James Whitlock1
1 Marshall Day Acoustics, Auckland, New Zealand
A novel method for measuring the airborne sound insulation of partitions
Gabriel Whittle¹, Daniel Wong-McSweeney, Joshua Meggitt, Andrew Elliott
¹University of Salford, Salford, United Kingdom

Parameter identification of two coupled oscillator model for pure intrinsic thermoacoustic instability
Roeland Wildemans¹, Viktor Kornilov¹, Philip de Goey¹, Ines Lopez-Arteaga¹,²
¹Eindhoven University Of Technology, Eindhoven, Netherlands, ²KTH Royal Institute of Technology, Stockholm, Sweden

High-resolution vibro-acoustic measurement and analysis of the DLR ISTAR aircraft to assess engine-induced cabin noise
René Winter¹
¹DLR - German Aerospace Center, Göttingen, Germany

First ideas for a revision of ISO 9614
Volker Wittstock¹, Spyros Brezas, Fabian Heisterkamp
¹Physikalisch-technische Bundesanstalt, Braunschweig, Germany

Deployment of an IoT System for Adaptive In-Situ Soundscape Augmentation
Trevor Wong¹, Karn N. Watcharasupat¹, Bhan Lam¹, Kenneth Ooi¹, Zhen Ting Ong¹, Furi Andi Karnapi¹, Woon Seng Gan¹, Samuel Yeong², Irene Lee²
¹School of Electrical and Electronic Engineering, Nanyang Technological University, Singapore, Singapore, ²Building & Research Institute, Housing & Development Board, Singapore, Singapore

A new voice for noise so it can be better understood
Sebastian Wschiansky¹
¹FOEN (Swiss Federal Office for the Environment), Worbentalstr 68, 3063 Ittigen, Switzerland

Study on regional road network planning based on time and noise integrated resistance function
Zhipeng Wu¹
¹Guangdong University of Technology, Guangzhou, China

Model test analysis of control effect of building foundation elastic pad on subway environmental vibration
Yubin Wu¹, Ruixiang Song¹, Yanan Wu¹, Lei He¹, Bideng Liu¹, Qiong Wu¹, Dan WU¹, Jing Zhang¹
¹Institute Of Urban Safety And Environmental Science, Beijing Academy Of Science And Technology, Beijing, China

Long-term evolution of noise annoyance depends on the type of transportation noise - what are the main drivers for the observed trends and their differences?
Jean Marc Wunderli¹, Mark Brink
¹Empa, Dübendorf, Switzerland

Design and validation of microperforated panel absorbers using Occam’s razor and causal inference
Ning Xiang¹, Cameron, J. Fackler¹, Michael Hoeft¹
¹Rensselaer Polytechnic Institute, 110 8th Street, Troy, New York 12180, United States

An experimental study of the spanwise coherence generated by porous coated cylinders in uniform flow
Zilun Xiang¹, Elias Arcondoulis¹, Reza Maryami¹, Yu Liu¹
¹Department of Mechanics and Aerospace Engineering, Southern University of Science and Technology, Shenzhen, People’s Republic of China

Sound environment of bedrooms in typical long-term care facilities in China
Mingxuan Xie¹, Zhixiao Deng¹
Acoustical design of large stadium buildings
Wei Xiong
South China University of Technology, Guangzhou, China

FDTD-Based Simulation and Analysis of Noise Reduction Effects in Hospital Wards
Yiquan Xu
School of Architecture, Southeast University China, Nanjing, China

Analysis of Spatial and Temporal Variation of Noise Level at Intersections of a Mid-Sized City in India
Adarsh Yadav
Indian Institute of Technology Roorkee, India, Indian Institute of Technology Roorkee, India, Indian Institute of Technology (BHU), Varanasi, India

Masking effect of sounds during treatment on dental drill sound
Tomomi Yamada
Osaka University, Osaka, Japan, Osaka University Dental Hospital, Osaka, Japan

Viewing the changes in community annoyance due to aircraft noise over the times
Ichiro Yamada
RION CO. Ltd., Tokyo, Japan

Appropriate usage of multi-layered OTPA to identify intensive measuring part among sequential parts
Ryusei Yanagita
Osaka Institute of Technology, Shome-16-1 Omiya, Asahi Ward, Japan

A prediction model of speech transmission index based on reverberation time in non-native linguistic context
Da Yang
Harbin Institute Of Technology, 66 No. 66 West Dazhi Street, Nan Gang District, Harbin, China, China

Study on the Optimal Strategy of Campus Concert Hall——Take the Concert Hall of Sun Yat-sen University as an Example
Chenxi Yang
South China University of Technology, Fuzhou, China

A Study on the Noise Optimization through the Analysis of Electric Vehicle Noise Paths
Yoon-Sang Yang
Daehan Solution Co., Ltd., Namdong-gu, South Korea

Influence of Structural Form on the Acoustic Black Hole Array Coupled with Damping Layers
Zhengcheng Yao
Beihang University, Beijing, China

Wave-based numerical investigation on diffraction correction for a low-height barrier in energy-based sound propagation model for road traffic noise
Yosuke Yasuda
Kanagawa University, Yokohama, Japan
Relationship between the shape of amplitude envelope and the hearing sensation of fluctuation on the simulated exhaust sound of motorbikes
Nozomiko Yasui
1
Saitama University, 255 Shimo-Okubo, Sakura-ku, Saitama City, Japan

Noise generated by a drum brake at various operating conditions
Akash Yella1, Aditya Chaudhary1, Ajay Bharinikala Yuva Venkat1, Sriram Sundar1
1Indian Institute of Technology Tirupati, Tirupati, India

Measurement of vibro-acoustic noise of drum brake under various contact conditions
Bharinikala Yuva Venkat Ajay, Aditya Chaudhary2, Akash Yella1, Sriram Sundar2
1Indian Institute of Technology Tirupati, Tirupati, India

Polynomial Chaos-Based Procedural Generation of Synthetic Training Data in Machine Learning for Automated Acoustic Monitoring
Ömer Yildiz, Sören Keuchel, Olgierd Zaleski, Peter Gross, Julian Storch, Matthias Weigold

A virtual reality tool to aid in soundscapes in the built environment (SiBE) through machine learning
Şemiha Yılmazer1, Patricia Davies1, Cengiz Yılmazer2
1Purdue University, Ray W Herrick Lab 177s Russell Street West Lafayette, United States, 2CSY R&D Architecture and Engineering, Cyberpark, Bilkent, Ankara, Turkey

Principle dimensions of perceptual attributes in indoor public spaces
Şemiha Yılmazer1, Volkan Acun1, Donya Dalirnaghadeh1, Ela Faslija1, Zekiye Şahin2, Elif Mercan2
1Purdue University, Ray W Herrick Lab, 177s Russell Street, West Lafayette, United States, 2Bilkent University, Department of Interior Architecture and Environmental Design, Ankara, Turkey

A Qualitative Approach to Explore Audio-Visual Interaction in a Hospital Environment
Şemiha Yılmazer1, Zeynep Uğurlu2
1Purdue University, Ray W Herrick Lab 177s Russell Street, United States, 2Bilkent University, Department of Interior Architecture and Environmental Design Ankara, Turkey

Suppression of quasiperiodic thermoacoustic oscillations via genetic programming
Bo Yin1, Yu Guan1, Stephane Redonnet1, Vikrant Gupta2, Larry K.B. Li3
1The Hong Kong University of Science and Technology, Sai Kung, Hong Kong, 2Southern University of Science and Technology, Shenzhen, China

Low-order network modelling of the effect of Helmholtz resonators on nonlinear thermoacoustic modes in annular combustors
Liming Yin1, Dong Yang1
1Southern University of Science and Technology, Shenzhen, China

Relationship between exposure and listening disturbance response due to transportation noise in Japan
Shigenori Yokoshima1, Makoto Morinaga2, Sohei Tsujimura3, M.S. Koji Shimoyama4, Takashi Morihara5, Takashi Yano6
1Kanagawa Environmental Research Center, Hiratsuka, Japan, 2Kanagawa University, Yokohama, Japan, 3Ibaraki University, Hitachi, Japan, 4Organization of Airport Facilitation, Minato, Japan, 5National Institute of Technology, Ishikawa College, Tsubata, Japan, 6Kumamoto University, Kumamoto, Japan
Study on the ground attenuation of engine run-up and APU noise for developing the airport noise model in Japan
Takatoshi Yokota¹, Koichi Makino¹, Toshiyasu Nakazawa², Masayuki Sugawara², Naoaki Shinohara², Kazuyuki Hanaka³
¹Kobayasi Institute of Physical Research, Tokyo, Japan, ²Aviation Environment Research Center, Organization of Airport Facilitation, Tokyo, Japan, ³Narita International Airport Promotion Foundation, Chiba, Japan

Occupational noise legislation in Asia-Pacific region
Sakae Yokoyama¹, Tomohiro Kobayashi¹
¹Kobayasi Institute of Physical Research, Kokubunji, Japan

Subjective evaluation of wind turbine noise using 3-dimensional audio-visual reproduction system
Miki Yonemura¹, Hyojin Lee², Shinichi Sakamoto³
¹The University of Tokyo, Komaba, Meguro-ku, Japan, ²Seoul National University, Gwanak-gu, South Korea, ³The University of Tokyo, Komaba, Meguro-ku, Japan

A study on the new PET composite sound-absorbing material applicable to automotive interior materials
Sukjun Yong¹, JangSeok Park¹
¹Daehan Solution, Incheon city, South Korea

Synergetic Effect of Vehicle Interior Sound and Design on Comfortability in Cabin
Junji Yoshida¹, Kanta Imamori¹
¹Osaka Institute of Technology, 5-16-1 Omiya, Asahi-ku, Osaka-shi, Japan

Psychophysiological responses to traffic noises in urban green spaces
Boya Yu¹, Yuying Chai
²Beijing Jiaotong University, Beijing, China

Numerical Analysis of the Flow-induced Whistling Noise of Ventilation Wall Based on Fluid-structure Coupling Method
Qingqing Yu¹, Fei Xue¹
¹School of Mechanical Engineering, Southeast University, Nanjing City, P.R. China, ²Nanjing Research Institute of Electronics Technology, Nanjing City, P.R. China

Dynamic Layout Optimization of Stiffeners in Plate Structures Based on Power Flow Response
Huan Yu¹, Xiaoyan Teng¹, Xudong Jiang²
¹Harbin Engineering University, Harbin, China, ²Harbin University of Science and Technology, Harbin, China

Acoustic monitoring to evaluate the effect of anthropogenic noise within a park
Giovanni Zambon¹, Andrea Potenza¹, Alessandro Bisceglie¹, Chiara Confalonieri, Claudia Canedoli¹, Emilio Padoa Schioppa¹, Roberto Benocci¹
¹Department of Earth and Environmental Sciences, University of Milano Bicocca, Piazza della Scienza 1, Milano, Italy

Deriving parameters for characterisation of the track quality in relation to environmental vibration
Hielke Zandberg¹, Agnes van Uitert, Arnold Koopman
²Prorail, Utrecht, Netherlands

Identification and Reduction of Interactional Noise of a Quadcopter in Hover and Forward Flight Conditions
Nikolas Zawodny¹, Nicole Pettingill³, Christopher Thurman¹
¹NASA Langley Research Center, Hampton, United States
Sell and Buy Quiet - life cycle score estimation using online searches for impact wrenches
Edward Zechmann
1NIOSH, Cincinnati, United States

Experimental acoustic testing of alternative ventilation ducts
Suzana Zekić1, Luis Gomez-Agustina2, Haydar Aygun2, Issa Chaer3
1Imtech Engineering Services, Twenty, Kingston Road, UK, 2London South Bank University, 103 Borough Road, UK, 3Imtech / London South Bank University, Twenty, Kingston Road / 103 Borough Road, UK

Comparison of Pure Tone Audiometry and Otoacoustic Emission based Hearing Assessment for Classical Music Students
Georgia Zepidou, Steve Dance
1London South Bank University, London, United Kingdom, 2AECOM Limited, London, United Kingdom

Numerical investigation of power flow input into a fuselage due to wing vibrations based on jet engine vibration loads
Sebastian Zettel1, René Winter1, Marco Norambuena1, Marc Böswald1
1DLR - German Aerospace Center, Göttingen, Germany

Vibration and acoustic radiation control of a panel with piezoelectric oscillators.
Yongyuan Zhang1
1The Institute Of Acoustics Of The Chinese Academy Of Sciences, Beijing, China

Programmable time-serial resonances for broadband spectrum matching
Yumin Zhang1, Keming Wu2, Lixi Huang2
1Foshan University, Nanhai District, Foshan, China, 2The University of Hong Kong, Hong Kong, China

Active control of interior road noise using the remote microphone technique
Zhe Zhang1, ChenLu Shi1, Xiao Lv1, ZiHong Ling1
1Catarc, Tianjin, China

Research on indoor noise evaluation and renovation design of university library——Taking the library of Wushan campus of South China University of Technology as an example
Yang Zhang1, Hongwei Wang1
1South China University Of Technology, Guangzhou, China, 2State Key Laboratory of Subtropical Building Science, Guangzhou, China

Acoustic analysis of coupled loudspeakers for low frequency duct noise reflection
Shang Li1, Xiaochen Zhao1, Xinyu Zhang1
1Harbin Engineering University, Harbin, China

Low frequency sound insulation of membrane-type acoustic metamaterials with negative pressure cavity
Tuo Xing, Xianhui Li, junjuan Zhao, Xiaoling Gai, Fang Wang, Xiwen Guan
1Institute Of Urban Safety And Environmental Science, Beijing Academy Of Science And Technology, Beijing, China

Acoustic performance of micro-cracked slit absorber
Congshuang Jiang, Xianhui Li, Weimin Xiao, Hongbin Su
1Institute Of Urban Safety And Environmental Science, Beijing Academy Of Science And Technology, Beijing, China

Dynamic analysis of negative stiffness noise absorber with magnet
Min Yang1, Weiming Xiao1, Erjing Han1, Junjuan Zhao1, Wenjiang Wang1, Yunan Liu1
Tunable acoustic analysis and prediction of membrane sound absorber with magnet
Junjuan Zhao¹, Yueyue Wang¹, Wenjiang Wang¹, Liying Zhu¹, Xianhui Li¹, Min Yang¹
¹Institute Of Urban Safety And Environmental Science, Beijing Academy Of Science And Technology, Beijing, China

The response of a conical flame to a dual-frequency excitation
jianyi Zheng¹, Lei Li², Guoqing Wang³, Liangliang Xu¹, Sirui Wang¹, Xi Xia¹, Fei Qi¹
¹Shanghai Jiao Tong University, Shanghai, China, ²Beihang University, Beijing, China, ³King Abdullah University of Science and Technology, Thuwal, Saudi Arabia

Broadband noise attenuation in the flow duct using metamaterial-based acoustic liners
Jingwen Guo¹, Renhao Qu¹, Yi Fang¹, Siyang Zhong¹, Xin Zhang¹
¹The Hong Kong University of Science and Technology, Hong Kong, China

Pulsed and Continuous Signal Enhancement Based on Improved Noise Power Spectrum Density Estimation in the Passive Underwater Acoustic Data
Yun Zhong¹, Qisong Wu¹
¹Key Laboratory Of Underwater Acoustic Signal Processing Of Ministry Of Education Southeast University, NanJing, China

Three-dimensional nonlinear thermoacoustic instability analysis based on Green’s function approach
Weipeng Zhou¹
¹Beihang University, Beijing, China

Time delay estimation via average magnitude differences among multiple microphone signals
Zhen Zhu, Hongsen He, Jingdong Chen

3D printed sound-absorbing materials with double porosity
Tomasz G. Zielinski³, Nicolas Dauchez², Thomas Boutin², Mikel Leturia², Alexandre Wilkinson², Fabien Chevillotte³, François-Xavier Bécot³, Rodolfo Venegas⁴
¹Institute of Fundamental Technological Research, Polish Academy of Sciences, Warsaw, Poland, ²Université de technologie de Compiègne, Compiègne, France, ³MATELYS Research Lab, Vaulx-en-Velin, France, ⁴University Austral of Chile, Valdivia, Chile

Reducing destructive interferences when synthesizing sound fields in the free field
Franz Zotter¹, Matthias Frank, Gregor-Johannes Müller, Julia Pinkas, Oliver Bayer
¹University Of Music And Performing Arts Graz, Graz, Austria

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Jason Nengsong Zou¹, wanghongwei hongwei wang
¹华南理工大学, 广州, China
List of Abstracts
Drone noise in my backyard: the challenges for public acceptability

Roalt Aalmoes¹, Marta Tojal Castro¹, Naomi Sieben¹, Rui Roosien¹
¹Netherlands Aerospace Centre NLR, Amsterdam, Netherlands

The introduction of drones in urban areas for surveillance, parcel delivery services, air taxis, or other services have raised the issue of public acceptability. How can this concept known as Urban Air Mobility (UAM) be successfully introduced in an area without upsetting communities? And how can not yet known benefits of these services be compared to feared drawbacks? Noise impact is already considered to be one of the main concerns for successful introduction of UAM, but focusing on noise levels exclusively may not be enough.

Based on recent research on noise annoyance and how it affects individuals and communities, a holistic approach, including noise impact, as well as non-acoustical factors, is presented to address the annoyance towards these disruptive air vehicles. Subjective measures should be considered including demographic factors, as well as perceptional factors, such as the visual environment where these vehicles operate, and emotional factors such as attitude towards drones and air taxis. Using this approach, studies on noise impact of UAM will be able to evaluate the use cases in their intended setting and with the appropriate target communities to assess the true impact and define the real challenges to overcome for noise research in the coming decade.

Link to paper
Burden of disease due to transportation noise in the Nordic countries – a NordSOUND study.

Gunn Marit Aasvang, Leo Stockfelt, Mette Sørensen, Anu Turunen, Nina Roswall, Tarja Yli-Tuomi, Mikael Ögren, Virpi Kollanus, Timo Lanki, Jenny Selander, Natalia Vincens, Andrei Pyko, Göran Pershagen, Gerhard Sulo, Anette Kocbach Bølling

1Norwegian Institute Of Public Health, Department of Environmental Health, Norway, 2Norwegian Institute of Public Health, Centre for Disease Burden, Norway, 3Occupational and Environmental Medicine, School of Public Health and Community Medicine, Institute of Medicine, Sahlgrenska Academy, University of Gothenburg, Gothenburg, Sweden, 4Department of Occupational and Environmental Medicine, Sahlgrenska University Hospital, Gothenburg, Sweden, 5Danish Cancer Society Research Center, Copenhagen, Denmark, 6National Institute for Health and Welfare, Finland, 7Institute of Environmental Medicine, Karolinska Institutet, Sweden, 8Center for Occupational and Environmental Medicine, Region Stockholm, Stockholm, Sweden

Environmental noise is of considerable public health concern, and quantification of the health impacts is important for preventive strategies. In this project we estimated the burden of disease due to road traffic and railway noise in four Nordic countries and their capital cities in terms of DALYs (Disability-Adjusted Life Years). Available data on noise exposure were used, including data from strategic noise mapping according to the Environmental Noise Directive, END (Directive 2002/49/EC). High degree of noise annoyance (HA), high degree of sleep disturbance (HSD) and ischemic heart disease (IHD) were included in the analyses based on exposure-response associations recommended by WHO. Country-specific estimates of IHD from the Global Burden of Disease (GBD) study were used. Since several aspects of the noise exposure modelling vary considerably between the Nordic countries, no comparable estimates could be made for the entire countries. For the capital cities comparable estimates ranged from 330 to 485 DALYs/100,000 for road traffic noise, and from 40 to 140 DALYs/100 000 for railway noise. High annoyance and high degree of sleep disturbance accounted for the largest part of DALYs for road traffic and railway noise, respectively. Further harmonization of noise exposure modelling is important for comparative disease burden assessment.
Experimental setup for laser vibrometry measurements of the vibrating horn in Ultrasonic Metal Welding

Elie Abi Raad¹, Florian W. Müller², Uwe Reisgen², Michael Vorländer¹

¹Institute for Hearing Technology and Acoustics, Aachen, Germany, ²Welding and Joining Institute, Aachen, Germany

Ultrasonic Metal Welding is a type of welding used in the production of electric car batteries. Currently, it suffers from quality fluctuations, and there is a need for online quality control techniques. One technique being investigated involves the measurement of the vibrations of the welding horn using laser vibrometry. However, this comes with two obstacles. First, measurements close to the welding site, which contain the most information, are difficult to do. This is due to the interference of particles ejected during welding, which interfere with the laser beam. Second, it is possible that the use of reflective tape for vibrometry changes the vibrations measured, due to heating of the horn during welding. This work investigates these problems and presents some solutions. The effects of the reflective tape on the measurement is investigated, by measuring the vibrations of the horn during welding and free run, with and without reflective tape, and with and without prior heating of the tape. Furthermore, the interference of ejected particles is minimized using a special experimental setup, and measurements are done without any reflecting tape.
Improving Accuracy of Airfoil Trailing Edge Noise Models with Turbulent Flow Anisotropy for Cambered Airfoil

Hussain Ali Abid¹, Annabel Markesteijn¹, Sergey Karabasov¹, Nick Zhang², Mahdi Azarpeyvand²

¹Queen Mary, University of London, Mile End Rd, Bethnal Green, London, United Kingdom, ²University of Bristol, Bristol, United Kingdom

In turbomachinery applications such as wind turbines, and aircraft airframe, flow-induced noise and vibration are significant noise sources. There are five main types of airfoil self-noise, with trailing edge noise (TEN) being the most dominant high-frequency broadband noise. The Amiet TE noise model is a low-order analytical model that requires the surface pressure (SP) near the trailing edge for TEN modelling. The accuracy with which the SP spectrum is calculated determines the accuracy of the TEN modelling. The SP spectrum is calculated using the physics-based TNO-Blake (TB) Model and its recently produced improved version. Most studies have focused on using the TB model for symmetric airfoil, with little attention paid to modelling the TEN of cambered airfoil. We use TB model variants on the SP spectrum prediction in this study, which are enforced with the Amiet TEN model for far-field noise modelling. The SP models' source comes from a high-fidelity Large-Eddy-Simulation simulation (LES) based on CABARET method. The simulation is carried out using the NACA65410 airfoil with a chord length of 0.3m and an angle of attack of 0, 2, 4, 6, and 8 degrees at a Reynolds number of 5.2e5. The SP spectrum and velocity spectrum used to improve the TEN model's accuracy for cambered airfoil.

Link to paper
Improved methods for source characterization on trains

Mats Åbom¹, Karl Bolin, Stefan Jacob
²KTH-The Marcus Wallenberg Laboratory, Stockholm, Sweden

One challenge for railway noise predictions is to characterize noise from various auxiliary equipment, e.g., fans, compressors, transformers. The noise from such sources can be a dominating contribution under low speed operation or stand still. To better handle this problem the EU-project TRANSIT investigates improved methods for acoustic source characterization. As a starting point it is assumed that an acoustic source is enclosed by a control surface. The surface is sub-divided into smaller areas and each area is assumed to act as an acoustic one-port coupled to all the other areas. The properties of each area can then be described by its volume flow and internal impedance. The resulting acoustic pressure at a receiving point, can finally be expressed as a product of the source volume flows and a matrix representing the acoustic installation effects (“source+radiation impedances”). To simplify the method one can assume uncorrelated source surfaces and use an ISO procedure for sound power to determine the volume flows. The acoustic installation effects can be obtained using a monopole point source to measure or calculate the pressure at selected receiving positions. This simplified method has been validated under controlled laboratory conditions and tested on real equipment on trains.

Link to paper

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Effects of a noise-induced audiometric notch on tinnitus distress

Emre Gurses¹, Esma Akis²
¹Hacettepe University, Ankara, Turkey, ²University of Southampton, Southampton, United Kingdom

Noise-induced hearing loss (NIHL) is a widely known occupational health problem. Two initial characteristics of NIHL are audiometric notch and tinnitus. Many studies focus on the relationship between NIHL and either audiometric notch or tinnitus, however an investigation on the link between audiometric notch and tinnitus is still missing. The objective of the current study is to evaluate tinnitus distress in individuals with noise-induced audiometric notch. A group of 11 individuals with a history of noise exposure and sensorineural hearing loss were included. Tinnitus mapping, including location, loudness, pitch and minimal masking level; residual inhibition (RI), tinnitus handicap inventory (THI), and Mini-Tinnitus Questionnaire (TQ 12-T) were performed. Audiometric notch was observed at 6 kHz, being in line with previous studies, in 46% of the participants. However, a significant number of participants (54%) had audiometric notch at 4 kHz. According to THI and TQ 12-T results, noise-induced audiometric notch was associated with moderate tinnitus distress. Additionally, tinnitus pitch was closely correlated to the notch frequency and easily inhibited by the sound.
Experimental observation of the sound field around a moving source using parallel phase-shifting interferometry

Mariko Akutsu¹, Toki Uda¹, Yasuhiro Oikawa², Kohei Yatabe²

¹Railway Technical Research Institute, Kokubunji-shi, Japan, ²Waseda University, Shinjyuku-ku, Japan

Railway noise is still one of the issues in the wayside environment despite of various countermeasures. For effective countermeasures, it is important to reveal characteristics of sound sources and sound propagation. Using parallel phase-shifting interferometry (PPSI) which measure the air density by interfering the reference light with object light, we tried to observe the sound field around a moving source. This system utilize laser and high-speed camera makes it possible to observe unsteady phenomena and visualize sound waves accurately. As a moving source, a speaker emitting 40kHz sinusoidal sound was mounted on a model, and the model was launched at 100 km/h.

As a result, we succeed in observing the sound waves generated from the moving source clearly and visualizing the frequency modulation by Doppler effect. Furthermore, the result was averaged in sub-pixel to understand easily. These results clearly show the difference in frequency depending on the relative position to the sound source as it is in theory.
The role of nozzle exit-lip surface roughness on jet noise

Jaswanth Kalyan Kumar Alapati¹, Srinivasan K²

¹Indian Institute of Technology Madras, Chennai, India, ²Indian Institute of Technology Madras, Chennai, India

This paper attempts to describe the jet noise sensitivity to the surroundings by considering the surface roughness of the nozzle exit lip. A thick lip convergent nozzle is used, and its lip surface roughness is altered by attaching sandpapers of various grades ranging from fine to coarse. Far-field acoustic measurements for different under-expansion levels are carried out by changing the nozzle pressure ratio from 1.5 to 6.5. The results are compared with that of the smooth lip nozzle. The jet noise (screech tone) varies with the surface roughness of the exit lip due to changes in the receptivity caused by the diffuse reflection of upstream acoustic waves by the lip. The screech tone is eliminated at higher pressure ratios with the coarse sheets, while screech amplitude is decreased for fine-grade ones.
What is a soundscape intervention? Exploring definitions and identification criteria and a platform to gather real-world examples

Cleopatra Moshona¹, Francesco Aletta², Helen Henze¹, Xiaochao Chen², Andrew Mitchell², Tin Oberman², Huan Tong², André Fiebig¹, Jian Kang², Brigitte Schulte-Fortkamp¹

¹Technische Universität Berlin, Berlin, Germany, ²University College London, London, United Kingdom

Possible definitions for the concept of “soundscape intervention” and criteria that could be used to identify stages in a design-oriented framework are discussed. This is in line with the Part 4 of the ISO 12913 series on soundscape being currently developed. The long-term goal is observing frequent/recurring situations or strategies that can be collated into design toolkits and formulate design briefs that local authorities will be using to communicate with soundscape consultants. For some time already, the soundscape concept has attracted attention from policy-makers and practitioners of the built environment, as it advocates for more engagement with local communities in design processes. This is reflected in several documents published by national and international agencies calling for consultation and participation of the public in the definition of soundscape interventions. However, this intended framework did not really make any significant breakthrough in the planning and design community, possibly for the lack of conspicuous empirical evidence (i.e., case studies and success stories) showing the benefits provided by the soundscape approach, and some lack of consensus about what a “soundscape intervention” is in the first place. Therefore, an online platform will be presented that can be used for data collection of soundscape intervention examples.
On the vibro-acoustic modeling of panels excited by diffuse acoustic field (DAF)

Yahya Allah Tavakoli¹, Catherine Marquis-Favre¹, Mohamed Ichchou², Nacer Hamzaoui³

¹Univ Lyon, ENTPE, LTDS UMR 5513, 3 rue Maurice Audin, 69518 Vaulx-en-Velin, Lyon, France, ²LTDS - CNRS UMR 5513, Vibroacoustics & Complex Media Research Group, Ecole Centrale de Lyon, Écully, 69134, Lyon, France, ³Laboratoire Vibrations Acoustique, Univ Lyon, INSA-Lyon, LVA EA677, Villeurbanne, F-69621, Lyon, France

Composite materials along with isotropic materials possess abundant applications to various engineering disciplines like aerospace and mechanical issues. The design optimization of composite materials such as sandwich panels essentially needs an accurate vibro-acoustic modeling. Such a modeling of these materials and a sound synthesis can lead to a design approach based on relevant psychoacoustic analyses. In this research, the mathematical/numerical and experimental steps required by the vibro-acoustic modeling of composite and isotropic plates excited by a diffuse acoustic field (DAF) are discussed. Herein, the analytical modeling was performed by 4th and 6th order problems adapted for the composite and isotropic plates, and moreover, the numerical modeling was carried out via the Finite Element Method (FEM). The experimental observations were also performed by means of an acoustic test cabin used for ideally generating a diffuse acoustic field (DAF). The various types of analytical and numerical simulations including synthesized sounds required by future psycho-acoustic analyses, as well as experimental observations including recorded sounds were investigated and compared. Finally, based on the various analyses, the research illustrates how such investigations and comparisons are necessary for designing and enhancing the mechanical and vibro-acoustic properties of materials.

[Link to paper]
Analysis of high frequency noise sources on air conditioning variable speed compressors

Vitor Almeida¹, Gabriel Dei Agnoli¹, Osmar Pinheiro¹, Felipe Feitosa¹
¹Tecumseh do Brasil LTDA, Sao Carlos, Brazil

The improvement on energy consumption requires application of new technologies in existing products. On the past decades, optimization of power consumption on variable speed rotary compressors for air conditioning applications was achieved by replacing induction motors to brushless DC (BLDC) motors driven by a frequency inverter. Besides the positive behavior of the motor type change on compressor efficiency, acoustic problems on the compressor became more complex. This article makes a revision of the main noise generation mechanism by BLDC motors of an air conditioning compressor via numerical finite element and experimental analysis aiming a noise reduction on a tonal component around 8 kHz band. Results indicate harmonic components on the forces exciting some specific resonance frequencies of the stator. The harmonic components show up in the force signals via pulse width modulation of the inverter electronic controller. The structure-born noise is radiated through the compressor shell. Among the possibilities to mitigate the noise issues, it was chosen to optimize the electronic control reduced the excitation levels of the stator and the tonal component of 8 kHz band in about 10 dB improving the sound quality of the compressor.
Strategic distribution of resonators’ parameters for broadband vibration mitigation

Felipe Alves Pires\textsuperscript{1}, Regis Boukadia\textsuperscript{1}, Elke Deckers\textsuperscript{1}, Wim Desmet\textsuperscript{1}, Claus Claeys\textsuperscript{1}

\textsuperscript{2}KU Leuven / Flanders Make, Leuven, Belgium

Locally resonant metamaterials have recently come to the fore as novel lightweight and compact Noise, Vibrations and Harshness (NVH) solutions. They can be designed/obtained by assembling nominally equal resonant elements, which are tuned to the desired frequency range, onto a host structure in a sub-wavelength manner. This combination leads to tunable frequency ranges, known as stop bands i.e. frequency regions where free wave propagation is not allowed. Nonetheless, these stop bands are typically only effective in a limited frequency region. In order to broaden the frequency range of noise and vibration reduction, an optimization procedure could be applied in order to obtain the ideal distribution of resonance frequencies and masses to achieve a minimal sound radiation over a certain frequency region. However, this approach typically requires a considerable computational time. For this reason, this paper proposes a set of guidelines that define a strategy for broadband NVH reduction without the use of optimization. The proposed strategy is applied to a finite plate with a predefined added grid for the resonator positions. The performance of the strategy is numerically analyzed by assessing the vibration response of the plate for multiple excitation locations and within different frequency ranges. The obtained responses are then compared to the response of the plate with an optimized grid of resonators. This study shows that the proposed strategy leads to a reasonable vibration reduction with similar levels with respect to the response obtained from optimization.

[Link to paper]
Technical aspects of physical implementation of an active noise control system: challenges and opportunities

Maja Anachkova¹, Simona Domazetovska, Zlatko Petreski, Viktor Gavriloski

¹Faculty Of Mechanical Engineering, Skopje, Macedonia

Active noise control systems have become a subject of intensive worldwide research that have aroused considerable interest as being a promising solution to the problem of low-frequency noise control. Advanced real-time signal processing technologies offer opportunities that have been adopted in many active noise control industry applications, as well as in the modern urban environment where noise reduction is gaining priority status. Depending on the application, the concept of active sound control can be implemented using different control strategies. The development and application of such systems requires in-depth knowledge and theoretical analysis in the field of digital signal processing, sensor technology, adaptive control, understanding in hardware solutions for acquisition and data processing, as well as software capabilities for modeling, visualization and control of signals. Also, the construction of such a system must give an overview of the choice and characteristics of its components in terms of the impact of the elements that make it up on its accomplishment. This paper provides an insight into the engineering aspects for implementation of an active noise control system in a duct, emphasizing all technical requirements that need to be analyzed and might further affect the systems overall performance.

Link to paper
Beyond Standards: In Search of Heterogeneous Approaches to Sound in the Design and Planning of the Public Realm

Sven Anderson¹
²Theatrum Mundi, London, United Kingdom

The public realm constitutes the integral connective tissue that defines the contemporary cityscape, within which different individuals, communities and institutions engage with each other through cooperation and negotiation. Sound remains a neglected dimension of this domain, generally coming into consideration only through efforts to ameliorate the urban soundscape and to attend to the impact of environmental noise. As the densification of urban territories continues, the role of sonic experience as a more critical and complex driver for urban design must be reassessed. The project Sound-Frameworks: Collaborative Frameworks for Integrating Sound Within Urban Design and Planning Processes (EC grant agreement ID 101032632) explores new methodologies to accelerate this area of research through the production of three resources: A sound in practice survey, a publication on guidelines for best practice and an online tool to guide the integration of sound in the design of the public realm. This paper discloses the project’s initial trajectory and intersectoral objectives. It explores how the synthesis of heterogeneous approaches to working with and thinking through sound can be informed by perspectives developed through environmental acoustics, architecture, spatial planning, sound studies and artistic practice.
A model of the rotating rigid wheelset and its influence on the wheel and track rolling noise

Víctor T Andrés¹, José Martínez-Casas¹, Francisco D Denia¹, Giacomo Squicciarini², David J Thompson²

¹Instituto de Ingeniería Mecánica y Biomecánica, Universitat Politècnica de València, Camino de Vera, s/n, 46022, Valencia, Spain, ²Institute of Sound and Vibration Research, University of Southampton, Southampton SO17 1BJ, United Kingdom

The dynamic and acoustic behaviour of the railway wheel is defined by its numerous vibration modes and natural frequencies. The modes whose contribution to the rolling noise radiation are predominant generally have 2 or more nodal diameters and appear above 2 kHz. The vibration due to these modes is decoupled from the rest of the wheelset, allowing the wheel to be treated separately. The error produced in the wheel noise prediction by this treatment appears at the low and medium frequencies and is negligible since the wheel emission occurs mainly at the high frequency range. However, given the dynamic coupling between the wheel and track, the changes in the dynamics of the former affect the latter, whose radiation is predominantly in the low and medium frequency range. Therefore, in order to correctly study both elements, it is necessary to include the contribution of the rest of the wheelset in the wheel response. In this work, this contribution is introduced through an analytical approach considering the rigid body motion of the wheelset and a benchmarking against an equivalent numerical formulation is carried out for validation purposes. In addition, the inertial effects associated with the rotation under straight circulation conditions are considered.

[Link to paper]
The challenging measurement of acoustic effect of road surface on truck tyre noise by standard close proximity method

Joël Lelong¹, Fabienne Anfosso Lédée¹
¹Université Gustave Eiffel, Bron, France

The CPX method is an efficient tool for assessing and comparing road surface acoustic properties. For heavy trucks, the standard method ISO 11819-2 requires that noise measurements are also performed with a "pick-up" type of tyre with noise emission characteristics of heavy goods vehicles, and proposes the tyre "H1". However this tyre does not comply with European regulations since November 2016. The objective of this experiment is to test the Standard Reference Test Tyre SRTT-C2 for light trucks as a replacement. To this end, our CPX trailer was adapted to the large size of the test tyre. Then, the relevance of the SRTT-C2 to characterize road surfaces acoustically has been demonstrated in previous papers. The current paper presents a complementary study of the representativeness of this tyre, by comparing spectral effect on different pavements between CPX measurements with the SRTT-C2 tyre and SPB measurements of real trucks in the traffic. Combined SPB and CPX measurements were performed on three road sites, completed by CPB measurements to characterize the transfer function SPB/CPX. The results show that the SRTT-C2 tyre has a different spectral behaviour from that of heavy trucks (regardless of the number of axles) particularly in low frequencies.

Link to paper
Thermoacoustic instabilities in the presence of colored noise

Sadaf Arabi\textsuperscript{1}, Maria Heckl\textsuperscript{2}

\textsuperscript{1}Keele University, Newcastle Under Lyme, United Kingdom, \textsuperscript{2}Keele University, Newcastle Under Lyme, United Kingdom

In this paper, we take advantage of using a Green’s function approach as an analytical tool to study linear and nonlinear aspects of thermoacoustic systems. Green’s function is defined as the impulse response of a system, it has a clear physical meaning in combustion systems, and it provides a fast and flexible tool to predict thermoacoustic instabilities in both time and frequency domains. In this study, we consider a Rijke tube, which houses two sources: a heat source and an external noise source. The heat source is modelled by an amplitude-dependent $nt$-law, the noise source is assumed to emit two types of noise (pink noise or white noise). We use the Green’s function approach to derive an integral equation for the acoustic field in the Rijke tube, and we also derive an algebraic equation for the thermoacoustic eigenfrequency. Both equations are validated. The results that we found, show that the presence of noise (whether pink or white noise) results in “triggering” an instability and in accelerating the growth of the amplitude. These effects become more pronounced as the level of noise increases. The influence of pink noise is stronger than that of white noise. We also studied how the hysteresis behavior (a nonlinear effect in dynamical systems) is affected by the noise, using the heat source position and heater power as bifurcation parameters. Our study reveals that the width of the bistable region decreases as the strength of noise increases.
VIBWAY: A user-friendly computational for the prediction of railway-induced ground-borne vibration and noise

Robert Arcos¹, Kenny Fernando Conto Quispe¹, Hassan Liravi¹, Arnau Clot¹, Jordi Romeu¹

¹Universitat Politècnica de Catalunya, Carrer Colom, 11 08222 Terrassa (barcelona), Spain

This paper aims to introduce a computationally efficient and user-friendly toolbox, called VIBWAY, able to predict vibration and re-radiated noise levels in two situations. On the one hand, it can predict levels in existing buildings due to new lines or after the application of mitigation measures in existing ones. Thus, it can be used to assess the performance of vibration countermeasures applied at the track, vehicle and/or the building. On the other hand, it can predict levels in new buildings to be constructed close to an existing railway line. The VIBWAY toolbox is based on a non-interface 2.5D FEM-SBM approach for the wave propagation on the soil, on semi-analytical approaches for the track and the building and on multibody modelling of the train vehicle.
Assessment of hearing loss risk due to impact noise in industrial environments

Jorge Arenas¹, Jorge Cardenas¹, Christian Robertson¹, Jose L. Urnia²
¹University Austral of Chile, Valdivia, Chile, ²Asociacion Chilena de Seguridad, Santiago, Chile

Impact noises are often found in industrial environments and they are predominant in mining, construction, factories, workshops, and shipyards. It is well-known that impact noises are more likely to cause noise-induced hearing loss than continuous noise of equal energy. Impulse noises are characterized by their high intensity over a short period of time and many countries have defined impulse noise exposure limits and criteria in occupational settings. They are based on the sound level measurements made using standard sound pressure level meters and dosimeters. However, because of their metrological limitations, it is not appropriate to use these instruments when dealing with such high peak levels and short duration times. Extensive research on hearing damage produced by impulse noise generated by firearms has been presented, mainly on police and military personnel. These studies have led to damage risk criteria contained in various versions of the standard MIL-STD-1474. Although industrial noises can reach similar peak sound pressure levels, not many results have been published on the subject. In this work, several common sources of industrial impact noise were measured in-situ, at the worker locations, using a specialized system equipped with high-dynamic-range microphones and a very high data acquisition rate. The signals were post-processed to obtain the main metrics defined for impulse noise exposure assessment. Then, occupational hearing loss risk was estimated using different criteria. It is shown that many common industrial processes reported a very high risk of impulsive noise to human hearing.
ENVIRONMENTAL NOISE ANNOYANCE TRENDS IN SELECTED LOCATIONS IN BRATISLAVA

Lubica Argalasova¹, Alexandra Filova¹, Katarina Hirosova¹, Martin Samohyl¹, Jana Babjakova¹, Lenka Matejakova¹, Jana Jurkovicova¹

¹Comenius University, Faculty of Medicine, Institute of Hygiene, Bratislava, Slovakia

The rapid development in traffic density and the economic transformation since 1989 has brought new problems concerning road traffic noise in Slovakia. The aim is to follow the time trends of noise annoyance in monitored localities in Bratislava at time intervals of 10, 20, and 30 years. We used the validated methodology for subjective assessment of noise annoyance in young and healthy individuals, as well as a method of objectification by direct measurement of sound levels. Respondents (n=3,465) were university students, living in the exposed and control dormitories representing a homogenous sample. The sharp increase in traffic noise burden in the exposed area was found at the first 10-year interval (LAeq=67.5 dB). A slight decrease occurred after 2014, and in 2019 up to LAeq=63.9 dB. A sharp increase in road traffic noise annoyance was observed in the first 10-year interval (ORMH=2.56 (95% CI=1.93–3.42) vs 6.01 (95% CI=4.97–7.95) with a slightly decreasing trend in 2019. An increase in noise annoyance from entertainment facilities was observed as well. Despite a slightly declining trend, road traffic noise annoyance is still an important issue and there is a need for preventive measures to reduce such exposure in residential areas.

Link to paper
Fluid-Structure Interactions and Aeroacoustic coupling of Airfoil with Flexible Membrane(s)

Muhammad Irsalan Arif¹, Randolph Chi Kin Leung¹, Garret Lam¹, Muhammad Rehan Naseer¹

¹The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong

In this paper, fluid-structure interactions of a NACA 0012 airfoil mounted with short flexible membrane(s) and its coupling effect on airfoil aeroacoustics are presented. A time-domain direct aeroacoustic simulation coupled with structural dynamics is carried out at a low Reynolds number of 50,000 to explore the aeroacoustic-structural interactions. Two different airfoil configurations based on single and dual membranes are analyzed. The membrane deflections and their impact on the flow field are characterized in wavenumber-frequency domain to analyze the structural dynamics due to flow unsteadiness within the laminar boundary layer and the resulting acoustic waves emanating from the airfoil trailing edge. A strong correlation between the membrane displacement and downstream propagating flow is observed for all configurations whereas the correlation is considerably weakened between the membrane displacement and upstream acoustic waves which ultimately results in the airfoil self-noise reduction without affecting the airfoil aerodynamics. The extent of noise reduction for dual membrane airfoil configuration is observed to be considerably higher than the single membrane airfoil configuration which corresponds to a much lower correlation among the upstream propagating acoustic waves and membrane deflection for both the membranes and redistribution of upstream flow energy into different frequencies.

[Link to paper]
Numerical simulation of vibroacoustic damping by granular materials

Takumi Asakura

Tokyo University Of Science, 2641, Yamazaki, Noda-si, Chiba, Japan, Japan

Recently, many efforts related to vibration reduction of plate vibration using granular materials can be seen. In this paper, a simulation method of the damping effect of bending vibration of the plate by granular material combining following two kinds of methods was proposed. One is the discrete element method (DEM) which simulate the motion of the granular material. The other is the finite-difference time-domain (FDTD) method which simulate the vibration of the thin plate. By using this coupling method, influence of the granular material on the plate vibration was investigated. Validity of the proposed method was confirmed by comparison between the results of the calculation and the model experiment.
Differences between measured and simulated room impulse responses

Lukas Aspöck¹, Michael Vorländer¹
¹Institute for Hearing Technology and Acoustics, RWTH Aachen University, Aachen, Germany

Simulation models based on geometrical acoustics mostly do not immediately deliver a simulated room impulse response, but intermediate results such as an energy histogram or an energy decay curve. At this point, further models are required to generate a room impulse response of the simulated environment, which are essential for the process of auralization. While for various simulated scenarios, the application of a reflection model based on a basic theory is sufficient, detailed comparisons of simulated and measured room impulse responses reveal differences which are attributed to the lack of diffuse reflections in the applied reflection model. These deviations can also substantially affect derived room acoustic parameters. This work presents and explains the shortcomings and discusses potential improvements to be considered in the simulation process.

Link to paper
A basic protocol to characterize classroom acoustics of primary-schools

Arianna Astolfi¹, Greta Minelli¹, Giuseppina Emma Puglisi¹
¹Dipartimento Energia - Politecnico Di Torino, Corso Duca Degli Abruzzi 24, Italy

With the aim to promote a fast and effective characterization of the sound environment in educational facilities and an adequate classroom acoustics design, this work provides a basic measurement protocol which consists of a minimum number of parameters and positions to be considered. The present study involved 29 primary-school classrooms where background noise level during silent and group activities, reverberation time, speech clarity, useful-to-detrimental ratio and speech levels have been acquired in occupied condition along the main axis and in one or two offset positions. Two cut-off values of maximum reverberation time to ensure optimal acoustic conditions in the case of moderate and severe requirements, respectively, were assumed equal to 0.8 s and 0.6 s, according to literature and subjective data. For each cut-off value, classrooms were divided in two consistent groups either if they were compliant or non-compliant with such requirements, respectively. Given the strong correlation among the measured quantities, cut-off values were also identified for the other acoustical parameters. The main result of the work suggests that more convenient parameters, such as clarity in the central location of the classroom, can be used beyond reverberation time, which implies a more laborious measurement procedure.
Audio-frequency surface wave characteristics above porous and comb-like surfaces

Keith Attenborough, Shahram Taherzadeh

1Open University, Milton Keynes, United Kingdom, 2Open University, Leighton Buzzard, United Kingdom

Part of the solution for the sound field due to a point source in air over a porous boundary has the form of an airborne surface wave. Analytical expressions for the surface wave characteristics are reviewed and corresponding analytical expressions for group speed are obtained from a thin air layer approximation for the impedance of a comb-like surface, from two approximate models for the acoustical properties of porous media and from a model for identical slanted slit pores. Predictions of absorption coefficient spectra for a hard-backed porous layer with flow resistivity sufficiently low that there is extended reaction are made using two of the approximate models and compared with those of a relatively exact slanted slit pore model. The model derived specifically to predict the acoustical properties of porous asphalt is found to be the least satisfactory. The various models are used to obtain analytic expressions for the surface wave group speed. Predictions of surface wave characteristics including group velocity are compared with data obtained over arrays of parallel aluminium strips.

Link to paper
Non-linear behavior of the transfer impedance of a Micro-Slit-Plate

Alessia Aulitto¹, Avraham Hirschberg¹, Ines Lopez Arteaga¹

¹Eindhoven University Of Technology, Eindhoven, The Netherlands

The influence of the slit length and interactions between slits in a micro-slit plate (MSP) are investigated in the high amplitude regime. MSPs are plates with arrays of slit-shaped perforations, with width of the order of the acoustic viscous boundary layer thickness. The geometry discussed in this work is typical for fabrication by cutting and bending the plate, without removing material. Micro-slit plates designed with optimal acoustic properties in the linear regime will not be optimal when non-linear effects become significant resulting in vortex shedding. Impedance tube measurements of the transfer impedance on accurately manufactured micro-slit plates are compared to prediction by 2D incompressible Navier-Stokes model and to a quasi-steady theory. At moderately high amplitudes, the vortices remain close to the edges of the slit. The impedance of the plate is predicted within 20% by the model of a single isolated slit. At higher amplitudes, the vortices are traveling far away from the slit and a complex behavior. In this region, three-dimensional effects become important. For very high amplitudes, the vortices shed at neighboring slits start to interact, which affects the impedance.

Link to paper
Strategic Noise Mapping in France to 2023: Coupling a national database with the open-source model NoiseModelling

Pierre Aumond¹, Sophie Cariou², Olivier Chiello¹, David Ecotière¹, Adrien Le Bellec¹, Damien Maltete², Claire Marconot², Nicolas Fortin¹, Sylvain Palominos¹, Gwendall Petit¹, Judicaël Picaut¹

¹UMRAE, Université Gustave Eiffel, CEREMA, France, ²CEREMA/DTeclTM, Sourdun, France

The Environmental Noise Directive (END) requires the realization of strategic noise maps, every 5 years, in order to evaluate the noise impact of roads, railways, airports and the main industries on the inhabitants. To achieve round 4 for major roads and major railways, France has decided to create a national database called PlaMADE, which gathers all the necessary input data (traffic, building, population, relief...) in a unique format, a COVADIS GeoStandard. On the basis of these data, and using the open-source noise propagation calculation tool NoiseModelling, all the indicators and maps have been produced for the first time in an automatic way at a national scale. This paper presents the technical and methodological details of the coupling between the PlaMADE database and the NoiseModelling tool.

Link to paper
Optimisation of a Multi-Material Acoustic Black Hole

Beth Austin¹, Jordan Cheer²
¹University Of Southampton, Southampton, United Kingdom

Acoustic black holes (ABHs) have been proven as an effective passive vibration control measure. Typically, they are realised by introducing a geometric taper into the structure. This approach introduces thin structural sections which leaves the ABH prone to damage through fatigue. An alternative approach has been suggested in which the material properties vary within the structure, which can be realised through multi-material additive manufacturing. This allows the structure to maintain a constant thickness and this may reduce the effect of fatigue. Prior work has been performed to characterise the materials currently available that would be suitable for the ABH application. This paper investigates methods of optimising the design of the multi-material ABH, in order to minimise the reflection coefficient in a beam termination application.
The benefits of building information modelling in construction noise control in the pre-construction phase (a focus on urban area constructions)

Nasim Babazadeh1, Hans-Joachim Bargstädt1
1Bauhaus-Universität Weimar, Weimar, Germany

For inner-city construction activities, the propagated construction noise is considered the primary source of nuisance for the surrounding area. Due to the short distance between the site and neighboring buildings, passive noise control techniques such as noise barriers have a limited mitigating impact. As a result, construction companies should anticipate encountering complaints and lawsuits from residents of adjacent buildings, leading to project delays or cost overruns. Previous studies for construction noise control have primarily focused on a real-time solution such as data collection by sensors during the execution phase. Although the guidelines recommend that source management is the most effective method of controlling construction noise, there is no systematic approach for focusing on construction noise during the planning phase. Building Information Modeling (BIM) has been widely used to achieve effective project management, such as time and cost control. However, the benefits of BIM for noise-considered time planning in the pre-construction phase still need to be exploited. This research will focus on the potential of BIM for addressing construction noise as an additional factor during time planning. The findings show how multiple process plans using BIM-supported platforms can be planned and controlled to achieve the lowest risk of discomfort for neighboring area residents.

Link to paper
Acoustic emission at the wheel-rail contact with micro-slip and stick-slip

Laura Mariana Babici¹, Andrei Tudor², Jordi Romeu Garbi¹
¹Polytechnic University of Catalonia (UPC), Terrassa, Barcelona, Spain, ²University POLITEHNICA of Bucharest, Bucharest, Romania

The paper aims to analyse the occurrence of acoustic emission at the wheel-rail contact during micro-slip. The experimental model allows the contact pressure variation (MPa..GPa) and the sliding speed (0.01 to 0.5 mm/s) specific to the wheel-rail contact. It is determined experimentally and theoretically the appearance of the stick-slip phenomenon at the Hertzian contact of cylinder type (fixed-wheel specimen) - plane (mobile with very low speed - rail specimen). The experimental stand simultaneously measures the normal force, the friction force and the acoustic emission at different contact pressures, sliding speeds and rigidities of the wheel specimen fixing system. The specimens are made of UIC standard materials used in the driving wheels and rails.

The stick-slip phenomenon occurs at low micro-slip speeds and normal bending stiffness. Experimentally, it is found that the jumps specific to the stick-slip phenomenon (friction coefficient-COF) are accompanied by the acoustic emission (AE) at the cylinder-plane interface. The energy emitted by AE (WAE) is correlated with the energy consumed by friction during the stick-slip period (WCOF).

The theoretical model regarding the stick-slip phenomenon of the Hertzian contact with slip specific to the experimental stand allows the analysis of the stability of the stick-slip movement.
A machine learning- and compressed sensing-based approach for surrogate modelling in environmental acoustics: towards fast evaluation of building façade road traffic noise levels

Sacha Baclet\textsuperscript{1,2,3}, Siddharth Venkataraman\textsuperscript{1,2,3}, Erik Gomez\textsuperscript{1,3}, Hamza Bouchouireb\textsuperscript{2,3}

\textsuperscript{1}The ECO2 Center for Vehicle Design, KTH Royal Institute Of Technology, Stockholm, Sweden, \textsuperscript{2}The Marcus Wallenberg Laboratory for Sound and Vibration Research, KTH Royal Institute of Technology, Stockholm, Sweden, \textsuperscript{3}Department of Engineering Mechanics, KTH Royal Institute of Technology, Stockholm, Sweden

State-of-the-art urban road traffic noise propagation simulation methods such as the CNOSSOS-EU framework rely on ray tracing to estimate noise levels at specific locations on façades, so-called receiver points; this method is computationally expensive and its cost increases with the number of receiver points, which limits the spatial accuracy of such simulations in the context of real-time or near-real-time urban noise simulation applications.

This contribution aims to investigate the applicability of multiple data-driven methods to the surrogate modelling of traffic noise propagation for fast façade noise calculation as an alternative to these traditional, ray-tracing-based methods.

The proposed approach uses compressed sensing to select a small subset of receiver points from which the data set of the entire façade may be reconstructed, associated with a Kriging model and neural networks, used to predict noise levels for these sensors.

The prediction performance of each of these steps is evaluated on an academic test case, with two levels of complexity based on the dimensionality of the problem.
Sound insulation of lightweight wooden floor structures: ANN model and sensitivity analysis.

Mohamad Bader Eddin¹, Sylvain Ménard¹, Delphine Bard², Jean-Luc Kouyoumji³, Nikolaos-Georgios Vardaxis²

¹University of Quebec at Chicoutimi, 555 Bd De L'université, Chicoutimi, QC, Canada, ²Lund university, John Ericssons väg 3, 223 63 Lund, Sweden, ³Technological Institute FCBA, All. de Boutaut, 33000 Bordeaux, France

The artificial neural networks (ANN) approach is applied to estimate the acoustic performance for airborne and impact sound insulation curves of different lightweight wooden floors. The prediction model is developed based on 252 standardized laboratory measurement curves in one-third octave bands (50 - 5000 Hz). Physical and geometric characteristics of each floor structure (materials, thickness, density, dimensions, mass, and more) are utilized as network parameters. The predictive capability is satisfactory, and the model can estimate airborne sound better than impact sound cases especially in the middle frequency range (250 - 1000 Hz), while higher frequency bands often showed high errors. The forecast of the weighted airborne sound reduction index Rw was calculated with a maximum error of 2 dB. However, the error increased up to 5 dB in the worse case prediction of the weighted normalized impact sound pressure level Ln,w. A feature attribution analysis explored the essential parameters on estimation of sound insulation. The thickness of the insulation materials, the density of CLT material and the concrete floating floors and the total density of floor structures seem to affect estimations the most. A comparison between wet and dry floor solution systems indicated the importance of the upper part of floors to estimate airborne and impact sound in low frequencies.

Keywords: airborne sound, impact sound, insulation, prediction model, artificial neural networks

[Link to paper]
A comparison of numerical approaches to quantity sound insulation of lightweight wooden floor structures

Mohamad Bader Eddin¹, Jonathan M. Broyles², Sylvain Ménard¹, Delphine Bard³, Jean-Luc Kouyoumji⁴

¹University of Quebec at Chicotimi, 555 Bd De L’université, Chicoutimi, QC, Canada, ²The Pennsylvania State University, 104 Engineering Unit A, University Park, USA, ³Lund university, John Ericssons väg 3, 223 63 Lund, Sweden, ⁴Technological Institute FCBA, All. de Boutaut, 33000 Bordeaux, France

Quantifying air-borne and structure-borne sound insulation is an important design consideration for the indoor comfort of a building. Although sound insulation performance is commonly measured experimentally, numerical methods can have time-saving and economic benefits. Further, numerical methods can be incorporated within building simulations to provide an estimate of the acoustic environment. In response, this paper evaluates three different computational approaches for quantifying sound insulation in one-third octave bands (50-5000 Hz) of a lightweight floor including: an artificial neural network (ANN) model, an analytical (theoretical) model, and a finite element model (FEM). The three numerical methods are tested on the sound insulation of a cross laminated timber floor. The results of this study show that there are advantages for using each approach. The ANN model is able to accurately predict the sound insulation performance at high frequencies, but over-predicts the performance at low frequencies. Inversely, the analytical and FEM strategies provide closer estimates of low frequency sound insulation performance but overpredict the performance at high frequencies. While no model is able to accurately represent acoustic behavior across all frequencies, this work provides numerical approaches to quantify sound insulation performance.

Keywords: sound insulation, artificial neural networks, building acoustics, numerical analysis, floor structures

Link to paper
An audio-based vehicle classifier using convolutional neural network

Ekim Bakirci, Haydar Aygun
1London South Bank University, School of the Built Environment and Architecture, London, UK

Audio-based event and scene classification are getting more attention in recent years. Many examples of environmental noise detection, vehicle classification, and soundscape analysis are developed using state of art deep learning techniques.

The major noise source in urban and rural areas is traffic noise. Environmental noise parameters for urban and rural small roads have not been investigated due to some practical reasons. The purpose of this study is to develop an audio-based traffic classifier for rural and urban small roads which have limited or no traffic flow data to supply values for noise mapping and other noise metrics.

To develop an audio-based vehicle classifier a convolutional neural network-based algorithm was proposed using Mel spectrogram of audio signals as an input feature.

Different variations of the network were generated by changing the parameters of the convolutional layers and the length of the network. Filter size, number of filters were tested with a dataset prepared with various real-life traffic records and audio extracts from traffic videos. The precision of the networks was evaluated with the common performance metrics. Further assessments were conducted with longer audio files and predictions of the system compared with actual traffic flow.

The results showed that convolutional neural networks can be used to classify road traffic noise sources and perform outstandingly for single or double-lane roads.
Prediction of Far-Field Sound Radiation Using Blocked Pressures and Reciprocally Measured Vibro-acoustic Frequency Response Functions

Lucy Barton

University Of Salford, Salford, United Kingdom

In industry, the use of blocked forces for the characterisation of structure borne sound sources is now common practice, whereas the sound power is typically used for airborne sound sources. In principle, it should also be possible to use blocked forces (or blocked pressures) to predict airborne sound radiation using a similar approach and measurement methodology as the in-situ blocked force method. This is achieved by discretising the surface of the source into small unit cells, and measuring the vibration velocity whilst operational. In order to convert these velocities to blocked forces, the mobility of the source for each of the positions must also be known: and to predict the radiated sound, a measured vibro-acoustic frequency response function is also required. Typically vibro-acoustic FRFs are measured by exciting the structure with an instrumented hammer or shaker, but they may also be measured reciprocally using a volume velocity source. Described in the paper is an experiment conducted in a fully anechoic chamber to investigate the feasibility of the above approach, i.e. using blocked pressure and reciprocally measured vibro-acoustic FRFs to characterise and predict airborne sound. The method is validated by comparing the directly measured radiated sound pressure to that which is predicted according to the above.
Developing an American (ANSI) Standard for the Prediction of Wind Turbine Sound Levels

Mark Bastasch¹

¹Jacobs, 2020 SW 4th Ave, 4th Floor, Portland, OR 97201, United States

Common modeling methods used in the United States yield relatively similar results given sound power level from IEC 61400-11 and propagation consistent with ISO 9613-2 are typically utilized. Nonetheless, standardization of predictions is anticipated to result in a robust and repeatable process that increases regulatory confidence and understanding. American Clean Power (ACP) is recognized by the American National Standards Institute (ANSI) as an Accredited Standards Developer. A wind turbine sound modeling standard working group was established and reached consensus on a preferred method of predicting project sound levels during the siting and permitting process. The goal of this standard is to establish uniform method of predicting future projects sound levels such that pre-development sound assessment results or predictions used in research can be readily compared.

Link to paper
Strategic Modelling of Industrial Noise with Limited Input Data

Chris Skinner¹, Seckin Basturk¹, Hilary Notley²
¹AECOM, Nottingham, United Kingdom, ²Defra, London, United Kingdom

Historically, strategic modelling of industrial noise exposure on a national scale has taken a wide range of approaches. Where sound emission data of industrial sites are not available, numerous assumptions are often made. These include simplified modelling of industrial sites and adoption of generic sound power levels for different industry types. In most cases such assumptions significantly increase the uncertainty in strategic noise mapping outcomes.

This paper presents an alternative approach to strategic modelling of industrial sound which is based on the environmental permitting practice of large industrial sites in England. Drawing on this approach, a cost-effective and scalable modelling procedure has been developed to estimate sound emission levels and radiation patterns of industrial activities accounting for the local context of the site. This paper details the alternative modelling approach along with example prediction outputs. Potential future refinements to improve the modelling accuracy and opportunities to enhance site-specific input data in collaboration with national authorities are also discussed.
Acoustic assessment of an open-plan office environment against the newly published ISO 22955 acoustic parameters

Michel Batista¹
¹Subsonic Designs, 1383 Winged Foot Place, Copperleaf, Centurion, South Africa

This paper aims to assess the acoustic performance of an existing open-plan office environment with suspended sound absorbers below a hard reflective ceiling and low workstation dividers against the newly published ISO 22955 acoustic parameters. The room acoustic variables, such as sound absorption, screens between workstations, speech masking sounds and room dimensions all interact in a complex way affecting the values of single-number quantities presented in the ISO 22955 standard. In order to determine the in-situ performance, acoustic measurements were carried out on site. Odeon room acoustic prediction software was utilised to assess the efficiency of various acoustical remedies such as free hanging sound absorbers, wall to wall sound absorbing ceilings, dividers between work areas and increased height of dividers between workstations. The results from the in-situ room acoustic measurements demonstrate that the required value as described in the ISO 22955 standard is not easily achievable in the open-plan office environment without dividers with sufficient height between workstations and modest room acoustic features. The acoustic modelling results confirmed that the required level for the open-plan office, in terms of the ISO 22955 standard, is only attainable with a combination of room acoustic variables that go against modern interior designs.
ATEFA – Project’s results on UAM air traffic noise and air-taxi certification

Michael Bauer¹, Daniel Redmann²
¹Munich Aeroacoustics, Kirchheim, Germany, ²Kopter Germany GmbH, Hoehenkirchen−Siegertsbrunn, Germany

ATEFA, Germany’s first nationally funded research project on UAM community noise, aimed to provide first answers, how novel air traffic noise from air-taxis can be assessed in a realistic scenario. Two eVTOL air-taxi systems – diverse in design and acoustics – and one regional sVTOL were acoustically described and implemented in a traffic scenario which was covering the greater area around Munich in southern Germany, interlinking surrounding small towns, five larger cities of the region and the international airport. So far, in most studies generic noise emission data were used to discuss quite complex, but also generic air traffic scenarios. ATEFA did follow a different path, based on realistic technical data and passenger number predictions. Besides this, simulated certification procedures were carried out for the two air-taxi systems. This activity was performed for an understanding of the applicability of already existing rules and regulations regarding noise certification. The project will close by end of 2022, but significant results for air-taxi flyover simulations, large area noise mapping, and certification aspects are already part of this paper.
Coupling Statistical Parameters of High Resolution 3D-Texture Measurements and Tyre/Road Noise

Bernhard Baumgartner\textsuperscript{1}, Reinhard Wehr\textsuperscript{1}, Andreas Fuchs\textsuperscript{1}, Johannes Ruisz\textsuperscript{1}

\textsuperscript{2}AIT Austrian Institute of Technology GmbH, Giefinggasse 4, Austria

When investigating the generation of rolling noise, profound knowledge of the tyre/road interaction is inevitable. Research projects addressing the road surface influence on the noise generation are commonly based on standardized road surface texture parameters, e.g. mean profile depth or spectral analysis of surface profiles. Such quantities are calculated from line texture measurements or equally sized parts of 3D-road surface samples. AIT has recently developed a high-speed continuous 3D texture scanner which provides heightened spatial information down to 60μm. This allows the determination of a multitude of additional parameters of road surface geometries. In this paper, comparisons of line texture, statistical analyses of the variability of 3D texture parameters on real road sections, as well as basic statistical models to investigate correlations between these parameters and coupled Close-Proximity Method (CPX) measurements will be described.
Estimation of flexural wavenumbers in the presence of multiple wave components

Milena Bavaresco¹, Neil Ferguson¹, Claus Hessler Ibsen², Atul Bhaskar¹

¹ University Of Southampton, Southampton, United Kingdom, ² Vestas aircoil, Lem, Denmark

The separation of closely spaced spectral components is a known problem in signal processing, be it response data either in the spatial or temporal domain. Herein an experimental method based on the maximization of the correlation between measured data and an arbitrary plane wave field is investigated for its capability in distinguishing closely spaced flexural wavenumbers. Limitations arising from data sampling and windowing are considered. These processes are used along with numerical simulations as a basis to establish the boundaries within which the method successfully detects the components present. An example from experimental data is also shown, where an alternative method, the empirical mode decomposition, is applied to verify the results and to determine the accuracy of the correlation method in comparison to another existing technique.
A piezoelectric-nonreciprocal metamaterial with shaped eigenvectors using shunted networks

Amr Baz\textsuperscript{1}, Han Zhou\textsuperscript{2}

\textsuperscript{1}University Of Maryland, College Park, United States, \textsuperscript{2}University of Maryland, College Park, United States

This paper presents a class of passive nonreciprocal metamaterials (PNMM) which are designed to control the flow of acoustic waves along a one-dimensional periodic acoustic duct. The proposed PNMM consists of a multi-cell array of acoustic cavities which are provided with piezoelectric boundaries. These boundaries are connected to an optimally designed array of shunted inductive networks in order to spatially shape the eigenvectors of the array in such a manner that breaks the reciprocity of the acoustic duct. This approach distinguishes itself from other approaches where non-reciprocities are controlled either actively or passively.

A finite element model (FEM) is developed to analyze and predict the dynamic characteristics and behavior of the proposed PNMM for various shunting strategies and distributions of the networks. The predictions of the FEM are validated experimentally using a five-cell array that is tested using the Transmission Loss and Impedance tube of ACUPRO (Sage Technologies). In the experimental model, the inductances are synthesized electronically to enable significant tailoring of the eigenvectors of the PNMM. The obtained results indicate significant breaking of the non-reciprocity when the characteristics of the PNMM are determined during forward and backward wave propagations.
Health Impacts of Aircraft Noise on Local Communities

Paul Beckford

Hacan, London, United Kingdom

UK Air Navigation Guidance regards 51dB LAeq16hr for day time noise and 45dB Lnight for night time noise as the levels at which aircraft noise annoyance occurs. WHO guidelines (2018) concluded that health effects can occur at lower levels of 45 dB Lden and 40 dB Lnight.

Current policy recognises that noise annoyance can occur below 51dB LAeq yet it is not known how many people around UK airports may be adversely affected at these lower levels. This paper will seek to estimate the population size impacted by aircraft noise below 51dB LAeq around Heathrow airport.

It will also seek to provide an international comparison of the noise policies of different airports in Europe and globally, the size of the population impacted and the minimum threshold for the onset of health effects.

The most radical changes in UK airspace history will take place in the next decade. If more people are adversely impacted by aircraft noise at lower levels then this has significant ramifications for the cost benefit analysis of airspace changes. It is crucial that communities can understand the full health impacts of the proposals.
Guidebook how to reduce noise annoyance from road traffic

Hans Bendtsen¹, Christer P. Volk¹, Torben Holm Pedersen¹, Sebastian Eggers², Truls Gjestland³
²Force Technology, Venlighedsvej 4, 2970 Hørsholm, Denmark, ³LÂRMKONTOR GmbH, Hamburg, Germany, ³SINTEF, Trondheim, Norway

The objective of the FAMOS project was to develop a European guidebook with practical applications for the National Road Administrations on how to handle noise annoyance by non-acoustic moderators in planning of roads. When all technically feasible and economically possible measures to reduce the noise have been used, there can still be need for further reduction of the annoyance. Analyses reveal that only 1/3 of the variance in the annoyance response is caused by the noise level. 2/3 are determined by so-called non-acoustic factors. The annoyance response therefore can be altered without changes to the actual noise level. The project searched moderators that have a large impact on the annoyance without changing the noise level. The search was an international literature survey on annoyance studies. Moderators found were:

- Expectations to and visual appearance of noise barriers
- Presence of vegetation/greenery
- Access to a quite façade
- Neighbourhood soundscape
- Attitudes towards authorities and road owners
- Perceived traffic safety

Experimental tests using sound walks, questionnaires and listening tests have been performed to quantify some moderators. Various methods have been used to find, extract and analyse data and turn the results into models for moderators formulated for practical use.

[Link to paper]
Evolutionary optimization processes for acoustic applications where size matters

Jaime Galiana Nieves², Javier Redondo¹, Daniel Benitez Aragón¹, David Ramírez-Solana², Juan Manuel Herrero³

¹Instituto de Investigación para la Gestión Integrada de Zonas Costeras, Valencia, Spain, ²Universitat Politècnica de València, Valencia, Spain, ³Instituto Universitario de Automática e Informática Industrial, Universitat Politècnica de València, Valencia, Spain

In acoustics, the relevance of size, scale and shape of the structures involved in a problem often brings complications when it comes to find the best possible solution. Scenarios such as the design of a room or a sound diffuser are some of the problems that we can find in which shape and size are factors to consider. In recent years, computational optimization methods have been developed to bring a different approach to the solving of these problems. These methods, based on genetic algorithms, provides us with continuous modifications and combinations between the elements involved in a problem that can help us obtain solutions that would be almost impossible to find with regular analytic solving.

Our goal is to develop a multi-objective genetic algorithm to optimize various parameters of a design problem, being one of them related to the physical size of the element under study. For this purpose, we will not treat the objects being optimized as individuals, but as groups of individuals with the same proportions but variable scale, called “concepts”. With this method, we should obtain the optimum proportions for the problem faced, not only optimized individuals.
NVH investigation of automotive HVAC brushless motors

Saad Bennouna¹
¹Valeo, La Verrière, France

In the automotive industry, thermal systems are of critical importance in securing optimum vehicle operating, preserving battery capacities and ensuring passenger comfort. These systems involve a wide range of components with various technologies, designs and more innovation.

Currently, thermal engine market shares are decreasing as facing increasing electrification trends worldwide. Consequently, thermal systems may become major sources of noise and vibration that may emerge inside the car cabin. This may cause significant discomfort to passengers and can create disturbances to passersby outside the car.

As a system supplier, Valeo ensures NVH compliance according to internal standards and OEM specifications during development and production stages. However, as electrification trends involve more and more innovations with less technical background, ensuring NVH compliance becomes a formidable challenge to deal with. Among the main NVH sources, the HVAC Brushless motor is highly critical as implanted inside the car cabin.

This paper focuses on the main NVH topics encountered on HVAC BLDC motors. First, the NVH sources are analyzed from mechanical and magnetic design perspectives. Furthermore, solutions to control the NVH behavior are presented which sets the product’s intrinsic limitations and operating conditions. Finally, from a technical compliance perspective, specification design implications are discussed.

Link to paper
Towards an environmental sound map at Parco Nord of Milan, Italy

Roberto Benocci¹, Andrea Potenza¹, H. Eduardo Roman², Alessandro Bisceglie¹, Chiara Confalonieri³, Claudia Canedoli, Emilio Padoa Schioppa¹, Giovanni Zambon¹

¹University of Milano-Bicocca -- Department of Earth and Environmental Sciences, Piazza della Scienza 1, 20126, Milan, Italy, ²University of Milano-Bicocca -- Department of Physics, Piazza della Scienza 3, 20126, Milan, Italy

Green areas suffer the growing influence of urbanization and may benefit from the use of passive acoustic monitoring (PAM) which can provide biodiversity estimation and conservation especially in fragile environments such as urban parks and protected areas. A network of low-cost sensors has been distributed over an area of approximately 20 hectares at the Parco Nord of Milan, Italy, to highlight areas with different acoustic characteristics. The audio files analysed in this study were recorded at 16 sites on four sessions between 25 May and 29 June 2015 from 06:30 a.m. to 10:00 a.m.. Seven eco-acoustic indices have been computed and analysed. A map of eco-acoustic indices has been built and validated by comparing the results with an aural survey aimed at determining the sound components at each of the sixteen sites (biophonies, technophonies and geophonies). This approach may represent a useful tool for an integrated approach aimed at conservation planning and development decisions.
Study of vertical noise profile through Helium-filled-balloon measurements in the city of Milan, Italy

Roberto Benocci¹, Fabio Angelini¹, Giovanni Zambon¹

¹University of Milano-Bicocca -- Department of Earth and Environmental Sciences, Piazza della Scienza 1, 20126, Milan, Italy

Considering the actual “vertical” housing development in the last few decades, the number of people living in high-rise building is increasing. At present in the city of Milan about 500 (0.4% of total) buildings exceed the height of 50 m, with a number of residents of about 14000 (1% of total). For this reason, we planned an experimental campaign to study the vertical noise profile through Helium-filled-balloon measurements in the city of Milan, Italy. Results show that the noise levels increase with the height with respect to a ground-reference measurement, as a result of the contribution coming from an extended area. The highest levels are reached at about 90 m. Critical issues regarding this measurement technique are also outlined.

Link to paper
In situ attenuation of speech in offices with mixed activities according to ISO 22955.

Morten Roar Berg¹, Alexander Andreas Hasselström², Cheol-Ho Jeong²

¹Ecophon, Hyllinge, Sweden, ²The Danish Technical University, Copenhagen, Denmark

The international acoustic standard “ISO 22955: Acoustics – Acoustic quality of open offices”, published in 2021, defines a number of different space types described in terms of their acoustic characteristics and target values. Space type 6 is of particular relevance because of its ubiquity, describing an open-plan office for mixed activities. Target values are generally prescribed based on activity type except for space type 6, which prescribes target values for the descriptor “in situ acoustic attenuation of speech,” denoted $D_{A,S}$ between different work activities. This approach is novel in terms of prescribing acoustic target values as values are generally prescribed for the entirety of a space. Further investigation is warranted to substantiate this approach. The present paper details measurements of $D_{A,S}$ values in three offices with relatively high degrees of acoustic treatment and designed for mixed activities. Measures of $D_{A,S}$ between different activity types indicates that target values of space type 6 may be problematic to attain under some conditions. Alternative configurations of acoustic design in the measured offices and potential implications are hypothesised. Findings related to the theoretical background of the standard, as well as opportunities for further research, are discussed.

Link to paper

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Tyre/road noise measurements on ISO tracks according to the UNECE Regulation 117

Truls Berge¹, Piotr Mioduszewski²

¹SINTEF AS, Strindvegen 4, NO-7034 Trondheim, Norway, ²Gdansk University of Technology, ul. Gabriela Narutowicza 11/12, 80-233 Gdansk, Poland

Within the Polish-Norwegian research project ELANORE, a limited Round Robin Test has been performed on 3 ISO tracks in Northern Europe. The basic objective of the project is to improve the EU directive on labelling of tyres for noise and rolling resistance. This directive is based on the measurement procedures proscribed in the UNECE Reg.117. On all test tracks the same car, test tyres and test equipment as well as personnel were used to minimize the measurement uncertainties. All tracks were built according to the specifications of ISO 10844:2014. Five sets of C1 test tyres were used which consisted of two summer tyres, one all-season, one winter and one set of the SRTT tyres. Except for the SRTT tyres, the other 4 had labelled noise values from 67 to 74 dB. In addition to the test conditions specified in Reg.117, a modified test was also included, where the load and inflation pressure were adjusted to better fit the test vehicle specification. Due to some adverse weather conditions at two of the test tracks, only a part of the test program was accomplished. The paper will present preliminary results from these measurements. A follow-up tests are planned for 2022.

Link to paper
Implementation of measurement uncertainties into vehicle noise regulation

Truls Berge\(^1\), Hans-Martin Gerhard\(^2\)

\(^1\)SINTEF AS, Strindvegen 4, NO-7034 Trondheim, Norway, \(^2\)Acoustic Consultant, Weissach, Germany

The current vehicle noise regulation UN R51.03, does not provide specific considerations for the measurement uncertainties related to the measuring method for external pass-by noise. The measurement method is based on the ISO Standard ISO 362-1:2007. While the ISO system mandates a detailed description of the expected uncertainties, the UN-ECE has not overtaken these uncertainty considerations, as the application of the test method is limited to type-approval and conformity of production measurements, both under control of the vehicle manufacturer in agreement with a type-approval authority.

The UN ECE Working Party on Noise and Tyres (GRBP) in Geneva established in 2019 an Informal Working Group on Measurement Uncertainties (IWG MU), to evaluate the measurement uncertainty in general and to propose amendments to regulations to reduce the measurement uncertainty, starting with the most important sound emission regulations UN R51.03 (vehicles) and UN R117.02 (tyres).

This paper describes the principal work of the IWG concerning the contribution of the different parameters to the overall expanded uncertainties when testing vehicles according to the specifications in UN R51.03. The identified main contributors to the overall measurement uncertainties are variations due to the test track (site-to-site) and air temperature effects (day-to-day).
Quantification of the social cost of noise in France and application of the methodology to the Paris region

David Bernfeld¹, Fanny Mietlicki¹, Emmanuel Thibier²

¹Bruitparif, 32 Boulevard Ornano, 93200 SAINT-DENIS, France, ²Ademe, 500 Rte des Lucioles, 06560 VALBONNE, France

The National Agency for Ecological Transition (ADEME) carried out in 2021 a study of the social cost of noise in France that was estimated at 147.1 billion € per year. This cost has been calculated at 97.8 billion € per year for noise generated by transport, at 26.3 billion per year for neighborhood noise and at 21 billion € per year for noise in the workplace. Health costs are predominant (86% of total) and correspond mainly to the economic valuation of the burden of disease of noise as a result of its adverse effects (annoyance, sleep disturbance, cardiovascular and metabolic diseases, psychological disorders, learning difficulties, etc.). Secondly, it also includes non-health costs such as loss of productivity and property depreciation.

Bruitparif, the noise observatory for the Paris region, has applied and adapted the methodology to the data and studies available at the regional scale. This results to 42.6 billion € per year, i.e. 29% of the national total.

These studies provide reference elements for comparing the financial cost of noise prevention and mitigation measures with the social benefits that are likely to result in terms of improved well-being for the population and avoided costs for the community.

Link to paper
Hydre: a noise radar to automatically track down excessively noisy vehicles in real traffic conditions

David Bernfeld¹, Christophe Mietlicki¹, Fanny Mietlicki¹

¹Bruitparif, 32 Boulevard Ornano, 93200 SAINT-DENIS, France

The developments made by Bruitparif since 2016 around sound source localization technologies applicable to the field of environmental noise resulted in the launch on the market of a patented combined acoustic and imaging sensor called "Medusa". An article of law was voted in France at the end of 2019 in order to enable the experimentation of noise radars in order to punish drivers causing significant noise nuisances by their behavior. The evaluation process includes track trials, roadsite tests and a final phase with fines. We will describe this national experimentation and the context in which it takes place. We will then detail the prototype called "Hydre" that we have developed for this purpose, and will present case results showing how it solves the major difficulties of the legal measurement of the pass-by noise of vehicles in real traffic conditions.

Link to paper
LIFE project Cool & Low Noise Asphalt: monitoring the acoustic performance of low noise pavements in the city center of Paris

David Bernfeld, Carlos Ribeiro, Fanny Mietlicki, Jérôme Lefebvre, Giulia Custodi

Bruitparif, SAINT-DENIS, FRANCE, Ville de Paris / LEMVP, PARIS, FRANCE, Ville de Paris / DTEC, PARIS, FRANCE

In 2012, the City of Paris launched an experiment on a 200 meters section of the Paris ring road to test low noise pavements and their acoustic and mechanical durability over time, in a context of heavy road traffic. Bruitparif maintained a permanent noise measurement station to monitor the acoustic efficiency of the pavement over several years. Follow-ups have recently been implemented by Bruitparif in the vicinity of dwellings near major road infrastructures crossing the Ile-de-France territory, such as the A4 and A6 motorways. Today, for ring roads and motorways with traffic speed limits of 70 and 90 km/h respectively, the benefits of using low noise pavements is demonstrated. It is now interesting to study the contribution of low noise pavements in downtown areas with speed limits of 50 km/h or less. As part of the European LIFE “Cool & Low Noise Asphalt” project led by the city of Paris, in which Bruitparif is a partner, three innovative asphalt pavement formulas are being tested to fight noise pollution and global warming on three heavily exposed Parisian sites. Asphalt mixes combine acoustic, thermal, mechanical properties and durability. This article presents the latest results.

Link to paper
Regulation of nightlife noise in Paris: the contribution of innovative monitoring and perspectives

David Bernfeld¹, Cécile Revol¹, Fanny Mietlicki¹
²Bruitparif, 32 Boulevard Ornano, 93200 SAINT-DENIS, France

Recreational noise generated by nightlife in urban areas is a particularly delicate issue, as the complex nature of the noise sources involved (music, human voices, traffic…) makes it complicated to grasp from a technical point of view. It is also difficult to regulate since there is a highly subjective aspect to the perception of such noise.

Bruitparif has been involved in the observation of this type of noise in the most attractive areas of Paris since 2016. More than 40 « Medusa » sensors making it possible to identify the dominant source of the noise have been deployed in areas where nightlife noise is reported to be problematic by the local residents. This outdoor acoustic monitoring allows an analysis of the sound levels generated by customers of festive establishments or gatherings of people in public spaces, and provides objective data support that can then serve as a reference for discussions between the various stakeholders.

Measurement data coupled with modelling development is essential for the proper consideration of this problem, which is more than a simple nuisance. Indeed, it probably has important consequences for the health of inhabitants given that noise occurs during periods that are particularly critical for sleep quality.
Acoustic exposure, fire and belonging.

Karla Berrens
UB, Barcelona, Spain, UOC, Barcelona, Spain

In Catalunya, devils are people belonging to Colla (a group partaking in fire and drumming street performances) that carry and dance with fireworks and firecrackers at the end of a wooden stick. A Correfoc is a fire performance where people dressed as devils run around and dance on the streets with fireworks followed by a band of drummers. All together creates a temporarily very loud and visually attractive ambience. Like a very loud and rhytmical ball of fire passing through a street. Firecrackers and fireworks whistling and exploding produce very loud sounds, sometimes reaching 175dB. The sonic intensity of these performances has to do both with the sound emanating from the fireworks and drums, and the reverberation the streets of Barcelona can create.

Many devils are part of a Colla for decades, thus exposing their hearing to extreme levels of sound several times a year, and in peak season, several times a week. This results in devils having varying levels of aural diversity and their health being negatively impacted by the sound they willingly expose themselves to. These aural diversity is worn as a kind of “badge of belonging” and commitment to the Colla.

This paper examines the intricacy behind this sense of belonging and the reasons why the health impacts do not seem to deter participation in Correfocs. It also examines why are fireworks producers keeping their product so loud. It concludes proposing an aurally sustainable approach to partaking in this inherent element of Catalan popular culture.
DecoWind: Development of low-noise and cost-effective wind farm control technology

Franck Bertagnolio¹, Andreas Fischer¹, Ju Feng², Camilla Nyborg³, Andrea Vignaroli¹, Helge Aa. Madsen¹, Kurt S. Hansen², Alfredo Peña¹, Wen Zhong Shen³, Thomas Hansen⁴, Stefan Oerlemans⁶, Lars S. Søndergaard⁶, Erik Thysell⁶, Christer Volk⁶, Thomas Sørensen⁷

¹DTU Wind Energy, Roskilde, Denmark, ²DTU Wind Energy, Lyngby, Denmark, ³Yangzhou University, Yangzhou, China, ⁴Siemens Gamesa Renewable Energy A/S, Brande, Denmark, ⁵FORCE Technology, Aarhus, Denmark, ⁶FORCE Technology, Hørsholm, Denmark, ⁷EMD International A/S, Aalborg, Denmark

DecoWind is a 3-year Danish research project whose goal is to devise advanced control strategies for wind turbines and farms for minimizing their acoustic impact. Noise propagation models (Nord2000 and WindStar) are verified through dedicated measurement campaigns onshore. Long-range offshore measurements are also conducted to understand these specific conditions. A Parabolic Equation method for noise propagation, which have mostly been restricted to academic use in the past, is integrated into an engineering context for wind farm control. This framework can be used to define a wind farm optimal control strategy. The energy production is maximized while limiting the noise impact at dwellings, depending on the considered site, by operating the turbines using their different noise operational modes. This framework is demonstrated through numerical test-cases.

In addition, a public survey is conducted to assess the socio-acoustical impact of wind turbine noise, looking at several factors. The ultimate goal is to produce a set of recommendations regarding wind turbine noise regulations that would connect the new engineering design capabilities and the findings regarding public annoyance.

The project is a collaboration between DTU, Siemens-Gamesa Renewable Energy, FORCE Technology, and EMD International.

In this contribution, the main achievements of the project are summarized.
Implementation of non-equal-partition multi-channel convolver

Luca Battisti, Angelo Farina, Antonella Bevilacqua, Antonella Bevilacqua

1University of Bologna, Via Dell'Università, 50, Italy

Convolution has become a largely exploited signal operation thanks to his several applications in digital signal processing. In the realm of audio elaboration, convolution has the particular meaning of imposing a spectral and/or temporal structure onto a sound. These structures are completely given by the signal with which the signal is being convolved, called Impulse Response (IR). These signals contain a sort of acoustical footprint that can be completely transferred to another sound, earning the same acoustic characteristics as a consequence.

With a multichannel approach, convolution assumes even a further meaning and a wider application field. Indeed, it’s exploited to deal with modern spatial sound techniques such as Ambisonics which necessitate matrix elaborations of the involved signals. Ambisonics recordings, for example, are made by special coincident multi-capsule microphone arrays, whose signals can be converted to standard Ambisonics format by a multi-channel convolver. A similar concept can apply to the mixing stage of audio production, where direction-based audio objects must be converted to the Ambisonics format to be reproduced in the relative speaker setups.

The aim of the work is to analyse an existing algorithm of a multichannel convolver software evaluating his efficiency. Moreover, the managing of the matrix of filters has showed weaknesses when assembling new matrices. Solution proposes a handy way to deal with matrices and to improve the efficiency of the algorithm.
Objective evaluation of multipurpose enclosures equipped with active acoustic enhancement systems

Lukasz Blasinski
Chair of Acoustics, Faculty of Physics, Adam Mickiewicz University, Poznan, Poland

Research on optimal acoustic parameter values that have been carried out for recent decades and the necessity to provide different acoustic solutions to events of a different type led to construction of rooms with variable acoustic conditions. Nowadays, active acoustic enhancement systems (AAES) become more and more popular. Application of such systems allows adjustments of acoustic parameters required for particular performance.

This paper presents results from measurements of objective parameters of multipurpose enclosures equipped with AAES. Investigated halls are located in Poland in the following cities: Łańcut, Mińsk Mazowiecki, Puławy, Wieluń and were intentionally built or renovated as multipurpose rooms. All of those halls were equipped with Yamaha AFC version 3 system. The measurements were performed according to ISO338-1/2 standards. In total 13 active acoustic system settings (presets) were analyzed to investigate their influence namely Reverberation Time (RT), Early Decay Time (EDT), Initial Time Delay Gap (ITDG), Center Time (Ts), Clarity (C80, C50), Definition (D50), Interaural Cross Correlation (IACC) and Speech Transmission Index (STI).

The analysis of the obtained results showed that it is possible to obtain the appropriate acoustic conditions with acoustic parameters values set in the suggested range for a given event using active acoustic systems.
Objective and subjective assessment of the speech intelligibility in rooms with an Active Acoustic Enhancement Systems

Lukasz Blasinski¹, Anna Pastusiak¹, Jedrzej Kocinski¹, Maciej Buszkiewicz¹

¹Chair of Acoustics, Faculty of Physics, Adam Mickiewicz University, Poznan, Poland

Speech Transmission Index (STI), apart from the Reverberation Time (RT), remains an important parameter used for the speech intelligibility assessment indoors.

As the Active Acoustic Enhancement Systems (AAES) are getting more and more commonly used, it was verified how such systems affect speech perception. In accordance with the 3382-1 and 3382-2 regulations, objective parameters were measured in two enclosures with the AAES. The RT values varied from 0.91 to 1.61 [s] for the hall in Mińsk Mazowiecki and from 0.75 to 1.52 [s] in Puławy. The STI values varied from 0.57 to 0.64 in Mińsk Mazowiecki and 0.64 to 0.69 in Puławy. Despite the significant differences in the RT values, STI coefficients remained almost unchanged.

The listening test was designed to verify if the subjectively assessed intelligibility would confirm the objective measurements’ results. 50-element nonsense words (logatome) lists were used for in-situ experiments and, in the second part, binaural laboratory arrangement. Both parts involved over 120 listeners. Three scenes were selected: without AAES and two different AAES setups. In summary, subjective measurements’ results were compared with the obtained STI, RT and Clarity (C50, C80) values to prove their importance in indoors speech intelligibility evaluation.

Link to paper
Quantifying and Reducing Embodied Carbon in the Acoustic Design of Mass Timber Buildings

James Bligh
1
2Pliteq UK, London, United Kingdom

An adoption of mass timber construction is the construction industry’s best shot at reducing its significantly large contribution to global CO₂ emissions. Acoustic design in mass timber buildings typically relies on mass and facing materials in order to meet design criteria, and can account for a high proportion of the embodied carbon (CO₂e) per m² on a build. In order to fit with the ethos of mass timber construction; low embodied carbon, reusable, cradle to cradle materials must be adopted.

This paper presents the findings of a study into the relationship of acoustic performance and CO₂e, and proposes alternate approaches that reduce the CO₂e/m² of the acoustic design by up to 66% with little to no detriment to acoustic performance. Through single variable analysis in third party laboratory testing, and in situ testing, it has been found to be possible to utilise low CO₂e acoustic systems that reduce the CO₂e/m² in not only the acoustic design, but structural, M&E and architectural disciplines, too.
Predicting the existence of thermoacoustic instabilities is a key step in the design of modern gas turbines and the choice of their operating conditions. The stability of a combustion system crucially depends on the acoustic boundary conditions. To systematically investigate the influence of these boundary conditions, a test facility with variable inlet and outlet geometries has been developed. Cold flow tests confirmed that the acoustic terminations allow for a change of the reflection coefficient from close to open end to anechoic to almost closed end over a large frequency range. In the present work, we present the design of an adjustable exit boundary enabling a change in the thermoacoustic stability without modifying the flame operating conditions. Experiments have been conducted in a turbulent axial atmospheric combustor. The acoustic reflection coefficients in hot condition of the exit boundary are measured for different boundary geometries and the impact of these geometries on the flame stability is assessed. A parametrized model is derived and reproduces the experiments well.
In situ characterisation of exemplary rail vehicle structure borne sound sources

Jenny Böhm¹, Haike Brick¹
¹German Centre For Rail Traffic Research at the Federal Railway Authority, Dresden, Germany

A narrowband characterisation of structure borne sound sources is needed for an accurate prediction of rail vehicle interior noise. Typical rail vehicle sources are relatively large and heavy structures. In 2019, a measurement method for the indirect determination of the blocked force was standardised. It can be applied in situ, with the source connected to an arbitrary receiving structure and was found to be promising for rail vehicle applications in recent research projects. One major challenge is the need to measure the coupled velocity and mobility of all relevant degrees of freedom (six directions per coupling point). Within the European Shift2Rail project DESTINATE, measurements were carried out using a traction motor and an HVAC unit as exemplary sources to investigate the suitability of the in situ method for rail vehicle sources. The measurements include translational and rotational degrees of freedom. Recently, they were further analysed to investigate the effects of neglecting degrees of freedom. The results will be shown in this contribution.

Link to paper
Annoyance and sleep disturbance responses in people living in the vicinity of wind turbines in the Netherlands

Anne Bolders¹, Marije Reedijk¹, Irene van Kamp¹
²National Institute of Public Health and the Environment (RIVM), Bilthoven, Netherlands

In order to achieve global and national climate goals, wind energy production in the Netherlands and elsewhere will likely continue to grow, and the size and capacity of new and replaced turbines will increase. Therefore, it is important to understand the impact of wind turbines on people living in their vicinity. Current evidence on health effects of living in the vicinity of wind turbines in The Netherlands is lacking. To fill this knowledge gap we conducted a nationwide survey among 3500 people living within 5 km distance of wind turbines, of whom 662 people (19%) participated. They completed a questionnaire about annoyance and sleep disturbance responses to wind turbine related exposures (e.g., mechanical sound, sound of blades, and visual aspects), as well as questions about general health, perception of risks, and attitudes. Information about local wind turbine features (distance, hub height, capacity, and rotor diameter) was available for each address. This paper presents preliminary descriptive results for annoyance and sleep disturbance responses to wind turbine sound. These findings and their limitations are discussed against the background of the challenges encountered and considerations for future research.

Link to paper
Socioeconomic inequalities in burden of disease due to traffic noise in the Nordic countries

Anette Kocbach Bolling¹,², Jesse Daniel Thacher³, Søren Toksvig Klitkou², Carl Michael Baravelli², Eva Andersson⁴,⁵, Leo Stockfelt⁴,⁵, Natalia Vincens⁴, Mette Sørensen³, Anu Turunen⁶, Tarja Yli-Tuomi⁶, Mikael Ögren⁴,⁵, Virpi Kollanus⁶, Timo Lanki⁶, Jenny Selander⁷, Gerhard Sulo², Gunn Marit Aasvang¹,²

¹Department of Environmental Health, Norwegian Institute Of Public Health, Norway, ²Centre for Disease Burden, Norwegian Institute of Public Health, Norway, ³Danish Cancer Society Research Center, Denmark, ⁴Occupational and Environmental Medicine, School of Public Health and Community Medicine, Institute of Medicine, Sahlgrenska Academy, University of Gothenburg, Gothenburg, Sweden, ⁵Department of Occupational and Environmental Medicine, Sahlgrenska University Hospital, Gothenburg, Sweden, ⁶National Institute for Health and Welfare, Finland, ⁷Institute of Environmental Medicine, Karolinska Institutet, Stockholm, Sweden

Environmental noise is the second largest environmental risk factor in disease burden estimates for Europe. While socioeconomic inequalities in noise exposure have been reported, the impact of socioeconomic status (SES) on the disease burden attributable to noise exposure has to our knowledge not been reported previously. The aim of this study is to assess the impact of SES on traffic noise exposure and the associated disease burden in selected Nordic populations. We employed nationwide data on road traffic noise exposure and SES from Danish and Norwegian Nationwide Models. The impact of household income and education on traffic noise exposure was assessed using linear regression analyses. Burden of disease estimates were calculated for populations stratified according to their level of income and education in terms of Disability-Adjusted Life Years (DALY) for high degree of noise annoyance, high degree of sleep disturbance and ischaemic heart disease. The most consistent finding observed for the Danish population was that, compared to medium and low household income, high household income was associated with lower noise exposure. Moreover, the burden of disease estimates for high noise annoyance were up to 20% lower in the high compared to the lower household income groups.
Vibroacoustic Metamaterials as Add-On Solution for Noise Reduction in Existing Casing Structures

Manuel Bopp¹, Albert Albers¹
²KIT-IPEK, Kaiserstr. 10, Germany

Vibroacoustic metamaterials (VAMM) have the potential to reduce unwanted noise components in a very targeted and narrow-band frequency range. Many VAMM concepts are based on mechanical resonators that act as vibration absorbers in their natural frequency and thus absorb energy that would otherwise be radiated in the form of airborne sound and perceived as noise. Often, during the design phase, it is not yet possible to adequately assess which surfaces will be acoustically problematic and in which frequency ranges disturbing noise components are going to be. In addition, many VAMM concepts can only be manufactured using additive manufacturing (AM) processes, due to their complex geometry. However, AM parts often have strongly anisotropic material behavior, depending on the manufacturing process, which makes a prediction of the vibroacoustic behavior even more difficult. Direct integration into casing structures during the design phase is therefore not practical and economically feasible in most cases.

This paper therefore investigates the extent to which retrofitted resonators can be effectively used in existing casing structures. For this purpose, FDM-printed bending resonators made of ABS and PLA are used, which have already been measured with regard to their natural frequencies in a previous publication. Different variants are attached to a demonstrator housing and the surface vibration velocity is measured using a 3D laser scanning vibrometer, and compared with the basic variant without resonators. The radiated airborne sound is also measured. Furthermore, a comparison is made with a dynamic FEM simulation in order to be able to evaluate its prediction quality, in particular with regard to the additively manufactured resonators.
Accelerated sound propagation using an error-free Fourier method coupled with the spectral-element method

Nikolas Borrel-Jensen¹, Allan Peter Engsig-Karup², Maarten Hornikx³, Cheol-Ho Jeong¹

¹Acoustic Technology, Department of Electrical Engineering, Technical University of Denmark, 2800 Kongens Lyngby, Denmark, ²Department of Applied Mathematics and Computer Science, Technical University of Denmark, 2800 Kongens Lyngby, Denmark, ³Department of the Built Environment, Eindhoven University of Technology, 5612 AZ Eindhoven, The Netherlands

Simulating acoustics using numerical methods efficiently and accurately has been an active research area for the last decades and has applications in computer games, VR/AR, and architectural design. However, their extensive computation time makes these methods challenging for large scenes and broad frequency ranges. This work attempts to accelerate the simulations using rectangular decomposition, enabling error-free propagation in the bulk of the domain consisting of air. We exploit the analytical solution to the wave equation calculated using the Fast Fourier Transform with near-optimal spatial and temporal discretizations satisfying the Nyquist criterion. Coupling with the spectral-element method near the boundaries results in a method capable of handling complex geometries with realistic boundaries, though with the caveat that additional errors and computational overhead may result from the interface. This talk will investigate the accuracy and efficiency of the proposed domain decomposition method compared to a spectral-element method running in the entire domain.

[Link to paper]
Artificial intelligence-based collaborative acoustic scene and event classification to support urban soundscape analysis and classification

Yuanbo Hou\textsuperscript{1}, Dick Botteldooren\textsuperscript{1}

\textsuperscript{1}Ghent University, Gent, Belgium

A human listener embedded in a sonic environment will rely on meaning given to sound events as well as on general acoustic features to analyse and appraise its soundscape. However, currently used measurable indicators for soundscape mainly focus on the latter and meaning is only included indirectly. Yet, today’s artificial intelligence (AI) techniques allow to recognise a variety of sounds and thus assign meaning to them. Hence, we propose to combine a model for acoustic event classification trained on the large-scale environmental sound database AudioSet, with a scene classification algorithm that couples direct identification of acoustic features with these recognised sound for scene recognition. The combined model is trained on TUT2018, a database containing ten everyday scenes. Applying the resulting AI-model to the soundscapes of the world database without further training shows that the classification that is obtained correlates to perceived calmness and liveliness evaluated by a test panel. It also allows to unravel why an acoustic environment sounds like a lively square or a calm park by analysing the type of sounds and their occurrence pattern over time. Moreover, disturbance of the acoustic environment that is expected based on visual clues, by e.g. traffic can easily be recognised.

[Link to paper]
Performance optimisation of small reverberant room with hanging diffusers

Patrick Bouché, Kevin Verdière, Simon Campeau

1 Mecanum Inc., Sherbrooke, Canada

Small reverberant room can be an efficient and economic tool to provide fast sound absorption measurements in diffuse field of homogeneous sound absorber or more complex structure and useful for development, testing or evaluating specification requirements in many industrial fields. A 5.7 m³ reverberant room with a Schroeder frequency around 1275 Hz can have some diffusivity issues in lower and middle frequencies leading to an unsuitable level of consistency, reliability, and repeatability. This paper presents the results of a study to improve the measurement performance of this small reverberant room by adding hanging diffusers. Using Ray-Tracing method, a numerical parametric study was done to estimate sound absorption of various material by varying the number, the position, and the orientation of these diffusers based on ASTM C423 and E795 standard. Moreover, extra simulation has been performed to evaluate the effect of sample size on sound absorption consistency in function of frequency. Following these prescriptions, an experimental study was done to confirm these improvements on frequency dependent sound absorption and single rating numbers such as NRC (Noise Reduction Coefficient) and SAA (Sound Absorption Average).
Correlation Between Acoustic, Luminous, Thermal Dimensions of A Urban Park In an Oasis Settlement and emotional response of Visually Impaired Users

Samiha Boucherit\(^1\), Massimiliano Masullo\(^1\), Djihed Berkouk\(^2\), Luigi Maffei\(^1\)

\(^1\)Università Degli Studi Della Campania Luigi Vanvitelli, Aversa, Italy, \(^2\)Department of Architecture, Biskra University, Biskra, Algeria

Occupants' interaction with urban spaces and their behavior is often influenced by environmental dimensions: thermal, visual, acoustic or air quality. Many studies have investigated the relationships between occupants' behavior and these dimensions, but just few of them have addressed occupants with special needs, such as the visually impaired. This study, based on measurements' campaign and research activities conducted at Biskra (Algeria) inside an urban park in an oasis settlement, provides further investigations about the relationship between acoustic, luminous, thermal dimensions and the emotional response of visually impaired users as a basis for validating and improving their wellbeing in important spaces of the urban environment such as the public parks. The methodological approach is based on both quantitative and qualitative assessment. The objective study is based on evaluating the physical dimensions of the site, while the subjective one is based on conducting in-situ questionnaires such as a multi-items Likert scale and multi-sensory evaluation towards the environment. Findings obtained from this study could offer a new vision to planners and designers to improve the wellbeing of visually impaired users by including the multisensorial dimensions as constitutive elements of architectural, urban and environmental projects.

[Link to paper](#)
Compact asymmetric treatments for perfect sound absorption in ventilated problems

Jean Boulvert, Jean-Philippe Groby, Gwénaël Gabard, Vicent Romero-García

1Laboratoire d’Acoustique de l’Université du Mans (LAUM), UMR CNRS 6613, Institut d’Acoustique - Graduate School (IA-GS), Le Mans, France

This presentation introduces compact asymmetric treatments for sound absorption, i.e., simultaneous cancellation of reflection and transmission, in a lined duct of constant cross section. The treatments are composed of side by side and sub-wavelength resonators. They are thus compact, which facilitates their practical use. The simplest asymmetric treatment is formed by a pair of detuned resonators that can lead to a perfect monochromatic sound absorption. Furthermore, the combination of multiple pairs of resonators generates multiple low quality factor absorption peaks leading to an absorption plateau. Two compact asymmetric treatments are presented: one is composed of quarter-wavelength porous resonators to prove their ability to achieve perfect sub-wavelength absorption in a duct problem and the other is composed of Helmholtz resonators flush mounted on the walls of a large cross-section duct. In both cases, the evanescent coupling between the resonators has an important impact on the treatments behavior and is thus accounted for during their optimization. The experimental results are found in good agreement with the theory and a mean absorption coefficient of 99% over a large target and subwavelength frequency range is observed for each treatment.

Link to paper
Acoustical privacy in the built environment: Past, present and future

Ethan Bourdeau¹, Viken Koukounian¹

¹International Well Building Institute, New York City, United States

Although the need to consider acoustics in the built environment is well-accepted, an understanding of ‘what’ constitutes ‘good acoustics’ is not. The authors present posteriori—reviews of historical events and of empirical evidence—to develop an understanding of the current landscape of Standards, Guidelines, and Codes. More specifically, special attention is devoted to the development of speech privacy metrics, as well as that of auditory and non-auditory effects of noise and sound on health. With a refreshed understanding of theory, a priori—i.e., an acoustical framework for design and/or performance verification with a special interest in speech privacy—is renewed and its impacts on the ongoing development of Standards, Guidelines and Codes is discussed.

Link to paper
Morphology influence on the acoustics of permeo-elastic media

Claude Boutin\textsuperscript{1}, Rodolfo Venegas\textsuperscript{2}

\textsuperscript{1Entpe-Universite de Lyon, 69518 Vaulx-en-velin, France, \textsuperscript{2University Austral of Chile, Institute of Acoustics, Valdivia, Chile}

This paper deals with the acoustics of permeo-elastic media. These media consist of a rigid porous skeleton on which flexible elastic films are fixed and interact with the fluid saturating the pores. They can correspond to foams, the thin membranes playing the role of films and the rigid structure being formed by the struts. The acoustics of permeo-elastic media can deviate from that of conventional porous media due to the fluid/film interaction at the pore scale. This introduces an elastic component in the energy that interacts with viscous and inertial effects. The actual behavior is established by the two-scale asymptotic homogenization method. It is shown that the film effects depend strongly on the pores and the film arrangement. Different wave propagation regimes are identified depending on the nature of the local flow. Considering (i) fully connected, i.e., no pores are closed by the films, (ii) unconnected, i.e., all pores are closed, and (iii) partially connected, i.e., some pores are closed by the films, the study reveals under which conditions the fluid-film interaction significantly influences the macroscopic acoustic behavior. Depending on the morphology, the permeability or compressibility (or both) can exhibit singularities or anomalous properties due to inner resonance or anti-resonance.

[Link to paper]
Predicting the behavior of commercially available building foundation isolation materials using a four-parameter fractional Zener model

Matthew Golden¹, Colin Bradley¹, Faiz Musafere¹, Josh Havin¹

¹Pliteq Inc., Toronto, Canada

In this paper we apply a four-parameter fractional Zener model to describe the short and long term creep behavior of a viscoelastic building foundation isolating material currently in use globally in noise and vibration mitigation applications. Building from the classical rheological models composed of springs and dashpots suitably combined (Maxwell, Kelvin-Voight, Zener), we include a fractional derivative component in the form of a Scott-Blair element composed of a Riemann-Liouville derivative of non-integer order. The parameters are identified empirically through measured stress-strain results and hysteresis curves for the material in compression. The model is then compared to the results of a 168h constant load creep test of three commercially available materials.

[Link to paper]
Enhanced micro-perforated wall-treatments for reducing the boundary layer noise in a low-speed wind-tunnel: modelling, characterization and optimization studies.

Teresa Bravo\(^1\), Cedric Maury\(^2\)

\(^1\)CSIC, Madrid, Spain, \(^2\)Ecole Centrale Marseille, Marseille, France

Micro-perforated aero-acoustic liners are robust non-fibrous wall-treatments able to achieve significant axial attenuation in low-speed ducted flows, if their input impedance is suitably optimized. They are also potential candidates for broadband reduction of the flow-induced noise, useful to increase the signal-to-noise ratio in wind-tunnels test section or for fan noise control when inserted in casing treatments. The current theoretical and experimental study determines under which range of frequencies, holes diameter and free stream flow velocity, micro-perforated partitions are able to efficiently reduce the boundary layer noise, either by absorption or transmission mechanisms, depending on the spectral content of the aero-acoustic excitation. The formulated analytical models, either modal- or wavenumber-based, are validated against wind-tunnel measurements of the overall power injected by a low-speed boundary layer into a micro-perforated partition and its aerodynamic transmission loss. A hole-based Strouhal number is found below which little back-scattering of the wall-pressure components occurs. Optimization studies are performed to determine the range of parameters that enhance the total absorption or transmission of boundary layer noise, with special emphasis on the low frequency content of the wall-pressures.
Experimental investigation of possible improvements of ISO 9614

Spyros Brezas¹, Volker Wittstock², Fabian Heisterkamp³
¹Hellenic Mediterranean University, Rethymno, Greece, ²Physikalisch Technische Bundesanstalt, Braunschweig, Germany, ³Federal Institute for Occupational Safety and Health (BAuA), Dortmund, Germany

Sound power level is the key quantity to describe the noise emission of products and is needed to reduce noise at work, at home, and in the environment, e.g. for promoting and selecting low noise products (Sell and Buy Quiet). Sound power determination based on sound intensity measurements has advantages in non-ideal acoustic environments, e.g. indoors, but outside of acoustic test rooms, and is standardized in the ISO 9614 series. The current version of all three parts of ISO 9614 is their first edition. The advances of technology and knowledge indicate that the whole series should be revised. The improvement of the sound intensity method was investigated regarding a number of aspects. The use of a single spacer up to frequencies, which are outside of the currently usable frequency range, was studied. The effect of electrical noise was investigated to extend the applicability of the method to low noise sources. The discretization of the enveloping surface is discussed in relation to the accuracy grade of the measurements. The possibility to measure with more than one probes is also presented. The results indicate that there is the possibility for a substantial improvement of the ISO 9614 series.

[Link to paper]
Field-testing of noise abatement measures

Haike Brick¹, Jenny Böhm¹
¹German Centre for Rail Traffic Research, Dresden, Germany

The strengthening of rail transport must be accompanied by a reduction in emissions. Regarding acoustics, innovative measures to increase noise protection must therefore be developed and investigated. Nevertheless, the determination of the sound reduction effect of mitigation measures on the railway infrastructure or in the propagation path is not yet standardised. There is a need for the development of a measurement and evaluation procedure, which is practice-oriented, reliable and allows the assessment of innovative measures in approval procedures. The German Centre for Rail Traffic Research (DZSF) at the Federal Railway Authority - an independent, scientific research facility of the German Federal Government - will support these activities. In addition to theoretical investigations, the Open Digital Test Field, which is being set up by the DZSF in the Lusatia region between Halle (Saale) - Cottbus - Niesky, is available for practical tests. Before starting the field tests, measurement procedure and boundary conditions are to be defined. The requirements and methods for quantifying mitigation measures formulated in previous research projects are outlined and reviewed. The presentation will discuss a derived proposal and show the selection of acoustic test sections in the Open Digital Test Field that meet the requirements.

[Link to paper]
In-situ characterization of acoustic materials featuring a membrane or a rigid perforated facing with a PU probe

Baltazar Briere de La Hosseraye\(^1\), Jieun Yang\(^1\), Maarten Hornikx\(^1\)
\(^2\)Eindhoven University of Technology, Eindhoven, Netherlands

The in-situ characterization of acoustic materials is one of the main challenges in room acoustics. Previously, the characterization of a single porous layer backed by a hard wall was successfully done by combining pressure-velocity measurements near the surface of the material with an impedance model fitting approach. In practice however, most porous materials are mounted behind a membrane or a rigid perforated facing.

By again combining pressure-velocity measurements and a model fitting procedure, this work studies the possibility to characterize such systems. This was done by measuring a variety of perforated facings and membrane facings, whether in front of an air cavity or backed by a porous layer and comparing the obtained impedance model parameters to the reference values. Good agreement was observed between the retrieved parameters and the references, with error in retrieved moving mass, facing thickness, cavity depth, porous layer thickness and porous layer flow resistivity not exceeding 15%.

Link to paper
Effects of traffic speed reduction interventions on noise-induced annoyance and self-reported sleep disturbances: a longitudinal study in Zurich

Mark Brink¹, Simone Mathieu², Jürg Artho³, Stefanie Rüttener²

¹Swiss Federal Office for the Environment, Bern, Switzerland, ²City of Zurich, Department of Health and Environment, Zurich, Switzerland, ³University of Zurich, Department of Psychology, Zurich, Switzerland

For the purpose of evaluating acceptance and effects of permanent speed reductions on noise level, noise annoyance and self-reported sleep disturbance, we surveyed about 1300 randomly sampled inhabitants, before and after a speed regime changeover from 50 km/h to 30 km/h along 15 small- and mid-sized city streets in Zurich. Concurrently, individual noise exposure calculations based on traffic counts and on-site speed measurements were carried out. The results show a decrease of road traffic noise levels at the loudest facade point by an average of 1.6 dB during the day and 1.7 dB at night, a significant decrease of road noise annoyance and of self-reported sleep disturbances as well as a significant but moderate increase of the perception of road safety. Most importantly, the exposure-response relationships for annoyance and sleep disturbance were shifted towards lower effects in the 30 km/h condition by, depending on receiver point, between about 2 and 4 dB during the day and about 4 dB at night, indicating lower effects at the same average level. We conclude that besides the lower average level alone, additional factors related to the lower driving speed must play a role in the reduction of annoyance and sleep disturbance.

[Link to paper]
From the costs of noise to the value of soundscape?

Like Jiang1, Abigail Bristow2, Jian Kang3, Francesco Aletta3, Rhian Thomas4, Hilary Notley4, Adam Thomas5

1 Institute for Transport Studies, University Of Leeds, Leeds, United Kingdom, 2 Department of Civil and Environmental Engineering, Faculty of Engineering and Physical Sciences, University of Surrey, Guildford, United Kingdom, 3 Institute for Environmental Design and Engineering, University College London, London, United Kingdom, 4 Noise and Statutory Nuisance Team, Department of Environment, Food and Rural Affairs, London, United Kingdom, 5 Acoustics Audio, Visual and Theatre Team, Arup, Manchester, United Kingdom

The past two decades have seen an ongoing paradigm shift from noise control to soundscaping, and soundscape approaches have been widely applied in traditionally noise management projects. However, cost-benefit analysis (CBA), which is widely used for economic appraisals of projects that would impact on the sound environment, is still noise-based and residential-location-focused. As a result, benefits of wanted sounds are omitted, and only very limited receiver types and contexts are covered. While there is a wealth of literature on valuing the costs of noise and the benefits of noise reduction little research has been done on soundscape valuation, and consequently there is little evidence on the monetary value of soundscape, which is essential for developing soundscape-based CBA. Starting from the costs of noise this paper will discuss the motivation of soundscape valuation, methodology for primary soundscape valuation research, and the use of soundscape values, to contribute to the development of holistic soundscape CBA.
Linear time-continuous state-space realization of flame transfer functions by means of a propagation equation.

Philipp Brokof, Guillaume J. J. Fournier, Wolfgang Polifke

Technical University of Munich, School of Engineering & Design, Department of Engineering Physics and Computation, Munich, Germany

Low-order network models, commonly used to assess the thermo-acoustic stability of combustors, can be cast in a linear, time-continuous state-space representation. A standard linear eigenvalue problem for the system modes results, which can be solved in a robust and efficient manner. To represent the linear dynamics of any time-invariant flame in the state-space framework, this study presents an approximation of the distributed time-delayed flame response to acoustic velocity perturbations based on a spatially discretized propagation equation (PE). We derive the rational flame transfer function of a first-order-upwind-PE state-space model and discuss its relation to the Tustin approximation of flame transfer functions. For an exemplary discrete finite impulse response of a flame, a third-order-upwind-PE state-space model is shown to match the discrete flame frequency response with comparable accuracy as a rational approximation found by non-linear optimization. The numerical dissipation introduced by discretization of the PE ensures zero gain above the Nyquist frequency of the underlying discrete flame impulse response. Finally, we apply the PE state-space flame model to a generic Rijke tube and show that the predicted thermo-acoustic modes agree well with results obtained from a classical non-linearly optimized rational approximation of the frequency response function of the flame.
BS4142:2014+A1:2019 “Methods for rating and assessing industrial and commercial sound” is the standard that the Environment Agency requires to be applied for the assessment of most industrial sound sources. Since its publication in 2014 (in 2019 only some minor updates were introduced), it has become evident that the standard is prone to misinterpretation, particularly in relation to estimating uncertainty of the assessment and in terms of context at which the sound occurs. As a consequence, quality of most of noise impact assessment reports submitted to the EA has been very low.

In order to improve quality in environmental measurements and assessments of noise impact, the EA has established the Method Implementation Document for BS4142. MID provides details on how the standard shall be used for regulatory monitoring for application for or compliance with a permit. Where required, MID should be used to supplement the EA’s guidance called up by Noise and vibration management: environmental permits (formerly known as Horizontal Guidance Note H3 which has been withdrawn). However, it does not re-state all the provisions of BS 4142 and organisations are reminded of the need to comply with the criteria detailed in BS 4142:2014+A1:2019.
The forced sound transmission of finite periodic plates using a variational approach

Jonas Brunskog

DTU Electrical Engineering, Kgs. Lyngby, Denmark

Many engineering structures consist of plates being periodically stiffened or loaded. Examples can be wooden joist floors, dry walls with wooden or metal beams, or metamaterials for increased sound insulation. Even though some of these structures are well known and thoroughly studied in the past, there lack prediction models that can handle both the finiteness and periodicity in a simple and accurate manner. In two previous attempts, the periodicity of the structure have been tried to be incorporated in a variational technique based on integral-differential equations of the fluid loaded plate, based on [J. Brunskog, JASA 132, 1482–1493, 2012]. These attempts have not worked well: they show a poor fit with measured data. In this paper, this issue is investigated again, and a different tactics is used to incorporate the periodicity, using space harmonics. In this way, the paper try to explain the previous misfit and improve the model.
Achieving a better match between ordered and actual performance of urban low-noise asphalts – exploring better solutions for noise abatement

Simon Steiner², Felix Schlatter¹, Erik Bühlmann¹

¹Grolimund + Partner AG - environmental engineering, Bern, Switzerland, ²Swiss Federal Office for the Environment FOEN, Noise and NIR, Bern, Switzerland

Thanks to the paradigm shift in noise abatement, over 1000 low-noise road surfaces have been constructed in urban areas in Switzerland in the last ten years. Until now, such road surfaces were often ordered according to a Swiss standard for semi-dense asphalts (SDA). The difficulty with low-noise road surfaces in urban areas from a noise abatement point of view is that the acoustic performance often varies by more than 3-4 dB when newly constructed – a variability in the product that is hardly acceptable to noise abatement professionals. This study investigates how a better match can be achieved between the ordered and the actual effect, by narrowing down the mixture design in the Swiss standard for SDA. For this purpose, several variants for a revised standard were analysed regarding the statistical risk of acoustic non-conformity. The analysis is based on a large dataset from a connected InterNoise22 paper where statistical analyses of acoustic measurement data and data from the laboratory tests of over 200 constructed low-noise surfaces in Switzerland are presented. This paper makes recommendations for revised mixtures in an improved Swiss standard for SDA, carefully balancing the advantages of the different variants with the practical limitations they bring.
Recommendations for the successful design of urban low-noise asphalts – findings from the statistics of over 200 mixtures

Erik Bühlmann1, Felix Schlatter1
2Grolimund + Partner AG - environmental engineering, Bern, Switzerland

In many countries, low-noise road surfaces have become an established measure to reduce road traffic noise. The focus often is on the high-speed network, where porous asphalts (PA) have been used successfully for decades. For urban areas, however, the design of effective low-noise asphalt mixtures remains a challenge, as a pore structure is needed that does not clog at lower speeds. Frequently found solutions are fine textured asphalts in the medium void content range with small pores. The challenge in this particular range is to define mixtures that guarantee a certain acoustic performance. This is exactly where the study comes in: a combined statistical analysis of data from acoustic measurements and laboratory testing of over 200 road surfaces is performed to identify mixtures in the medium void content range (between 8-18% void content) that lead to reliable noise reduction. Multivariate statistical analysis on over 500 drill core examinations allowed us to identify meaningful subcategories of urban low-noise asphalt mixtures, each of which implying a certain effect mechanism and effectiveness in noise reduction. Based on this data, we give recommendations for successful grading curve ranges and other mixture design parameters for urban low-noise asphalts grouped into different performance categories.
Project STEER: Improving the EU Tyre Noise Label and its impact on European Roads

Felix Schlatter¹, Ulf Sandberg², Truls Berge³, Luc Goubert⁴, Erik Bühlmann¹
¹Grolimund + Partner AG, Bern, Switzerland, ²VTI, Swedish National Road and Transport Research Institute, Linköping, Sweden, ³SINTEF, Trondheim, Norway, ⁴BRRC, Belgian Road Research Centre, Brussels, Belgium

Tyre/road noise is the dominant component of overall vehicle noise at medium and high speeds and for cars even at low speeds. Consequently, road traffic noise can be reduced with the proliferation of quieter tyres. One way to achieve this is to give the tyre noise label greater attention among tyre and transportation consumers. Hence, the STEER project has evaluated the relevance and performance of the noise part of the European tyre label, looking at how it works in practice, analyzing its uncertainties and suggesting how it can be improved. Its main finding is that the uncertainties in the measurement of noise level for the label are too high to be acceptable. This paper focuses on the solutions offered by STEER for an improved tyre label. With four main improvements, the overall uncertainty of the current procedure can be halved. A few possible future strategies to increase the market share of quieter tyres have been analyzed and their effects quantified. If the tyre noise label is improved and the market share of quieter tyres can be increased as project STEER proposes, area-wide reductions of up to 3 dB in road traffic noise emissions compared to the present situation are possible.

Link to paper
Optimisation of railway noise barrier design using finite element and boundary element modelling methods

Cesar Bustos¹, Vincent Jurdic²

Arup, Glasgow, United Kingdom

The prediction of environmental noise barrier insertion loss (IL) is commonly undertaken from widely available empirical methods derived from measurements and geometrical acoustic approximations. The accuracy of these methods is limited when analysing non-standard design parameters, such as geometry; characteristics and location of sound absorbing materials; or diffraction effects close to the barrier. This article presents a new methodology to optimise the design of a railway noise barrier using a simplified numerical method. The numerical method is based on a two-dimensional hybrid finite element and boundary element analysis. The numerical method has been calibrated and tested against measurements of high speed trains. The model assumes an infinitely long train with pre-defined sound sources (e.g. rolling source, body aerodynamic, etc.). The numerical model quantifies the effect of various parameters upon the barrier IL including material properties; area and location of sound absorbing materials; diffraction over the barrier top; and analysis of energy build-up between train and barrier. These parameters are not easily quantifiable using standard methods and hence the innovation aspect of the methodology. The outcome of this study can be used to optimise and improve confidence in the detailed design of complex noise barriers.
Application of in-situ blocked forces for characterising structure borne vibration of heavy industrial machinery

Florian Cabaret\textsuperscript{1}, Jacob McCormick\textsuperscript{1}, Kian Samami\textsuperscript{1}, Oliver Farrell\textsuperscript{1}, Andrew Elliott\textsuperscript{2}, Joshua Meggitt\textsuperscript{2}

\textsuperscript{1}Farrat Isolevel Ltd, Altrincham, United Kingdom, \textsuperscript{2}University of Salford, Salford, United Kingdom

Industrial machinery can generate excessive vibration, potentially reducing their productivity and disturbing their surroundings. Thus, it is essential to control vibration in industrial environments and accurate predictions are required to adopt mitigation measures in the initial design stages. It is first necessary to perform measurements on the vibration source to characterise its operational behaviour, and the obtained properties can be expressed in terms of its blocked forces according to ISO 20270:2019. The data can be obtained from the source mounted on a specific receiver, but still deliver intrinsic quantities that remain valid for any different receiver structures. Although good agreements have already been achieved between predictions and on-board validations from light weight structures, proving the theory is well understood, it has not yet been applied effectively to heavier assemblies which will be the focus of this work. A source characterisation case study is presented in this paper for a typical heavy industrial installation known as a press softly mounted on an inertia block isolated from the surrounding factory floor. A description of how the passive properties of the press were obtained and vibration predictions at different positions of the coupled assembly will also be given.

[Link to paper](#)
The impact of China's traffic noise spectrum on the Single-number-quantities (SNQs) evaluation of airborne sound insulation in the new era

Yangsheng Cai

1Fujian University Of Technology, Fuzhou, China

The ISO 717-1 specified the weighted sound reduction index calculation method of airborne sound insulation, also includes two spectrum adaptation terms C and Ctr, to take into account different spectra of environmental and living noises. The reference spectrum for Ctr is A-weighted urban traffic noise, and it is meant for noise sources such as traffic noise (urban road traffic, railway traffic at low speeds, propeller driven aircraft), disco music, and factory emission noise (low and medium frequency noise emissions). It should be noted that the spectra Ctr applied in ISO 717-1 was adopted from the Nordtest Method NT ACOU 061 (Nordtest, 1987). The means of transportation are undergoing great changes, and the characteristics of traffic noises are also changing significantly. Therefore, in order to better resolve the disputes caused by sound insulation and traffic noise in China, it is necessary to explore whether the existing evaluation standards are still applicable to various types of traffic noise. In this paper, the urban traffic noises in China have been measured and analyzed, a new spectrum adaptation terms for airborne sound insulation evaluation was established, and applied to the calculation of sound insulation of several common building components, and its applicability was discussed.
How Classroom Acoustic Conditions May Impact Autistic Students: A Review

Fernanda Caldas¹, Bruno Masiero¹, Lily Wang²
¹School of Electrical and Computer Engineering, University of Campinas, Campinas, Brazil, ²Durham School of Architectural Engineering and Construction, University of Nebraska - Lincoln, Omaha, USA

Data about the prevalence of autism worldwide diverge across different censuses. However, with the growing availability of diagnostic assessments, the number of diagnosed autistic persons has been increasing over the years and, with that, also the need for accommodations. One differentiating characteristic of autistic persons compared to those who are not is a hypo- or hypersensitive response to any sensory input, usually referred to as sensory processing disorder. Here we focus on auditory hypersensitivity. In room acoustics, and more specifically in the field of classroom acoustics, it is known that the design of indoor spaces affects speech intelligibility and comprehension for people regardless of their neurological condition, which is essential in learning environments. For autistic persons, high levels of reverberation and background noise may lead to a sensory overload. This situation could be ameliorated with the use of assistive technology or adequate acoustic design. In this paper we present a literature review regarding the impacts of room acoustics on autistic people, how it can be used as an accessibility tool, and propose ideas for work to be done to better identify and resolve acoustic issues for autistic persons in classrooms.
Sound environments and citizen action: what place for a participatory sciences tool? The case of the city of Rezé using NoiseCapture

Arnaud Can¹, Philippe Audubert², Pierre Aumond¹, Claire Guiu², Tristan Lorino¹, Emilie Rossa²
¹Université Gustave Eiffel, Bouguenais, France, ²Ville de Rezé, Rezé, France

Local authorities are increasingly interested in implementing participatory processes, associating inhabitants in decision-making. The Sonorezé project, involving researchers from the Gustave Eiffel University and the City of Rezé, evaluates the interest of a smartphone application for participatory noise measurement, namely NoiseCapture, as a vehicle for this citizen participation in the noise context. The project includes the recruitment of participants, the creation of participatory noise maps integrating different indicators, and the constitution of discussion groups that aim to elaborate concerted proposals regarding noise mitigation. In parallel, one will evaluate how access to this tool modifies the perception that inhabitants have of their soundscape, and facilitates their empowerment and the valorization of their inhabitant knowledge. This communication will present the whole workflow, highlighting how this framework helps to raise awareness of urban noise environments among inhabitants. Then, one will present in detail the dynamics of the recruitment, which amounts to more than 100 participants that performed almost 1000 measurements, at the stage of the first 4 months. The diversity of the participants' profiles, the temporal and spatial heterogeneity in the measurements, are however possibly an obstacle to the production of representative noise maps, which will be discussed in the communication.

Link to paper
Analysis of modulating tones in wind farm noise

Matthew Cand¹, Rylan Norcross¹
¹Hoare Lea LLP, Bristol, United Kingdom

The overall level of the noise from wind turbines generally remains the main regulatory driver for control of this source at neighbouring sensitive receptors. In addition, features sometimes present in the noise can increase its subjective disturbance: these are increasingly recognised and sometimes penalised. A fluctuating character in the aerodynamic noise is inherent to some degree, due to the rotation of the blades, but in some cases the Amplitude Modulation (AM) of the sound can become stronger. Tonality is another noise feature which can be detected in some cases due to resonances or emission from specific mechanical/electrical components in the turbine. Objective methods have been developed or adapted over the past years to objectively characterise the magnitude of both features in isolation. This paper considers cases where tones fluctuate, probably as they are emitted from a rotating component of the turbine. Different numerical quantification methods are compared and investigated and the implications on subjective response are considered.
Indoor acoustic comfort for ASD people: from independent living to educational environments

Federica Bettarello², Marco Caniato¹, Giovanni Pernigotto¹, Andrea Gasparella¹

¹Free University Of Bozen, Bozen, Italy, ²University of Trieste, Trieste, Italy

Autistic people, their families or caregivers need design processes capable of overcoming the difficulties of everyday life. In 2020, the Centre for Disease Control and Prevention reported that approximately 1 out of 54 children in the U.S. is diagnosed with an Autism Spectrum Disorder. Buildings are designed to provide a suitable living and learning environment for humans. Indoor comfort is necessary in different types of buildings, such as living, learning, working and healing environments. Good environmental quality is important as it affects health, comfort and productivity, significantly impacting on psychological and physiological aspects. The traditional reference could not be suitable in environments dedicated to individuals with special needs, since well-being strongly depends on individual differences in perception. It has been demonstrated that impaired individuals offer diverse responses to indoor environmental stimuli, in comparison with traditional users. Knowing this difference world would permit the realization of more inclusive spaces.

Thanks to the first results obtained, a comprehensive representative description of the peculiarities affecting these individuals’ acoustic sensitivity has been obtained. Further developments have been focused on similar acoustic aspects on collective spaces, such as schools, defining which aspects most stress autistic people, as regards building and room acoustics issues.
Main sensitivity drivers in indoor acoustic comfort for autistic individuals

Marco Caniato¹, Arianna Marzi¹, Andrea Gasparella¹
¹Free University Of Bozen, Bozen, Italy

The present study analyze the acoustic stress induced on autistic individuals, studied by means of questionnaires administrated to parents and professional caregivers. The acoustics comfort domain has a greatest impact on autistic people; indeed variations of spatial acoustic parameters can influence the sensitivities of each individual and the perceived stress is influenced by severity of autism, co-morbidities and age. The study highlights that there are clear differences if the indirect evaluations performed by parents or professional caregivers, in relation to the specific identification of stress sources. Acoustics domain is identified as the one causing the major stress, especially caused by noises and particular sounds such as voices, animal sounds and impacts, and its dependence on the severity of autism is evidenced. The proposed approach can be applied to well-being studies involving people with other types of conditions which could alter their perception of the built environment.
Finite element analysis of bending waves in Mindlin plates with Perfectly Matched Layers

Da Cao¹, Naohisa Inoue², Tetsuya Sakuma¹
¹The University of Tokyo, Bunkyo-ku, Japan, ²Maebashi Institute of Technology, Maebashi-shi, Japan

It is important to determine the boundary conditions of walls and floors precisely when simulating the building acoustics. For a certain room, the extension of the spans can be considered as infinite edges. The Perfect Matched Layer (PML) is an artificial absorbing domain for the wave propagations and is widely used in finite element analysis to simulate the acoustical free field conditions right now. In this paper, an effective PML technique for the plate structure will be presented. The PML formulation will be derived based on the Mindlin plate theory and the implementation method will be introduced. This technique will be validated through the numerical experiments. The accuracy and limits of the presented technique will be discussed based on the numerical results compared with the analytical results. The results show that the presented PML technique is effective and accurate to simulate the plate as an infinite large plate. It is expected to implement the technique in the further research of the structure borne sound, such as floor impact sounds.
An experimental investigation into the influence of installed passively controlled jet flows on wall-pressure fluctuations

Edoardo Carbini\(^1\), Jack Lawrence\(^2\), Anderson Proença\(^3\), Stefano Meloni\(^1\), Roberto Camussi\(^1\)

\(^1\)University of Roma Tre, Rome, Italy, \(^2\)University of Southampton, Southampton, United Kingdom, \(^3\)Cranfield University, Cranfield, United Kingdom

Jet-surface interaction (JSI) represents a significant noise problem in the installation of modern ultra-high bypass ratio turbofan engines. The use of chevron nozzles is known to reduce low-frequency jet mixing noise (JM) by increasing the velocity gradient in the jet shear layer. This effect is expected to influence the jet flow in the vicinity of the wing and to modify the jet-surface interaction noise. To clarify the physics of these two (JSI and JM) noise source mechanisms, an extensive experimental investigation has been conducted in the anechoic chamber of the Doak Laboratory at the University of Southampton. Various measurements were carried out on an isolated subsonic jet and an installed beneath a 2D NACA4415 airfoil using different nozzle shapes and passive vortex generator geometries. The wall-pressure field on the airfoil surface was investigated using a set of wall-pressure transducers flush-mounted in the streamwise and spanwise directions on the pressure side of the airfoil. The unsteady wall-pressure data were analysed in both time and frequency domains to assess changes in: 1) surface trailing edge spanwise correlation length, 2) streamwise convection velocity of the hydrodynamic pressure field, and 3) modification of the hydrodynamic pressure field in the vicinity of the surface trailing edge.
Applying Spanish Acoustic Regulations to mechanical ventilation with heat recovery systems. Case study.

Teresa Carrascal García¹, Amelia Romero Fernández¹, Belén Casla Herguedas¹
¹Eduardo Torroja Institute for Construction Science (IETcc), Serrano Galvache 4. 28033 MADRID, Spain

Due to recent changes in IAQ (Indoor Air Quality) and energy efficiency requirements, MVHR (Mechanical Ventilation with Heat Recovery) has become increasingly common in Spanish new build dwellings. Regarding acoustics, Spanish Decree RD 1367/2007 sets out limits for sound pressure levels due to building services and describes the noise measurement and assessment procedure, which applies also to ventilation noise. The assessment procedure consists of a series of measurements of different noise parameters and then the calculation of corrections due to tonal, low frequency and impulsive components. This paper shows an example of a MVHR fan unit installed in the ceiling of a common dwelling, where some measurements were performed. Based on these measurements, this paper discusses the noise measurement and assessment procedures and proposes some improvements for the Spanish acoustic regulations. In addition, it also analyses the available calculation methods (ASHRAE and VDI 2081) and their application to comply with Spanish requirements.

Link to paper
Insight into the sound field during a Direct Field Acoustic Test (DFAT)

Alessandro Carrella¹, Wes Mayne¹
¹MSI-DFAT Services LLC, 4900 Wethererdsville Rd, United States

Over the past 2 decades acoustic testing for the space industry has evolved from the ubiquitous reverberant chambers to using loudspeakers in what has been defined as Direct Field Acoustic Testing (DFAT). The initial need was to create a versatile system to provide a portable test facility to qualify space hardware on site as opposed to go to a dedicated test facility. Since that initial test carried out by MSI in the late ‘90s equipment and control strategies have improved and today it is possible to recreate an acoustic field which is very similar to that of a reverberant chamber. Using Multi-Input-Multi-Output (MIMO) control strategy has solved many of the initial issues. And it allows for control of the field’s diffusivity. However, unlike a test in a reverberant chambers, the acoustic fields produced in a DFA test is dependent on the parameters used by the controller, its specific technology, and the whole sound generation system. This paper attempts to provide a qualitative overview and insight in the acoustic field generated by a set of loudspeakers set around a test item. Particular focus is placed on the diffusivity of the field as this is a characteristic that is linked to the structural response of the device under test.

Link to paper
Manchester Soundscape Experiment Online 2020: an overview

Maria Luiza Carvalho¹, William J. Davies¹, Bruno Fazenda¹
¹Acoustics Research Centre, University of Salford, Salford, United Kingdom, ²Faculty of Arts, Federal University of Goias, Goiania, Brazil

This paper presents results from the Manchester Soundscape Experiment Online 2020. It consisted of a virtual reality (VR) experiment online where participants rated 12 different scenarios with questions. The selected locations were Piccadilly Gardens, Market Street, Peel Park, and a bus stop. Each site was visited and recorded with a 360 camera and soundfield microphone on three crowd densities (empty, medium, and busy). Audio stimuli were converted from first-order ambisonic recordings to head-tracked binaural using Facebook Spatial Workstation software. The questions included the eight soundscape attributes from ISO 12913, three emotional self-assessment manikins, and demographic information. A total of 63 nationalities composed the group of 158 participants. Results from Piccadilly Gardens demonstrated that the eventful and vibrant scales significantly increased with the number of people in the scene. This tendency also happened at Market Street and Peel Park on the arousal emotional state. The other sites had these increases but were not as significant. Future research will include verifying these findings in laboratory conditions alongside measurements of brain activity via electroencephalogram.

[Link to paper]
Optimization of a contra-rotating propeller rig for reduced psychoacoustic impact

Fabio Casagrande Hirono⁴, Antonio Torija Martinez⁴, Andrew Elliott⁴
²University Of Salford, Manchester, United Kingdom

With unmanned aerial vehicles emerging as potential alternatives for people and cargo transport, their noise impact will be a determining factor in their acceptance by the general public. Contra-rotating propeller configurations are often explored due to their improved aerodynamic performance and redundancy in case of failure compared to conventional single-propeller aircraft, but can be much noisier than their single-propeller equivalent. This work describes the optimization of a custom-made contra-rotating propeller rig for reduced psychoacoustic impact. The rig consists of two electric motors mounted on a rotating stand, positioned inside an anechoic chamber. A far-field microphone arc is used to collect acoustic pressure data, and a load cell is used to measure total thrust. The axial distance between the propellers is varied between 0.1 and 1 rotor diameters, and the number of blades is varied between 2 and 6 on both propellers. Meanwhile, the rpm is adjusted to maintain constant thrust across the different configurations. Acoustic pressure signals are investigated in terms of their physical acoustic characteristics and psychoacoustic features (such as Loudness, Sharpness, Tonality, Fluctuation Strength, Roughness and Impulsiveness) in order to determine the trade-offs and optimal choices in reducing the psychoacoustic impact of the rig.
Porous top layer optimization of cement concrete slabs for tyre/road noise reduction

Philippe Klein², Julien Cesbron¹, Simon Bianchetti², Éric Gennesseaux³, Thierry Sedran³, Julien Waligora⁴

¹UMRAE, Univ Gustave Eiffel, IFSTTAR, CEREMA, F-44344, Bouguenais, France, ²UMRAE, Univ Gustave Eiffel, IFSTTAR, CEREMA, Univ Lyon, F-69675, Lyon, France, ³Univ Gustave Eiffel, MAST-MIT, F-44344 Bouguenais, F-44344, Bouguenais, France, ⁴EIFFAGE Infrastructures GD, F-69964, Corbas, France

The I-STREET CUD-SF project aims at developing an urban pavement made of cement concrete slabs that can be easily removed and replaced for maintenance purposes. These slabs are made of a dense cement concrete body and a functionalized porous top layer ensuring water drainage and sound absorption. In order to optimize the porous layer for tyre/road noise reduction, several mix recipes with different porosity and maximum aggregate size were considered. Recipes with the most interesting absorption properties were preliminary selected based on absorption coefficient measurements performed on cylindrical test specimens with an impedance tube. A second phase was dedicated to evaluation of texture induced coast-by rolling noise levels with the tyre/road noise prediction model HyRoNE from 3D texture scans performed on rectangular laboratory samples. Finally, based on a porous medium model and a propagation model considering the tyre/road noise source as an omnidirectional point source over an impedance plane surface, the porous layer thickness of the selected mix was adjusted to minimize the predicted noise at roadside for different reference rolling speeds. This paper gives an overview of the results obtained at the different stages of the optimization process, prior in-situ assessment of the industrial solution in a near future.

Link to paper
Genetic algorithm for the optimization of damping material

Jain Chacko¹, Stefanie Retka¹
¹University Of Applied Sciences Würzburg-Schweinfurt, Schweinfurt, Germany

A main research topic in acoustics is the reduction of indoor noise, which has increasingly received attention in recent years. A commonly used solution to solve these problems is reducing noise using damping structures, which absorb sound. This work aims at the numerical optimization of damping structures in interior problems, following three goals. First, the optimal damping structure for the required frequency range has to be determined. Second, the optimal position of the damping material has to be found. Third, we are focusing on lightweight design, which means that the amount of damping material used, has to be kept to a minimum.

We present the implementation of a genetic algorithm into our open source code, which we use to optimize the damping behaviour and in consequence, the sound propagation for interior problems. We show an example of the application of this code.
The equivalent source method has been one of the most commonly used methods for sound source localization. It involves equivalent sources spread over the source plane (or region). The pressure fields from these equivalent sources are usually spherical harmonics. But, the spherical harmonic fields are derived for the Sommerfeld boundary condition with no reflection or reverberation. Data-driven methods help perform sound source localization in a reverberant environment when no prior information about the surroundings is available. The methods studied are linear regression (LR) with Adam, linear regression with L-BFGS, multi-layer perceptron (MLP) with one and two hidden layers. The simulations are conducted for two monopoles in rooms with different reverberation times and compared with one norm convex optimization (L1CVX). It is observed that overall, LR with L-BFGS gave the best results. Also, for low reverberation time, LR with L-BFGS was able to localize the sources better than L1CVX.
A large-scale study of the social response to construction noise in Hong Kong

Silver Chan¹, K.C. Lam², C.L. Wong¹, Richard Kwan³, Wilson Ho³, Morgan Cheng³, Max Yiu³

¹Environmental Protection Department, The Government Of The Hong Kong Special Administrative Region, ²Department of Geography and Resource Management, The Chinese University of Hong Kong, ³Wilson Acoustics Limited

Construction noise is an issue in many large cities with potential annoyance and disturbance effects. With an aim to providing necessary data for formulating noise control strategies, a large-scale social survey was commissioned in Hong Kong and undertaken by a team of acoustic experts in 2018-2020. Based on the interview of around 5,000 randomly selected households following the ISO standard on 11-point numeric scale (ISO/TS 15666, 2003), this was one of the few large-scale studies carried out in a dense and compact city. This paper describes the rationale and approach of the study, the sampling and questionnaire design. Some of the key study findings are presented, highlighting in particular the prevalence and nature of construction and domestic renovation noise; annoyance and sleeping response of the respondents that would be useful for developing construction noise management strategies in Hong Kong. The findings are also compared with the data collected in an earlier similar study undertaken 10 years ago to analyze the trend and changes in people's perception on construction noise impacts.

Link to paper
Reflections on an EDI Survey of UK-Government-Funded Research Networks in the UK

Simon Chandler-wilde\textsuperscript{1}, Debra Fearnshaw\textsuperscript{2}, Oliver Fisher\textsuperscript{2}, Eleri Jones\textsuperscript{3}, Samantha Kanza\textsuperscript{4}
\textsuperscript{1}\textit{University Of Reading, Reading, United Kingdom}, \textsuperscript{2}\textit{University of Nottingham, Nottingham, United Kingdom}, \textsuperscript{3}\textit{University College London, London, United Kingdom}, \textsuperscript{4}\textit{University of Southampton, Southampton, United Kingdom}

We discuss the results of a Community EDI Survey run in July-September 2021 by the Network of Networks, a union of research networks that are largely funded by the UK Engineering and Physical Sciences Research Council and fall under their remit. Responses were received from members of 19 networks, with, relevant to this meeting, 70\% of the 267 responses coming from members of the UK Acoustics Network. We discuss implications of the results for how we organise and support attendance at events across our networks, reflecting on feedback to questions on barriers and possible enablers to attending in-person events, and on feedback as to what does and doesn't work for events blending in-person and online attendance. To put this work in context we survey relevant literature on the value or otherwise of blended and online events for supporting the diverse membership of a network. The survey results also provide interesting feedback on the diversity of our networks and how inclusive our networks are perceived to be as a function of the identity of the respondents. We reflect also on lessons from this experience regarding how and how not to attract a strong response to surveys of this type.

\textbf{Link to paper}
Acoustic Black Holes (ABHs) can be realised as tapered structural features that focus and absorb vibrational energy. In a plate, the damping effect of ABHs can be used to reduce the radiation efficiency, particularly above the critical frequency of the plate. However, at lower frequencies, there is still significant radiation due to the low order modes of the plate. It has previously been shown that the combination of active control and ABHs can result in an effective broadband control solution with lower computational and power requirements compared to a standalone active configuration. This paper presents an investigation into how two different active control strategies affect structural response and radiated sound power of a plate with active ABHs (AABHs). It is shown, through an active vibration control strategy and an active noise control strategy, that the AABHs can be used to successfully control either the global structural response of the plate or the radiated sound power. However, it is also shown that controlling either response can lead to an enhancement in the other.
Acoustic Black Holes in Curved Plates

Kristian Hook\textsuperscript{1}, Jordan Cheer\textsuperscript{1}, Stephen Daley\textsuperscript{1}
\textsuperscript{1}Institute of Sound and Vibration Research, University Of Southampton, Southampton, United Kingdom

Acoustic Black Holes (ABHs) have been shown to produce significant vibration damping in both beams and flat plates. However, it is interesting to determine how more complex structures with singularly curved surfaces are damped by the addition of ABHs. Therefore, this paper presents an investigation into three different ABH designs that can be implemented into a curved plate. The performance of each ABH design is compared in terms of the global structural response of the curved plate.

[Link to paper]
Bayesian Parameter estimation of microphone positions, sound speed and dissipation for impedance tube measurements

Ziqi Chen¹, Cameron Fackler¹, Ning Xiang¹
¹Graduate Program in Architectural Acoustics, Rensselaer Polytechnic Institute, Troy, United States

With tube measurement widely used for acoustic measurements, calibration plays an important role in verifying and validating the measurement. This work applies a Bayesian method based on an air layer reflectance model to estimate the microphone positions, and sound speed in consideration of environmental effects on uncertainties of the normal incident impedance tube measurements. Bayesian theorem is applied to estimate the microphone positions and sound speed given the experimental data obtained from the transfer function method (TFM) in tube measurements. With a hypothetical air layer treated as material under test in front of a rigid backing in the tube, a parametric model is established for the TFM tube measurement to estimate the microphone positions using Bayesian inference. With the microphone positions accurately estimated, sound speed and losses due to tube interior boundary effects are also estimated within the same Bayesian framework. Bayesian analysis results show that Bayesian parameter estimation based on the air layer model is well suited in estimating the sound speed, microphone positions, and other parameters to ensure highly accurate tube measurements.
The effect of the vibrissa shaped cylinder on the aeolian tone mitigation

Guanjiang Chen¹, Xiao Liu¹, Bin Zang¹, Mahdi Azarpeyvand¹
¹University of Bristol, City Of Bristol, UK

This paper studies vibrissa shaped cylinder as a passive control method for reducing the aerodynamic noise of the flow past a cylinder. One elliptical cylinder is also investigated for comparison. The far-field noise results show that compared with the cylinder case, the tonal peak almost disappears in the vibrissa shaped cylinder case and the sound pressure level (SPL) could be reduced by up to 30dB within the velocity range from 8m/s to 35m/s. The elliptical cylinder only shows a slight SPL reduction by about 4 dB with a shift in the tonal peak frequency from St=0.2 to St=0.39. Furthermore, some noticeable variations occur in the noise directivity pattern for the vibrissa shaped cylinder case. The shift in the tonal peak frequency, the reduction in noise and modifications in the noise directivity is related to the changing and breakdown of the vortex shedding caused by the interference with the elliptical and vibrissa shaped cylinder surfaces. The LES is conducted to the elliptical and vibrissa cylinder case for the fluid field information to further understand the mechanism of the noise reduction due to the vibrissa shaped cylinder and elliptical cylinder.

[Link to paper]
Method of high precision pointing control for spacecraft system based on the active-passive integrated orthogonal micro-vibration isolation platform

Zhizhou Chen¹, Li Feng¹, Hu Xueping¹, Ma Xiaolong¹, Ma Longyu¹, Shi Junwei¹
¹Shanghai Institute Of Aerospace System Engineering, Shanghai, China

To acquire the high precision pointing control for spacecraft system under the disturbance of micro-vibration, and resolve conflicts between the vibration suppression and pointing control, a simultaneous-distributed control method was proposed in this paper. Based on this method and the Stewart platform, an active-passive integrated orthogonal micro-vibration isolation platform with multiple dimensions was developed. Six line-actuators according to the configuration of Gough-Stewart parallel mechanism were selected to build the platform. Specially, the displacement of the line-actuator was converted from the end deflection of two groups of active and passive integrated cantilever beams, which contained viscoelastic damping plate, aluminum material and macro fiber composite (MFC). It should be noted that the dynamic model of the platform system was strongly coupled and it was decoupled by employing the orthogonal configuration. By employing the simultaneous-distributed control strategy, the integrated control algorithm of vibration isolation and pointing was deeply studied. Furthermore, the dynamic behavior and control effects for the 6 degree of freedom (6-DOF) Stewart platform with different control strategies were compared and analyzed. Results showed the method had a good vibration isolation effect and reliable pointing accuracy, which could be applied for the spacecraft requiring high precision pointing.

Link to paper
Systematic Review of meta-analyses for noise

Yingxin Chen¹, Claire Blackmore¹, Katie Eminson¹, Xiangpu Gong¹, Anna Hansell¹

¹Centre for Environmental Health and Sustainability, University Of Leicester, Leicester, United Kingdom

In the context of constructing a burden of disease toolkit for noise exposures in England, we sought to identify meta-analyses to provide exposure-response coefficients that would update those available from the WHO Noise Guidelines for the European Region published in 2018. We conducted a systematic review of systematic reviews relating to noise exposure and selected health outcomes published in 2017-20. We used the AMSTAR checklist to score all selected systematic review papers at the same time as data extraction. A new review needed to have at least a moderate score on AMSTAR to be recommended as an alternative/update to the WHO analyses.

Twenty-three papers were included in the review, of which 11 studies provides quantitative effects estimates. Eight considered environmental noise associations with metabolic outcomes, seven with mental health outcomes, six with cardiovascular outcomes, and five studies systematically reviewed on wellbeing, sleep, and annoyance. We recommend one new meta-analysis on diabetes and one on hypertension, plus a further new meta-analysis on IHD to be considered for use in place of the WHO systematic review. Our review also suggested there are now enough papers available to conduct a future new meta-analysis for noise and dementia.

Link to paper
Outlook for the ISO 22955 standard

Yoan Le-Muet, Patrick Chevret¹, Thomas Bonzom², Laurent Brocolini³

¹Inrs, Vandoeuvre Les Nancy, France, ²Carsat Languedoc Roussillon, Aix en Provence, France

The ISO 22955 standard « Acoustic quality of open plan offices » was published in May 2021. It aims to provide principles, descriptors, and measurement methods to characterize acoustics, which are easy to use and correspond to the perception of the acoustical environment by the occupants of the spaces. The scope of the standard is the acoustics of open-plan offices and, more specifically, cognitive effects of noise, i.e. acoustic comfort and noise disturbance in association with the activity.

After more than a year of use of the standard, this document proposes to take stock of it and to identify potential paths of reflection for a possible future revision. Among the points of discussion considered, are the consequences of the evolution of office work, activities and concepts in the tertiary sector (flex office, co-working, teleworking, etc.), and their implication on acoustic quality. Another fundamental matter is the relevance of the indicators used in the standard and the associated required values.

[Link to paper]
Modelling of wheel/rail squeal noise in curves from mono-harmonic vibratory limit cycles

Olivier Chiello¹, Rita Tufano², Martin Rissmann²
¹UMRAE, Univ Gustave Eiffel, IFSTTAR, CEREMA, Univ Lyon, F-69675, Lyon, France, ²Vibratec, Railway Business Unit, 28 chemin du petit bois, 69131 Ecully, France

Most of the works in the literature agree to attribute the generation of wheel/rail squeal noise in curves to the important lateral slip imposed in the curve and the resulting instabilities. In models, the occurrence of the phenomenon is thus generally studied through a stability analysis based on the linearization of the contact forces. Despite its undeniable interest, the stability analysis does not allow the prediction of the amplitudes of the nonlinear self-sustained vibrations resulting from the instabilities. These nonlinear vibrations are most often calculated using a numerical integration of the dynamic equations of the system in the time domain. Some authors have proposed simplified methods allowing a direct calculation of stationary regimes, but limited to a reduced modal description of the system dynamics. In this presentation, an original method is proposed to determine approximate limit cycles from the wheel/rail contact mobilities expressed in the frequency domain. The contact condensation allows to be both more general and more functional to describe the dynamics of structures, in particular the one of the rail. Assuming a mono-harmonic vibratory cycle, the corresponding amplitude is determined from a power balance and the squeal level at the considered pulsation is obtained from analytical radiation factors.

Link to paper
Duration dependence of night-time noise effect for passively cooled residential bedrooms.

Anthony Chilton, Peter Leonard
Max Fordham LLP, London, United Kingdom

The Acoustics, Ventilation, Overheating: Residential Design Guide (“The AVO Guide”) was launched by the Association of Noise Consultants and Institute of Acoustics in January 2020. It provides a methodology for assessing the adverse effect due to break-in of external transport noise through façade openings provided for the purpose of mitigating overheating (i.e. passive cooling). Figure 3-2 of the AVO Guide indicates qualitatively how the SOAEL (Significant Observed Adverse Effect Level) is expected to vary with the duration for which the ‘overheating condition’ occurs. However, no quantitative guidance regarding the dependence on duration is given.

This study describes how the methodology used in the WHO Night Noise Guidance for Europe 2009 to evaluate outside-to-inside level difference can be extended to provide a quantitative definition of the SOAEL for transport noise affecting passively cooled residential bedrooms at night. A quantitative version of the AVO Guide Figure 3-2 is derived and presented. Comparison is made with the duration/frequency independent values suggested in the recently published Approved Document Part O (“ADO”). Commentary is also provided regarding the urgent need for better availability of relevant information on the frequency of occurrence of window openings for residential buildings in use.

Link to paper
Finite Element modeling of force amplification at the spindle due to a tire’s cavity mode: experimental verification

Won Hong Choi¹, J. Stuart Bolton², Kyosung Choo¹, Matthew Black²
¹Purdue University, West Lafayette, United States, ²Ford Motor Company, Dearborn, United States

Reduction of tire-road noise is an important issue when developing luxury cars and electric vehicles. In this context, the air-cavity mode is an important source of spindle forces transmitted to the suspension that then increase interior noise levels. When a tire rotates, the cavity mode near 200 Hz splits into two adjacent modes due to a Doppler effect and tire deformation. That split can lead to increased levels of both longitudinal and vertical spindle forces at the spindle since the two acoustic modes each contribute to both forces when the tire rotates. Thus, it is important to develop tools to identify the contributions of the split air-cavity modes to the spindle force. A FE simulation of the spindle force for a steady-state rolling has been verified by a comparison with laboratory test results obtained by using a wheel-force transducer mounted on Purdue’s Tire Pavement Test Apparatus. It was observed that the frequency split expands as the rotation speed increases and that the vertical spindle force increases when aligned with an odd-numbered circumferential structural mode. By using the correlated simulation model, parametric studies have been carried out focused on minimizing the vertical spindle force due to air-cavity mode near 200 Hz.
A Feasibility Study of Riblet for Aeroacoustics Applications

Chioma Muhammad¹, Tze Pei Chong¹
¹Brunel University London, Uxbridge, United Kingdom

Although the use of finlet, serration or porous surface has been shown a good level of success in reducing aerofoil trailing-edge noise, they are largely incompatible to the otherwise streamlined aerofoil body. This paper is a feasibility study to investigate the riblet, which has so far been quite successful as a drag-reducing device, for its potential to reduce the turbulent pressure sources that are important for aerofoil self-noise radiation. The completed results show that the riblet used in the current study can reduce the skin-friction coefficient, as well as the turbulence-intensity in the boundary-layer profiles. In addition, the turbulence structures in the convective field can be dissipated more rapidly when crossing the riblet surface. It is also found that (1) the riblet produces a slight reduction of the wall-pressure power spectral density level at the low and high frequency ranges, but experiences an increase at the mid frequency, (2) the riblet can reduce the lateral turbulence coherence length-scale across a large frequency range. The product of these two hydrodynamic sources represents an important mechanism for the radiation of the trailing-edge self-noise, whose low and high frequency ranges are found to be sensitive to the riblet effect where reduction can occur.
Distinct influence of everyday noise on cardiovascular stress

Jeppe Christensen¹, Klaudia Andersson²,³, Tobias Neher²,³
¹Eriksholm Research Centre, Snekkersten, Denmark, ²Institute of Clinical Research, University of Southern Denmark, Odense, Denmark, ³Research Unit for ORL – Head & Neck Surgery and Audiology, Odense University Hospital & University of Southern Denmark, Odense, Denmark

High-intensity environmental noise is known to be detrimental to cardiovascular health. However, individual differences have not been considered, and reported effects cannot be generalized to noise levels reflecting everyday life.
Here, we explore the relationship between daily-life sound exposure and heart rate with longitudinal data from ten individuals across three weeks. We analyze the daily short-term covariation between changes in heart rate and sound intensity using multi-level regression and Granger analysis.
We find strong evidence that everyday sound exposure is related to heart rate in all participants. Sound intensity is linearly and positively related to heart rate, while the ambient signal-to-noise ratio has a negative association to heart rate in louder environments. Across participants we establish a distinct temporal pattern of Granger causality with stronger influence of the sound environment on heart rate from 6:00 hrs to 16:00 hrs than for the rest of the afternoon/evening.
We propose that sound sensitivity measures represent a combination of the amount of effort asserted to listen under noisy conditions during the active periods of a day and the direct physiological sound-induced stress reaction. A thorough understanding of both factors is necessary to determine the full extent to which everyday noise influence long-term health.

Link to paper
Psychoacoustic Analysis of Various Train Pass-by Noise Using

Youngbeen Chung

1Department Of Mechanical Engineering, Hanyang University, Seoul, South Korea

Due to the recent high speed of railway, noise and vibration generated during operation has emerged as a major social problem. Specially, the internal noise of railway varies depending on various operating conditions such as speed, vehicle crossings, and tunnel entry, and has a great effect on the riding comfort of passengers. In this study, an evaluation method for binaural noise of train pass-by noise and a simple wave field model which can reflect the Doppler effect are examined. To reflect the binaural characteristics of train pass-by noise, binaural measurements were conducted for several types of train, different measurement distances and various measurement angles. The annoyances of measured binaural noises were analyzed using conventional sound pressure level, psychoacoustic metrics, and their rate of change. Also, the noise emitted from high-speed railways was measured and characterized. By its analysis result, moving sounds were synthesized considering an initial frequency and a frequency shift. The synthesized sounds were convolved to reflect binaural condition. Auditory experiments were conducted using the synthesized moving sound stimuli, and the effects of the Doppler frequency shift on annoyance of moving sound sources were obtained.

Link to paper
Dilatation wave velocities estimated from the plateau in sound insulation of cross-laminated timber (CLT) plates

Claire Churchill\textsuperscript{1}, Bernd Nusser\textsuperscript{2}, Christian Lux\textsuperscript{2}
\textsuperscript{1}TU Wien, Vienna, Austria, \textsuperscript{2}Holzforschung Austria, Vienna, Austria

There are four inherent problems when predicting the airborne sound insulation of cross-laminated timber (CLT) plates. (1) The internal loss factor of wood products is high and therefore difficult to measure using the structural reverberation time technique. (2) Solid wood is a low-density building material compared to reinforced concrete or masonry construction. (3) Timber is orthotropic. (4) Orthotropic behaviour includes low shear moduli. CLT plates, similarly to thick masonry or concrete plates, exhibit thick plate behaviour in the high frequency range (f>1600Hz). The high frequency sound insulation data of nine plates is examined. Transitions to a thick plate seems to occur in all measurements. However, a clearly observable plateau is only visible for six of the nine plates. Simple methods are applied to extract information about the CLT plates from this high frequency (f>1600Hz) measured data. The data extracted from the plate is compared to typical values for equivalent isotropic plates, where the bending stiffness is assumed to be $B_{iso} = \sqrt{B_x B_y}$. The results are discussed in the context of laboratory measurement of sound insulation.
A Boundary Element Method (BEM) Solver for Low Frequency Room Modes

Andrea Cicero\textsuperscript{1,2}, Jonathan A. Hargreaves\textsuperscript{1}

\textsuperscript{1}Acoustics Research Group, Newton Building, University of Salford, Salford, M5 4WT, United Kingdom, \textsuperscript{2}AC Acustica - Acoustic Design, Ragusa, 97100, Italy

Room modes are known to be problematic in small critical listening environments. They degrade the acoustic quality at low frequencies, producing peaks and nulls in the frequency domain and ringing in the time domain. The Finite Element Method (FEM) is currently the easiest way to predict such resonances for arbitrarily shaped rooms. This solves for mode frequencies and shapes, as well as Q-factors and decay rates. Such ‘eigenfrequency’ solvers are commonplace in FEM, but FEM has the disadvantage of needing to mesh the entire air volume in the room. The Boundary Element Method (BEM) avoids this and only requires a simple boundary mesh, but solution of its eigenfrequency problems is much more challenging and appears in only a few academic papers. Here we transfer those approaches to Room Acoustics. We implement the block Sakurai-Sugiura method, which uses a contour integral in the complex frequency plane to convert the BEM eigenfrequency problem, which is usually non-linear in wavenumber, into a standard linear eigenfrequency problem that is straightforward to solve. The method is demonstrated through application to a cuboid room and an irregularly shaped room, both with impedance boundary conditions. Results are validated against FEM and discussed.
The influence of thermo-hygrometric conditions on metamaterials’ acoustic performance: an investigation on a 3D printed coiled-up resonator

Matteo Cingolani¹, Gioia Fusaro¹, Massimo Garai¹
¹Applied Physics, Department of Industrial Engineering, University of Bologna, Bologna, Italy

In the last decades, coiled-up resonators have become popular within the metamaterial research community for narrow band, low frequency resonances combined to subwavelength thickness. Such structures are particularly suited to one of the most widespread manufacturing processes, i.e. PET-based 3D printing. Acoustic performance of coiled-up resonators depends on the geometrical parameters’ variation, which is influenced by thermo-hygrometric conditions; however, the deformation itself needs to be further investigated. For this reason, the present paper evaluates the correlation between temperature, relative humidity, and the geometrical parameters’ (spiral length and hole diameter) deformations and, consequently, the acoustic performance of a 3D printed coiled-up resonator. A combined approach through analytical, numerical, and experimental measurements quantified the frequency shift of the resonance peaks (within 300 Hz - 5000 Hz) in terms of sound absorption coefficient increasing the temperature (T=10-50° C), and the relative humidity (RH=20-80 %) of the samples. Relative humidity variations turned neglectable discrepancies on sound absorption’s peaks. On the other hand, the increase in temperature caused a frequency peaks’ shift following an exponential trend: this behavior is straight related to the exponential relationship between the temperature and specific volume function of polyethylene resins.
Relationships between loudness and preference judgments for fan sounds as a function of the reference sound pressure level

Eike Claassen1, Stephan Töpken, Steven van de Par
1Carl Von Ossietzky University, Acoustics Group, Department of Medical Physics and Acoustics, Oldenburg, Germany

In a prior study, the level of fan test sounds was adjusted in a listening test using an adaptive procedure, until they became equally loud or equally preferred as a reference sound at a fixed level. Depending on the test sound, level reductions of up to 15 dB compared to the 60 dB(A) reference level were necessary to reach equal loudness or preference compared to the reference sound. It turned out that the preference-equivalent levels were highly correlated with the loudness-equivalent levels, indicating that the preference decision and the loudness judgment were closely related to each other.

In a follow-up study, the measurements were extended towards a higher reference level of 75 dB(A) and a lower reference level of 45 dB(A). The preference-equivalent levels obtained at 75 dB(A) were again closely related to the loudness-equivalent levels.

For the lower reference level of 45 dB(A), the preference-equivalent levels deviate from the loudness-equivalent levels by 3.5 dB on average and also the inter-individual variability increased. This result suggests an increasing effect of additional fan-noise characteristics to play a role for the preference decisions on top of the perceived loudness especially at low absolute sound pressure levels.

Link to paper
Characterizing noise barriers: SOPRANOISE final report and outcomes

Jean-Pierre Clairbois¹, Massimo Garai², Paolo Guidorzi², Marco Conter¹, Andreas Fuchs³, Wolfram Bartolomaeus⁴, Michael Chudalla⁴, Fabio Strigari⁴, Christophe Nicodeme⁵

¹A-Tech Acoustic Technologies, Brussels, Belgium, ²University of Bologna, DIN Department of Industrial Engineering, Bologna, Italy, ³AIT Austrian Institute of Technology, Vienna, Austria, ⁴BAST Federal Highway Research Institute, Bergisch Gladbach, Germany, ⁵ERF European Road Federation, Brussels, Belgium

SOPRANOISE targets a three-step approach for assessing the in-situ intrinsic acoustic performance of road/railway noise barriers in regard to airborne sound insulation and sound reflection under direct sound field conditions. This approach goes from the in-situ inspections method (targeting at the acoustic effect in the far-field) to the standardized measuring methods EN 1793-5 and 6, with “quick and safe” measuring methods in between. Papers about SOPRANOISE have already been presented in 2020 and 2021 as progress reports. The research ended in February 2022 and the final outcomes are now presented. The main part of the pending work has been done within Work Package 4 (WP4). Herein, a new “quick and safe” method was designed and validated both in the lab and in situ. The new measuring equipment is portable, lightweight and uses a linear antenna; the measurement itself is fully automated and the results show a very good correlation with full EN 1793-5/-6 results. WP4 results are particularly successful and, together with the in-situ inspection, those methods are ready to be submitted to the relevant CEN/TC226/WG6 working group to draft a new framework on noise barriers assessment. All main reports are public available on the SOPRANOISE and CEDR webpages.
The latest Environment Agency Guidance for Noise and Vibration Management of Environmental Permits

Tony Clayton¹, Jon Tofts¹, Gillian Brown¹, Julija Smyrnowa¹

¹Environment Agency, United Kingdom

Environmental permits have conditions that require operators to control pollution – this includes controlling noise and vibration.

The Environment Agency (EA), Scottish Environment Protection Agency (SEPA), Natural Resources Wales (NRW) and Northern Ireland Environment Agency (NIEA) produced and published new guidance for Management of Noise for Permitted Processes in 2021, to help holders and potential holders of permits apply for, vary, and comply with their permits. The guidance is common to all four regulators. This guidance replaced the original Horizontal guidance for noise usually referred to as H3.

The paper will cover the development, authoring and publishing of the guidance. It will also cover some of the reasoning behind and the major clarifications which are contained within the new guidance. Issues with noise impact assessments and demonstrations of Best Available Techniques and Appropriate Measures will also be covered.

The guidance was developed to be consistent with the noise policies of all four devolved governments. The paper will briefly cover requirements of both operators and their consultants under legislation and the published guidance.
A 2.5D automatic FEM-SBM method for the evaluation of free-field vibrations induced by underground railway infrastructures

Hassan Liravi¹, Robert Arcos², Arnau Clot-Razquin²

¹Acoustical and Mechanical Engineering Laboratory (LEAM), Universitat Politècnica De Catalunya (UPC), C/ Colom 11, Terrassa 08222, Spain, ²Serra Húnter Fellow, Acoustical and Mechanical Engineering Laboratory (LEAM), Universitat Politècnica De Catalunya (UPC), C/ Colom 11, Terrassa 08222, Spain

This paper presents an efficient method to predict underground railway-induced vibrations. The method uses the finite element method (FEM) to model the railway tunnel structure and the singular boundary method (SBM) to model the wave propagation in the surrounding soil. The FEM mesh and the distribution of SBM collocation points at the tunnel/soil interface are generated using an automatic meshing strategy. The presented method is one of the main components of VIBWAY, a user-friendly prediction tool to address railway-induced vibration problems. This paper presents three calculation examples in which the soil response due to forces applied on the tunnel structure are computed in terms of transfer functions. The results obtained for each one of the calculation examples are compared with those computed using a model based on a 2.5D FEM-BEM approach. The presented comparisons show that the proposed approach is a suitable strategy for predicting underground railway-induced vibrations, both in terms of accuracy and computational efficiency. Moreover, the use of an automatic meshing strategy and the SBM formulation not only eases the implementation of the approach but it also makes it easier to use, which is one of the key features of the VIBWAY tool.

Link to paper
Modelling and visualization of surround buckling in electrodynamic audio transducers

Mattia Cobianchi\textsuperscript{1}, Christopher Spear\textsuperscript{1}
\textsuperscript{2}Bowers & Wilkins / Sound United, Southwater, United Kingdom

The surround (or front-suspension) of electrodynamic transducers typically used in loudspeakers and headphones is a device that provides the axial restoring force for the diaphragm movement and restrains the lateral and tilting movements. A non-linear phenomenon typical of surrounds is pressure-induced buckling, a sudden change in the shape of the surround under load. The question addressed by this paper is how to predict the conditions under which a surround will buckle, and how to measure and visualize it in physical prototypes. The modelling methodology was based on structural finite-element analysis, while the measurement of transducer displacement and video recording with a high-speed camera allowed the experimental verification. This methodology has been applied and tested on semi-circular rubber surrounds. The impact of working temperature and manufacturing tolerances are also discussed. It was found that it’s possible to predict the pressure threshold triggering a specific buckling mode within a 10\% error. Full 3D modelling is advisable to assess the buckling pressure of non-axisymmetric modes common in real transducers. At the same time, 2D modelling has been proven enough for the evaluation of the worst-case scenario / lowest buckling pressure.

\textbf{Link to paper}
Achieving Global Consensus on Acceptable Sound Levels for Overland Supersonic Flight

Peter Coen¹, Alexandra Loubeau¹, Jonathan Rathsam¹, Gautam Shah¹
²NASA, Hampton, United States

The National Aeronautics and Space Administration has committed to deliver to the International Civil Aviation Organization’s Committee on Aviation Environmental Protection (CAEP) data defining community response to sounds from supersonic aircraft designed such that their sonic boom is replaced with a soft “thump”. The dataset will correlate public perceptions to acoustic levels, supporting efforts to develop international standards for permissible noise from supersonic overflight. NASA is preparing for community overflight tests with the X-59, a research aircraft that generates the “sonic thump”.

For global consensus on standards, NASA seeks response data broadly representative of the response of the international population. NASA has engaged the international community through briefings at CAEP meetings and workshops with international participation. A virtual workshop in December 2021 focused on strategies for estimating noise exposure levels and conducting surveys to characterize annoyance levels relative to the “thump” sounds.

An overview of NASA’s effort, focusing on plans and technical goals for the community response tests is presented. Results of the workshop are briefed, including considerations for ensuring broad representativeness of results and estimation of the sound levels across the test community. Workshop feedback will be discussed, along with how it will be addressed in NASA’s planning.
Experimental and Numerical Studies on the Hilbert Fractal Architecture as an Acoustic Metamaterial

Gianni Comandini¹, Valeska Ting², Mahdi Azarpeyvand³, Fabrizio Scarpa¹

¹Bristol Composite Institute (BCI), Department of Aerospace Engineering, Bristol, United Kingdom, ²Bristol Composite Institute (BCI), Department of Mechanical Engineering, Bristol, United Kingdom, ³Department of Aerospace Engineering, Bristol, United Kingdom

Experiments and numerical methods were used to investigate the key parameters which affect the transmission loss behaviour of Hilbert fractal acoustic metamaterials. The tests were conducted using a four-microphone impedance tube, and the numerical simulation was performed using COMSOL Multiphysics software. Fractal order and cavity slot widths on Hilbert fractal metamaterials were investigated. 3D printing manufacturing techniques were used to make polylactic acid specimens. The COMSOL model developed utilised thermo-viscous and lossless domains with boundary layer mesh in the fractal cavities. The tests and simulations’ frequency range were 0.2 kHz to 3.0 kHz, with parametric gap widths ranging from 0.5 mm to 3.0 mm.

There is a reasonable agreement between the numerical models and the experimental results; the second-order Hilbert fractal had the most significant effect on transmission loss, with an experimental peak of nearly 50 dB around 1600 Hz. Moreover, multiple transmission loss peaks were observed as a function of the gap width in the five Hilbert fractal orders studied. The gap width is one of the critical parameters for optimising the performance of the Hilbert fractal as an acoustic metamaterial.
Improving the intelligibility of underground station public address / voice alarm systems using horizontal line array

Diego Cordes\textsuperscript{1}, Douglas Shearer\textsuperscript{2}

\textsuperscript{1}Sustainable Acoustics, Winchester, United Kingdom, \textsuperscript{2}LSBU, London, United Kingdom

As London’s extensive underground network passenger communication is highly dependent on its Public Address/ Voice Alarm system, attention to its efficacy is of great importance. In its current state, the system lacks 21st-century performance which could be implemented using modern technologies. Underground station currently struggle to achieve the minimal life safety intelligibility requirements established by the British standard and bringing an uncomfortable experience to millions of daily passengers. A reinterpretation of the line array / planar source concept in computer simulations has been used to raise the intelligibility beyond the minimal requirements by achieving a homogeneous sound distribution close to the public, with minimal room excitation. This approach minimises destructive reverberant interference and hence proves to improve intelligibility.

\textbf{Link to paper}
Sonic boom, more than two centuries of investigation!

François Coulouvrat

Institut Jean Le Rond d’Alembert - CNRS & Sorbonne Université, Paris, France

Seventy-five years ago, Chuck Yeager on Bell-X1 broke the sound barrier. Five years later, Whitham published his seminal paper linking the shape of a supersonic body to its boom. In 1962, the French-British agreement was signed, launching the Concorde program. First flight occurred seven years later, a climax period for sonic boom research, before its current renewal following the first SSBD demonstration of in-flight boom reduction in 2003. Before this "golden-age", sonic boom, though not known under this name, was not ignored. Booms from meteoroids may have been one of the clues proving their extraterrestrial origin (Biot, 1803) following the hypothesis of Chladni (1794). Infrasound of great Siberian meteorite was recorded in 1908. Shock from the tip of a cracking-whip, the oldest human-made supersonic object, was visualised by Carrière's schlieren shadow photographs in 1927. This method was already used by Mach in 1887, exhibiting the conical shockfront produced by a bullet, now bearing his name but earlier conceptualised by Doppler. During World War One, trying to localise acoustically artillery guns, Esclangon established the modern ray-tracing equations launched from the Mach cone of a supersonic gun shell. The paper will briefly discuss these early works and some others.
A new sustainable material for in-situ absorption in noise barrier walls

Andrew Cowsill

Sealed Air, Alsfeld, Germany

Perforated macrocellular foams produced using recyclable polyolefin resins have existed as acoustic absorption panels for almost 20 years. They have broad acoustic absorption with good resistance to moisture, salt and UV exposure. Adoption of In-Situ sound reflection standards, in the Rail and Road noise barrier industry; along with renewed focus on sustainable design has led to renewed interest in this technology. Traditional foam panel formats did not attain acceptable in-situ sound reflection performance. The purpose of this study was to evaluate an improved structure of foam to the industry norms required of absorptive components of the noise barrier wall; and then subject this to a lifecycle analysis. A new structure showed good reflection results in-situ, using a reduced mass of raw material. The novel panel was evaluated to a range of acoustic and mechanical testing standards to assess suitability for adoption in Noise Barrier Wall applications. The material was subsequently subjected to lifecycle analysis and the resulting product issued with an environmental product declaration. This paper concludes that the new material is well suited to widespread use in in-situ category A3 noise barrier walls.

Link to paper
Predicting Speech Intelligibility for People with a Hearing Loss: The Clarity Challenges

Trevor Cox¹, Michael Akeroyd², Jon Barker³, John Culling⁴, Jennifer Firth², Simone Graetzer¹, Holly Griffiths², Lara Harris¹, Rhoddy Viveros Munoz⁵, Graham Naylor², Zuzanna Podwinska¹, Eszter Porter²

¹University Of Salford, Salford M5 4WT, United Kingdom, ²University of Nottingham, Nottingham, UK, ³University of Sheffield, UK, ⁴Cardiff University, Cardiff, UK, ⁵Universidad Austral de Chile, Chile

Objective speech intelligibility metrics are used to reduce the need for time consuming listening tests. They are used in the design of audio systems; room acoustics and signal processing algorithms. Most published speech intelligibility metrics have been developed using young adults with so-called ‘normal hearing’, and therefore do not work well for those with different hearing characteristics. One of the most common causes of aural diversity is sensorineural hearing loss. While partially restoring perception through hearing aids is possible, results are mixed. This has led to the Clarity Project, which is running an open series of Enhancement Challenges to improve the processing of speech-in-noise for hearing aids. To enable this, objective metrics of speech intelligibility are needed, which work from signals produced by hearing aids for diverse listeners. For this reason, Clarity is also running Prediction Challenges to improve speech intelligibility models. Competitors are given a set of audio signals produced by hearing aid algorithms, and challenged to predict how many words a listener with a particular hearing characteristic will achieve. Drawing on the learning from the challenge, we will outline what has been learnt about improving intelligibility metrics for those with a hearing impairment.
We present a new approach to the modelling of sound radiated from vibrating structures that will provide a platform for simulation of larger problems by the method of Dynamical Energy Analysis (DEA), which characterises sound using densities in a ray-dynamical phase space. We consider in particular the radiated acoustic power from plates with diffuse bending vibrations, which we characterise using a two-point correlation function of normal velocities. Such field-field correlation functions are transformed to ray-dynamical phase space densities using a Wigner transformation, which allows insertion into ray-based methods such as DEA. Using correlation functions to characterise plate vibrations also allows the method to cater for stochastic, noisy driving of such systems. The results for the radiation efficiency of a plate are presented in an asymptotic form, with leading contributions from the plate interior and its boundary and with corner corrections also being given for particular boundary conditions and right-angled corners. A notable feature of this analysis is that the bulk contribution vanishes below a critical frequency, and the asymptotic estimate of radiated power then leads with a boundary contribution. This is shown to agree well with a more traditional calculation based on modal analysis in the special case of a rectangular plate.
Basic study on voice evacuation guidance system using precedence effect in virtual space with wall reverberation

Takeru Daimon¹, Ayumu Osumi¹, Youichi Ito¹
²Nihon University, Chiyoda-ku, Japan

We have studied voice evacuation guidance system using a precedence effect, which was a psychoacoustic effect. This system can be realized rapid evacuation to the safety area in the environment with poor visibility such as smoke and dust, because it uses voice announcements to guide evacuation. A basic design of construction of sound space suitable for the system and sound adjustment in the field, such as speaker position and sound pressure level setting is required, when applying this system to a building. In this research, we propose to support the basic design for constructing the above system by using VR (Virtual Reality) technology. If the basic design can be performed in the virtual space using VR technology, the time required for the design can be significantly reduced, because there is no need to experimentally design. In this report, we constructed a virtual space that reproduced the wall reverberation in the real space, and compared the evaluation characteristics of the preceding sound effect between the real space and the virtual space. As a result, we confirmed that we could obtain the same level of evaluation characteristics of precedence sound effect in real and virtual spaces.
The effect of loudness on spatial knowledge acquisition in a virtual outpatient polyclinic

Donya Dalirnaghadeh¹, Semiha Yilmazer
¹Bilkent University, Bilkent University, Faculty Of Art, Design And Architecture, Department Of Interior Architecture And Environmental Design, Bilkent, Ankara 06800, Turkey, Turkey

This study aims to find out whether changing the loudness level of sound sources creates soundmarks that aid spatial knowledge in a virtual outpatient polyclinic. Furthermore, it aims to examine the effect of loudness on perceptual attributes of the sound environment. In reference to the crossmodal correspondence of brightness and loudness and the positive perceptions associated with brightness, we explore whether the loudness of a sound source alters the perception of the sound environment. In this study, a virtual simulated outpatient polyclinic has been created with varying additions of a sound with different loudness levels. Twenty-four participants were assigned to one of the three groups: a control group (no change in the sound environment of the polyclinic), a normalized loudness group (addition of an announcement and alarm sound with normalized loudness level to the background), increased loudness (announcement and alarm sound were 3dB louder than the background). The results showed that group 3 was rated as more contented, less annoying, and more energetic and stimulated than the other groups. Additionally, there was a trend towards group 3 performing better than the other groups in spatial knowledge tasks.
Feasibility Study for Otoacoustic Emission Hearing Assessment of Classical Music Students

Stephen Dance\(^1\), Eric Ballestero\(^2\)

\(^1\)London South Bank University, London, United Kingdom, \(^2\)University of Le Mans, Le Mans, France

Since the introduction and enforcement of the Control of Noise at Work Regulations in 2008 continuing research has been undertaken on more than four thousand students at the Royal Academy of Music to understand their hearing acuity. Standard pure tone audiometric screening methods were employed for both entry and exit testing for the undergraduate students. Due to COVID standard audiometry was not possible, however it presented an opportunity to trial otoacoustic emission based hearing assessment. A feasibility study was undertaken in July 2021 involving 119 classical music students. The results showed very similar trends in hearing and thus provide reassurance that OAE can be used to assess the hearing of music students.

Link to paper
Analysis of Combustion Noise Sources Using Doak’s Momentum Potential Theory

Raffaele D’Aniello¹, Karsten Knobloch¹, Carolin Kissner¹
²German Aerospace Center (DLR), Institute of Propulsion Technology - Dep. Engine Acoustics, Berlin, Germany

Noise emissions of modern lean combustors are related to different sources. Direct combustion noise is generated by heat release fluctuations, while indirect noise sources include the acceleration of entropy and vorticity inhomogeneities through the nozzle-guide-vane or at the combustor exit. The latter noise source is characterized by the coupling of fluctuations convected in non-uniform mean flow, which can e.g. cause vortical or entropic fluctuations to be partly transferred into acoustics. Due to the complexity of the sources, a clear and quantitative separation of the different phenomena in terms of primitive variables presents a significant challenge. This study therefore proposes an alternative framework for the description of combustion noise based on Doak’s Momentum Potential Theory (MPT). The MPT defines a Generalized Acoustic Field (GAF) and describes the sound production in terms of mean energy fluxes carried by the respective acoustic, thermal and turbulent fluctuating momentum components. To confirm the ability to identify the different combustion noise sources, the method was applied to Large-Eddy Simulation data of a non-reacting swirl-combustor simulator. Finally, the coherent character and spectral behavior of the GAF were investigated using a Spectral Proper Orthogonal Decomposition (SPOD) analysis and correlated to the source distributions.

[Link to paper]
Synchronization in multi-sensor measurements: importance and methods

Tyler Dare

1The Pennsylvania State University, State College, United States

Measurement methods with multiple sensors are powerful tools in assessing and diagnosing noise. As sensor counts increase, the number of sensors can exceed the number of available channels in a single data acquisition system. In these cases, multiple data acquisition systems can be used, but synchronizing the sampling of each system is critical for an accurate measurement. In this tutorial, different methods of synchronization are discussed, along with the benefits and drawbacks of each. Additionally, methods of post-processing data to synchronize measurements are presented for use in cases where hardware-based synchronization is not feasible.

Link to paper
Fine tuning topological waveguides using asymptotic analysis

Bryn Davies

Imperial College London, London, United Kingdom

We use asymptotic methods to quantify the properties of topological waveguides and show how these concise results can be used very efficiently to design materials with specific, custom specifications. This work uses a general method that we recently developed for studying localised eigenmodes in periodic media with defects. The results of this analysis characterise the existence of localised eigenmodes, determine their eigenfrequencies and quantify the rate at which they decay away from the defect. These results are obtained using both high-frequency homogenisation and transfer matrix analysis, with good agreement between the two methods. This approach is ideally suited to studying problems arising in topological wave physics. We demonstrate the efficacy of our approach by studying materials based on the Su-Schrieffer-Heeger model (a simple example of a one-dimensional crystal supporting topologically protected modes). We show that our theory accurately predicts the localised eigenmodes and we use it to design rainbow devices that separate frequencies according to custom requirements.

[Link to paper]
Can acoustic design accommodate aural diversity?

Bill Davies

1Acoustics Research Centre, University Of Salford, Salford, United Kingdom

Up to now, the acoustic design of almost everything has assumed a typical listener with “normal” hearing. This includes the physical environment (homes, workplaces, public space), products that make sound (transport, appliances, loudspeakers), and systems for broadcast and reproduction (TV, radio, games). But at least one in five people in the world has atypical hearing. They are either narrowly medicalised (e.g., hearing aids) or mostly ignored (e.g., noise sensitivity). As the global population ages this proportion will increase. Aural diversity is a way of reconceptualising human experience of sound that emphasises the broad and semi-continuous distribution of differences that exist in detecting, processing and responding to sound. This paper explores whether acoustic design could adapt to incorporate the concept of aural diversity and what might be gained in doing so. The literature is reviewed to see how several different kinds of aural divergence are currently characterised and to identify some other auditory differences that are under-researched. A conceptual framework is proposed in which a single “normal” hearing model could be replaced with a hearing distribution or a multi-dimensional space of aural experience.

Link to paper
The imaginary part of the diffuse field forced normalized radiation impedance of a rectangular panel

John Davy
RMIT University and CSIRO, Melbourne, Australia

This paper modifies previous approximate formulae for calculating the imaginary part of the azimuthally averaged forced normalized radiation impedance experienced on one side of a rectangular panel mounted in an infinite rigid plane baffle by a forced travelling wave on the rectangular panel which is excited by an infinite plane sound wave incident at an angle to the normal to the rectangular panel on one side of the rectangular panel. This modification is made so that the formulae can be analytically integrated over all possible solid angles of incidence on one side to obtain formulae for the imaginary part of the diffuse sound field forced normalized radiation impedance of the rectangular panel. The paper also gives existing formulae for the real part of this diffuse sound field forced normalized radiation impedance. The reason for developing approximate formulae for the imaginary part of this diffuse sound field forced normalized radiation impedance is so that they can be used when approximating the equation for the diffuse field sound transmission coefficient of a limp single leaf wall.
Experimental investigation on a side-by-side twin rotor system in pusher configuration

Elisa De Paola¹, Alessandro Di Marco¹, Luana Georgiana Stoica¹, Leonardo Falcini¹, Roberto Camussi¹

¹Università degli studi Roma Tre, Rome, Italy

Growing interest in electric propulsion, together with the increased deployment of unmanned aerial vehicles, results in the consequent need for a clear understanding of the physical phenomena under propeller interactions which represent a primary noise source in multi-rotor configurations. To this purpose, the effect of rotor-to-rotor interactions of a twin pusher propeller configuration at static thrust conditions was experimentally investigated through aerodynamic and aeroacoustic measurement campaigns. The propellers tested refer to the APC-8x45MR rotor with an 8 inches diameter. The aerodynamics and aeroacoustics of several configurations were investigated using PIV technique, Pitot tube acquisitions, and microphone measurements performed in an anechoic environment. The propeller speed was varied within a typical range in the applications for both co-rotating and counter-rotating layouts. To define critical relative positions, many tip-to-tip separation distances were considered highlighting the general effects. Owing to the deformation exhibited by the rotor wakes due to their proximity, the pressure and velocity signals were conditioned to inspect the driving mechanisms responsible for the noise emission. Results provide a deeper insight into the physics involved and show different types of interaction effects on the fluid-dynamic field as a function of the propeller position, allowing the identification of the main critical configurations.

Link to paper
Clustering analyses to assess HVAC noise in real-world conditions

Domenico De Salvio¹, Dario D'Orazio¹, Massimo Garai¹
¹University Of Bologna, Viale del Risorgimento, 2, Italy

The assessment of systems' noise during measurements is usually carried out in an empty state of the spaces under study. Long-term monitoring in real-world conditions can provide insights into the performance of systems during the day. Thus, it becomes useful to find methods able to separate coexisting sound sources in the same space. Clustering techniques can supply the lack of robust methods to perform the segregation. Previous works have shown reliable results about distinguishing human and mechanical noises through sound level meter long-term measurements. Sound pressure levels (SPLs) were post-processed via Gaussian Mixture Model and K-means clustering with a three-step algorithm. The first step is clustering validation and concerns the assessment of the optimal number of clusters among the candidate models. Then, SPLs were divided into the number of clusters obtained by the validation. Finally, statistical and metrical features were used to label the sound sources whether mechanical or human, depending on the algorithm that performed the clustering.

Carrying out these algorithms during real-time conditions is possible to monitor the actual HVAC noise providing more accurate analyses. Further studies will focus on broadening the ability to analyze the mechanical noise into its components, such as continuous and discontinuous sources.

Link to paper
Assessing human activity noise in workspaces using machine learning and numerical models

Domenico De Salvio¹, Giulia Fratoni¹, Dario D'Orazio¹, Massimo Garai²
¹Department of Industrial Engineering, University Of Bologna, Viale del Risorgimento, 2, Italy

Acoustic comfort of workspace environments is deeply dependent on the balance between indoor background noises. For example, colleagues’ speaking might affect task performances by downgrading privacy and productivity. Conversely, HVAC noise can reduce the employee’s distraction since such continuous mechanical noise is detrimental to speech comprehension. Therefore, in the analysis of workspaces’ acoustic comfort, different background noise sources identification becomes essential. In this regard, machine learning techniques are resourceful for clustering sound pressure level patterns among the unlabeled data. A previous work by the authors provided reliable results on separating noise sources via Gaussian Mixture Model and K-means clustering. Nevertheless, such method was applied to a single workspace, and thus it needs further investigation on a wider sample of environments. For this reason, in the present work long-term monitoring was carried out in various active workspaces extending previous results and confirming the procedure’s robustness. Moreover, simulations of the acoustic conditions by summing up the human activity contribution to the mechanical noise allowed obtaining more reliable speech intelligibility criteria at the workstations. Refining the numerical models’ setup through background noise levels obtained through machine learning analysis enhance the assessment of workers’ privacy condition in realistic scenarios.
Evaluation of the renovation of an urban highway viaduct using citizen science low-cost noise monitoring

Luc Dekoninck¹
¹Ghent University, Technologiepark Zwijnaarde 126, Belgium

A main highway in Belgium (E17) has transected the city of Ghent with a viaduct since 1970. This highway is the main north-south artery for heavy traffic from and to the ports of Antwerp and Rotterdam. The viaduct has significant maintenance issues and was subjected to multiple noise control actions in the past. Since 2014 a local citizens initiative named ‘Viadukaduk’ -mimicking the sound of the viaduct to allow public engagement in resolving the environmental issues. In 2020, a major renovation was initiated. Prior to this renovation (in 2015) noise measurements were performed at two dwellings at either side of the viaduct. In 2020, at the beginning of renovation, measurements were repeated at the two dwellings. Post-renovation, the two datasets, 2015 and 2020/2022, have been used to perform a noise evaluation due to the renovation of the viaduct, including the impact of changes in noise barrier type, road surface and bridge joints. Preliminary results show a change of 7 dBA, although at the impact of the renovation itself is limited to 1 dBA. The data collected during the renovation illustrate the different phases: speed reduction and lane changes, removing old screens, placement of new screens, refurbishing bridge joints etc.)

Link to paper
Acoustic echo modeling of people in acoustic arrays using LIDAR

Alberto Izquierdo¹, Lara Del Val¹, Juan J. Villacorta¹
¹University Of Valladolid, Valladolid, Spain

In the field of human detection using acoustic arrays, the design of beamforming and detection algorithms is of vital importance. Evidently, the acoustic echo is directly dependent on the ergonomic characteristics of the people, as well as on the clothes they are wearing. Traditional techniques use a large set of people to characterize the system and evaluate the detection and false alarm probabilities. This work proposes a different approach, where a reduced set of people is selected and a cluster of points with their ergonomic data is obtained by means of a 2D LIDAR. From this data and using a classical reflection model, the signals that would be received in an acoustic array are calculated and, using conformation techniques, the 3D acoustic image is obtained. The work compares these synthesized acoustic images with real acoustic ones.

Link to paper
Quantifying non-linear effects in acoustic source localization

Samuel Deleu¹, Romain Gojon¹, Jérémie Gressier¹
¹ISAE-SUPAERO, 10 Avenue Edouard Belin, 31000, Toulouse, France

Whenever acoustic source localization is considered, the assumed central hypothesis is the linearity of the acoustic wave. This hypothesis allows direct and inverse problems to be solved faster using the linearized Euler Equations or ray-tracing, for example. However, when considering high amplitude waves - acoustic shockwaves generated from a sniper shot, for instance - such simplification induces errors in the localization process. In the literature, acoustic source localization results relying on the linear hypothesis are considered to be acceptable without knowing how much error is made. This paper focuses on quantifying the errors due to non-linear effects on the source localization when the linear hypothesis is assumed. The proposed methodology consists of quantifying the accuracy of the sound source position by solving the Euler equations with a spectral difference scheme of order 3 for different configurations. First, a reference case in the linear regime is carefully computed. Then, the wave topologies are modified to resemble typical acoustical shockwaves: cylindrical N-wave signals from direct propagation and wall interaction are considered. The assessment is performed on multiple wave strengths and reflection angles to get a wide range of configurations from which errors due to the non-linear reflection will be thoroughly analysed.

Link to paper

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Techniques to establish accurate background noise levels in areas affected by operational wind turbine noise

Alexander Dell\textsuperscript{1}, Jason Baldwin\textsuperscript{1}, Jim Singleton\textsuperscript{1}, Gemma Clark\textsuperscript{1}, Ewan Watson\textsuperscript{1}, Colum Breslin\textsuperscript{1}, James Mackay\textsuperscript{1}

\textsuperscript{1}Tnei, Newcastle, United Kingdom

During the planning process for an onshore wind farm, the establishment of accurate background noise levels at nearby noise sensitive receptors is vital in determining the allowable noise limits at these locations. This is typically achieved through background noise monitoring at a selection of representative noise sensitive receptors. As onshore windfarms have become more prevalent, areas suitable for wind farm development are increasingly within the vicinity of operational wind farms. The result of this is background noise monitoring at receptors is now often influenced by nearby operational wind farms and is not a true representation of the unaffected noise levels at these locations. Current good UK practice (as set out in the Institute of Acoustics document ‘A good practice guide to the application of ETSU-R-97 for the assessment and rating of wind turbine noise’) proposes a number of solutions to account for this additional wind farm noise. One solution is to consider directional filtering or the subtraction of the predicted noise levels from the measured baseline data. Whilst both approaches are valid, it can often be unclear which approach is most appropriate for a particular scenario. Within this paper, the limitations of current good practice are discussed, and an alternative methodology is proposed which combines both approaches to establish the unaffected background noise levels. Specific examples of where this alternative approach has been used are presented within the paper as validation.

[Link to paper]
Low frequency attenuation of acoustic waves using sound-soft scatterers

Alexander Dell¹, Anton Krynkin¹, Kirill Horoshenkov, Gavin Sailor¹

¹The University of Sheffield, Sheffield, United Kingdom

The attenuation of acoustic waves by silencers is typically achieved through the employment of rigidly backed cavities, connected to a main waveguide by a perforated panel. This invokes a resonant response at frequencies determined by the dimensions of the perforation and the rigidly backed cavity. A limiting factor in this approach is that to achieve low frequency attenuation, either large cavity depths are required, which is often impractical, or narrow neck regions need to be used, where performance is limited due to the viscothermal losses. Within this paper, a non-rigidly backed perforated pipe is presented where the pressure release condition at each perforation creates an acoustic sound-soft boundary condition. By the introduction of sound-soft boundary conditions, a low frequency band gap is created as the first order mode is shifted to a non-zero value, the frequency of which is determined by the dimensions and separation of the perforations. Experimental results displaying this band gap are presented along with numerical models verifying the phenomenon and an ideal analytical model based upon the transfer matrix method.

[Link to paper]
Acoustic and thermal performance evaluation of residence facades

Dilara Demir Tunca¹, Gülten Manioglu¹, Nese Yügrük Akdag²

¹ISTANBUL TECHNICAL UNIVERSITY, ISTANBUL, TURKEY, ²YILDIZ TECHNICAL UNIVERSITY, ISTANBUL, TURKEY

The building envelope plays a critical role in providing acoustic and thermal comfort. However, in different environmental conditions such as different noise levels and climate, the design process becomes more complex. The aim of this study is to evaluate the performance of building envelope options in terms of acoustic and thermal performance. In this paper, it is desired to make a comparison of scenarios that meet the limit values of acoustic and thermal requirements recommended by the regulations in Turkey. Calculations have been made for a 4m x 4m bedroom with high sensitivity level affected by traffic noise in Istanbul. Simulations have been executed in condition for 30%, 50% transparency ratio, with brick, aggregated concrete, and aerated concrete block opaque components, and double glazing, double laminated glazing transparent components. The sound insulation value of proposed facades DnT,A,tr (dB), and the total energy consumptions (heating and cooling) Q (kWh) have been calculated. The scenario set up with aggregated concrete block and double laminated glazing transparent component achieved high performance in terms of acoustic and thermal comfort conditions. This study shows that the importance of acoustic and thermal performance should be considered together for more effective building design in accordance with user needs.

Link to paper
Radiation of a metaplate made of an acoustic black hole and local resonators

Jie Deng¹, Oriol Guasch², Laurent Maxit³, Nansha Gao¹

¹Northwestern Polytechnical University, Xi'an, China, ²GTM - Grup de Recerca en Tecnologies Mèdia, La Salle, Universitat Ramon Llull, C/Quatre Camins 30, 08022 Barcelona, Catalonia (Spain), ³INSA-Lyon, Laboratoire Vibrations-Acoustique (LVA), 25 bis, av. Jean Capelle, F-69621 Villeurbanne Cedex, France,

In recent years, acoustic black holes (ABHs) have been shown very effective to suppress radiation. However, below the cut-on frequency, the waves cannot be trapped into the ABH. In this paper, locally resonant metamaterials are introduced to the ABH plate to improve the low-frequency performance. The suggested material is called MMABH. The total mass of resonators is kept the same to the one when fabricating the ABH, such that the lightweight feature still remains valid for the MMABH. Using the Gaussian expansion component mode synthesis (GECMS) method, the band gap and the coincidences between the MMABH and the air are first characterized, together with the paramagnetic studies of the plate thickness and lattice constant. In what follows, the vibration field of the MMABH is recovered, showing that whole-band reduction can be achieved. The sound pressure, power and radiation efficiency are next characterized via a discretized radiation model. Likewise, the radiated power is substantially mitigated in the whole frequency range being considered. Finally, the implementation of non-negative intensity (NNI) shows that the sound reduction not only associates with the outstanding damping capabilities of the resonators and the ABH, but also involves the wave slowdown phenomenon that breaks the coupling with air.
Vibration of a metaplate made of an acoustic black hole and local resonators

Jie Deng\textsuperscript{1}, Oriol Gausch\textsuperscript{2}, Laurent Maxit\textsuperscript{3}, Nansha Gao\textsuperscript{1}

\textsuperscript{1}School of Marine Science and Technology, Northwestern Polytechnical University, Xi'an, China, Xi'an, China, \textsuperscript{2}GTM - Grup de Recerca en Tecnologies Mèdia, La Salle, Universitat Ramon Llull, C/Quatre Camins 30, 08022 Barcelona, Catalonia (Spain), \textsuperscript{3}INSA–Lyon, Laboratoire Vibrations Acoustique (LVA), 25 bis, av. Jean Capelle, F-69621 Villeurbanne Cedex, France,

In recent years, acoustic black holes (ABHs) exhibit fascinating damping effects at mid-to-high frequencies. However, flexural waves having long wavelength cannot be trapped in the ABH pit when there is a residual thickness at the ABH tip, therefore below the cut-on frequency the ABH effect fails to work. While locally resonant acoustic metamaterials allows mitigating vibrations in subwavelength scale, usually in a narrow band. In this paper we combine the advantages of the metamaterials and ABHs (MMABH) to control vibrations in the whole frequency band. The designed MMABH plate remains the same weight to the reference uniform plate. To characterize the MMABH performance, an artificial spring component mode synthesis (GECMS) method is suggested, based on the modal coupling between the resonators and the ABH plate via springs. The band gap for the infinite periodic MMABH and the modes for the finite MMABH have been accurately predicted with the GECMS, compared to a reference FEM model. Numerical results show that the low-frequency peaks of the ABH plate can be substantially suppressed when the resonators with proper loss factor are set at its first resonant frequency. The proposed MMABH shows great potentials for light-weight and whole-band vibration reduction.

[Link to paper]
Bayesian Optimization Based Adaptive Control of Thermoacoustic Instabilities

Bayu Dharmaputra¹, Alain Williner¹, Bruno Schuermans¹, Nicolas Noiray¹

¹ETH Zurich, Zurich, Switzerland

Thermoacoustics instability is one of the factors that limits the operational range of gas turbines. Both active and passive control strategies have been developed to suppress thermoacoustic instability. Active control strategies can adapt to the gas turbine's operational condition and hence provide a wider effectivity than the passive control strategies. However, it remains a challenge to best optimize the control parameters. This work proposes an adaptive control strategy by using Gaussian Process Regression with a modified Safe-Optimisation (SafeOpt) algorithm. The main benefit of the algorithm is it can safely explore the parameter space and minimize the cost function simultaneously. The performance of the algorithm in suppressing the thermoacoustic instability is experimentally demonstrated by stabilizing a turbulent combustor with loudspeakers actuation.

Link to paper
The sound quality analysis, used as a tool for the product design, has been defined and described in the literature and the characteristics describing the type of sound have been identified. However it is often not known how the subjective assessments and the human factor are taken into account in the procedure governing the studies of sound quality. Today making a product as quiet as possible is one of the most captivating challenge for the industrial sector, especially if it is for a household appliance. This case study show how the consumer perception of product sound quality is a fundamental variable to define the sound character. The classification of sound quality is based on the correlation between an objective measurement and the subjective judgment result. Psychoacoustic metrics like Loudness, Sharpness and Roughness, and the combinations of them into more sophisticated models, like annoyance, pleasantness and powerfulness are commonly used for analysis and prediction of product sound quality. However, some problems arise when the sounds are analyzed by different consumers. It is assumed that the reason for this is the human not ability to understand the difference between noise and annoyance and to focus consciously or unconsciously on the sound emitted by the appliance. For this reason the aim of this work is to validate a method to calculate a sound quality index applicable to the sounds produced by five kitchen hoods in a real installation condition.
Application of the SVM algorithm for the development of a model classification of the visual and sound landscape

Samantha Di Loreto, Fabio Serpilli, Valter Lori

1Università Politecnica Delle Marche, villa rosa, Italia

To ensure adequate management of the soundscape in urban environments, urban planning authorities need a range of tools that enable them to perform this condition. Analyzing and classifying a soundscape is necessary to adapt it to the expectations of the people who inhabit it. The term Soundscape is associated with three different research areas: ecology / anthropology, music / sound design and architecture / urbanism. In particular, in this paper, the third research area will be investigated, finding a correlation model between auditory and visual sensations of the urban landscape of the port of Ancona. The classification model that is used is the Support Vector Machines SVM which is proposed as a tool for a global assessment of the urban sound landscape. In this case study the algorithm is intended for the automatic classification of the sound landscape of the port of Ancona to understand how much the sound perception affects the visual one. The main results obtained are illustrated:
- 75 participants were selected who, after spending time in the indicated place, filled out a questionnaire consisting of 20 questions for the evaluation of the visual environment and 20 questions for the evaluation of the sound environment.
- The training set (train \_data) will consist of 1500 samples for images and 1500 samples for sounds.
- By applying the fitcsvm (SMO) algorithm, the value of each parameter used for the implementation algorithm was obtained and a random partition of the data was performed for a k-Fold cross-validation.
- Finally, the hyperplane equation of our specific system was calculated.
Pressure-velocity measurements of a small automotive fan at different working conditions. A noise generation perspective.

Alessandro Di Marco¹, Elisa de Paola¹, Luana Georgiana Stoica¹, Enrico Mollica²

¹University Roma Tre, Rome, Italy, ²SPAL Automotive, Reggio Emilia, Italy

Although noise from large fans has been extensively studied by the scientific community, few experimental studies have been performed on small-scale fans, where aerodynamic effects due to low Reynolds numbers need to be taken into account. For this reason, some preliminary experimental investigations have been carried out on cooling fans for automotive applications. The experimental campaign has been focused on the characterization of the flow outlet first, using a static Pitot on a 5.5-inch five-bladed fan, with and without its protective grid. After this preliminary phase, simultaneous measurements of velocity with hot-wire anemometry (HWA) and pressure fluctuations with microphones have been also carried out, the HWA probe being located downstream and two microphones positioned in the nearfield and far-field of the fan. The fan has been also studied at different working conditions, varying the rotational speed and applying specific fine grids at the intake, in order to well reproduce the presence of the cooler. Analyses in the time and frequency domain have been performed on the measured data, including cross-correlation between pressure and velocity signals, in order to find the main driving mechanisms that are related to the noise generation.
Acoustic and aesthetics: The effect of paint on fabric backed by a sound absorber

Angela Marion Díaz Mena¹, Haydar Aygun¹
²London South Bank University, London, United Kingdom

This project investigates the effects of paint on the acoustic properties of the cotton and canvas fabrics. Polyurethane foam was used to back the fabric, and the dependencies on the type of paint, painted area, area distribution, and the type of fabric were analysed. One hundred and nine samples of cotton and canvas fabrics were used for this investigation. The impedance tube method, which is performed via the transfer function method, was employed to determine the acoustic properties. It is shown that the absorption of the samples is affected by the type of paint and fabric, and painted percentage area, and establishing an effective set of these parameters will result in the acoustic transparency of the fabric.

Link to paper
Prediction of noise from mechanical ventilation systems in dwellings: case studies

Arne Dijckmans¹
¹Belgian Building Research Institute, Brussels, Belgium

Noise caused by mechanical ventilation systems in dwellings remains a common problem in practice. To help designers and installers, a simplified acoustic calculation tool has been developed which can be used without detailed acoustic knowledge. The tool is based on the prediction models in EN 12354-5 and VDI 2081 and takes into account the airborne duct sound. The model has been validated by multiple case studies in dwellings. For each case study, the noise levels and airflow rates of the mechanical ventilation system have been measured in each room. Generally, the global A-weighted noise level is predicted with an accuracy of ± 3 dB, on the condition that the airborne duct sound is dominant and sufficiently accurate acoustical input data are available for key components like fans, silencers and air openings. However, some measurement results cannot be predicted by the simplified calculation framework, e.g. when turbulence in two closely placed fittings leads to additional flow noise. The uncertainty also increases when the fan sound is dominated by tonal components.

Link to paper
Performing measurements in reacting flows is a challenging task due to the complexity of measuring all quantities of interest simultaneously or limitations in the optical access. To compensate for this, recent advances in deep learning have shown a strong potential in augmenting the information content in datasets composed of partial measurements by reconstructing the quantities that could not be measured. The present work analyses the use of such deep learning tools for the reconstruction of quantities in two different cases. First, Convolutional Neural Networks (CNNs) are used to reconstruct the heat release rate (HRR) from velocity measurements in a methane/air premixed flame under harmonic excitation. The CNNs are trained from complete datasets at some specific frequencies and amplitudes of excitation and their ability to reconstruct the HRR for different operating conditions with good accuracy is demonstrated. Secondly, an alternate approach based on Physics-Informed Neural Networks that do not require the training data to have all the quantities is explored. It is applied to a puffing pool fire where the velocity field is reconstructed from observations of pressure, temperature and density with good accuracy. Both approaches are also shown to be robust with respect to noise.
Spatial design outcomes of indoor soundscaping course as part of interior architecture education

Papatya Nur Dokmeci Yorukoglu¹

¹Çankaya University, Ankara, Turkey

Indoor soundscaping is a multi-disciplinary field that integrates sound, user experience, and architecture. At its core, it has the potential to redefine any enclosed acoustic environment. It nor solely considers the theories and methods of architectural acoustics or depends only on noise management techniques, yet primarily focus on user, perception, expectation, and experience. Through this perspective, listening to spaces should be an active act of an interior architect; an awareness that should be gained during the early years of architectural education. The elective course with the same name, ‘Listening to Spaces’ has been offered to interior architecture students since 2015 at Çankaya University, Ankara, Turkey under the Department of Interior Architecture, with the aim of implementing an important additional topic specific course to the present education curriculum of the Department as the course combines architectural, spatial and functional analysis methods from an acoustical perspective, in order to raise awareness on conscious listening of spaces with different functions. The course is conducted through interactive learning bases and the orientation is more research-based than teaching-based, although basic acoustical and soundscape theoretical knowledge is given. Students are expected to accomplish 6 tasks progressively following the cognitive processing dimensions parallel to Bloom’s taxonomy. The outcomes of the tasks and the final spatial design proposals has been evaluated and discussed as part of this study to highlight the importance of topic specific course integration to architectural design education.
IoT smart city framework using AI for urban sound classification

Simona Domazetovska¹, Damjan Pecioski¹, Viktor Gavriloski¹, Hristijan Mickoski¹
¹Faculty Of Mechanical Engineering In Skopje, Rugjer Boskovic Nn, Macedonia

The advances of artificial intelligence approaches for automatically extracting and classifying disturbing sounds have great potential and application in the development of smart cities. In this paper, an urban sound event classification system based on deep learning technologies has been created by using the MEL-frequency cepstral coefficients as feature extractors and the Convolutional Neural Networks as classifiers. The designed system was trained and tested using the UrbanSound8K dataset which resulted in high classification accuracy of 92.67% of the tested results. In addition to this, validation of unknown sound events was applied. Furthermore, we propose the creation of a stand-alone system capable of recording and classifying sounds within an urban environment and sending the classification data to the cloud. The implementation of such units could result in real-time sound classification which can be used in smart cities based on the Internet of Things technology. According to this, an IoT smart city framework using AI for urban sound classification was proposed. The created system could find its use in many applications by making contribution in creating a feasible and deployable real-time sound classification system.

[Link to paper]
Influence of several audio parameters in urban sound event classification

Simona Domazetovska¹, Viktor Gavriloski¹, Maja Anachkova¹
¹Faculty Of Mechanical Engineering In Skopje, Rugjer Boskovic Nn, Macedonia

This paper presents a system for recognition and classification of sound events established through the development of processes for detection and parameterization of sound signals that are used for further classification by applying machine learning algorithms. The focus is on the feature extraction process and the accuracy achieved when using different audio parameters. Five audio parameters were analyzed and tested on three machine learning algorithms in order to investigate their influence in recognizing the class of the disturbing sound events in the urban areas, thus yielding to a collection of 48 different combinations. The applied audio parameters: MFCC, Mel Spectrogram, Chromagram, Spectral Contrast and Tonal Centroid were chosen as they are widely used for urban noise classification, but their combination forming diverse feature vectors have not been still analyzed. The accuracy results were different for each combination of the audio parameters, thus leading to choosing best set of parameters that reach the highest recognition accuracy. The used algorithms: Random Forest (RF), Naïve Bayes (NB) and Support Vector Machines (SVM) classifier are chosen as they have shown very efficient classification in the field of urban noise recognition.
Noise and Pavement Rehabilitation Using Chip Seal Surfaces

Paul Donavan\textsuperscript{1}, Carrie Janello, Dana Lodico
\textsuperscript{1}Illegworth & Rodkin, Inc, Cotati, United States

In the United States, increasing number of local and state highway agencies are using chip seals for highway pavement rehabilitation due to their relatively low cost and simplicity of application. These surfaces can significantly increase both exterior traffic noise levels and interior noise for vehicle occupants. Recent studies have quantified these effects using pass-by and interior noise and on-board sound intensity (OBSI) measurements. In order to minimize these effects, the California Department of Transportation (Caltrans) has conducted research on different chip seal pavement designs near the City of Bishop, California. Previous measurements of chip seal pavement have indicated an average OBSI level of 106.2 dBA with a range of ±2 dB. The five quietest test sections at Bishop produced an average level of 101.8 dB with a range of ±0.6 dB. In this presentation, the previous pass-by and interior noise and OBSI measurements are provided along with the comparison of OBSI data to that measured at the Bishop sites. The performance and design information on the Bishop sites are also provided.
Investigation of vibration-based measurements of impact and airborne noise insulation

Wayland Dong¹, John LoVerde¹, Ben Shafer², Sunit Girdhar³

¹Veneklasen Associates, Santa Monica, United States, ²PABCO Gypsum, Tacoma, United States, ³Michigan Technological University, Houghton, United States

Standard impact and airborne noise insulation testing is based on measuring the average sound level in a reverberant field in order to estimate the incident and/or radiated sound power. While this method is straightforward, the variation under reproducibility conditions is significant and attempt to reduce the uncertainty has so far proven unsuccessful. It is possible that a significant portion of the uncertainty is due to unavoidable variation in reverberation rooms, and that measuring the vibration on the surfaces of an assembly may be a better measurement of the impact or airborne isolation of the assembly. Preliminary investigations have been performed by measuring the vibration levels on wall and floor assemblies in situ while excited by airborne and impact sources, and the results are compared to conventional test methods.
Studying the association between noise exposure, stress and characteristics of green spaces: protocol and pilot study

Javier Dopico1, Beat Schäffer1, María García Martin2, Natalia Kolecka3, Silvia Tobias1, Julia Schaupp2, Nicole Bauer2, Martin Röösli3,4, Danielle Vienneau3,4, Mark Brink5, Jean Marc Wunderli1

1Empa Laboratory for Acoustics/Noise Control, Swiss Federal Laboratories for Materials Science and Technology, Dübendorf, Switzerland, 2Swiss Federal Institute for Forest, Snow and Landscape Research, Birmensdorf, Switzerland, 3Swiss Tropical and Public Health Institute, Basel, Switzerland, 4University of Basel, Basel, Switzerland, 5Federal Office for the Environment, Switzerland

Urban areas are constantly growing, and densification is a common strategy to limit settlement expansion. However, this leads to loss of green spaces (GSs) and increasing noise pollution, which is detrimental to public health. Within a research project that aims at elucidating the stress-easing potential of green spaces in noise-polluted environments and the mediating and/or moderating role of annoyance, an extended cross-sectional field study will be performed in the city of Zurich, Switzerland. In total, 5000 participants will be contacted in three waves, during which an online survey will be carried out followed by a visit to a subsample at home to collect hair cortisol probes. Participants of this study were selected according to the characteristics of their residences (stratified by accessibility to GSs and noise exposure). Further, traits of individuals in addition to acoustic and non-acoustic attributes of GSs are accounted. Thus, the association of noise annoyance, perceived stress and long-term physiological stress responses among residents exposed to different road traffic noise levels and with different grades of access to GSs are studied. In this contribution, the study protocol and first results of a pilot study with 256 participants will be shown.
Amplitude death and growth in a pair of nonidentical thermoacoustic oscillators interacting via time-delay and dissipative coupling

Mohammad Hossein Doranehgard\textsuperscript{1}, Vikrant Gupta\textsuperscript{2}, Larry K. B. Li\textsuperscript{1}
\textsuperscript{1}Hong Kong University of Science and Technology, Hong Kong, Hong Kong, \textsuperscript{2}Southern University of Science and Technology, Shenzhen, China

We numerically explore the effect of asymmetric limit-cycle amplitudes on the quenching and growth of self-excited thermoacoustic oscillations in two nonidentical Rijke tubes interacting via time-delay and dissipative coupling. When either type of coupling is applied separately, we find that increasing the asymmetric of the (uncoupled) limit-cycle amplitudes can shrink the regions of amplitude death (AD) in both oscillators, while producing a new region in which one of the oscillators becomes amplified, a state we refer to here as amplitude growth (AG). We find that the AG region resembles a 1:1 Arnold tongue when only dissipative coupling is applied, but that it splits into two discrete branches when only time-delay coupling is applied. When both types of coupling are applied simultaneously, we find that the AD and AG regions change in ways that depend sensitively on the detuning between the two oscillators. The findings of this study could be used to gain a better understanding of the can-to-can acoustic interactions in modern gas turbines, facilitating the development of both passive and active strategies to control thermoacoustic instability.

\textbf{Link to paper}
Numerical simulations of sonic boom propagation over urban areas

Didier Dragna¹, Ariane Emmanuelli¹, Sébastien Ollivier¹, Philippe Blanc-Benon¹

¹LMFA, Centrale Lyon, Ecully, France

Acceptability of supersonic transportation by population requires an accurate prediction of ground noise levels generated by sonic boom. This study aims at predicting sonic boom propagation over urban areas. For this purpose, numerical simulations are performed; the full 2D Euler equations are solved using high-order finite-difference time-domain techniques. First, the case of an isolated building is considered. From a geometrical analysis, two characteristic zones are highlighted: an illuminated region in front of the building and a shadow zone at its rear. The sonic boom waveforms at the ground are composed of several arrivals, related to reflection at the building facades and diffraction at the building corners. The evolution of the noise levels is then shown to follow closely the geometrical analysis, with an amplification in the illuminated region and a large reduction in the shadow zone. Second, the case of two identical buildings is investigated. The acoustic field inside the street canyon is examined. In particular, the boom waveforms exhibit low-frequency oscillations, in addition to the geometrical arrivals. They are related to resonant modes of the canyon. Finally, an urban geometry representative of European city centres is considered. The variability of the boom waveforms and the noise levels is shown.
Vehicle pass-by noise auralization in a virtual urban environment

Christian Dreier¹, Michael Vorländer¹
¹Institute For Hearing Technology and Acoustics (IHTA), RWTH Aachen University, Kopernikusstr.5, 52074 Aachen, Germany

Auralization is a suitable method for the subjective evaluation of environmental noise. Due to its complexity, the plausible and immersive acoustic representation of outdoor scenarios in urban environments is an ongoing field of research. This work presents the design and implementation of a vehicle pass-by noise model with application in a real-time environmental noise auralization. The pass-by noise sources are implemented by procedural audio syntheses of engine and road-tyre noise with according directivities. In an audiovisual demonstration, the resulting source model is auralized considering the sound propagation phenomena in a virtual urban environment using the Virtual Acoustics framework.

Link to paper
Aural typical acoustics? A critical review of key standards and practices

John Drever¹, Mattia Cobinachi, Carmen Rosas Pérez
¹Goldsmiths, University of London, London, United Kingdom

The concept of aural diversity was born out of awareness that there is a deeply embedded and intertwined, singular model of hearing at the core of the preponderance of acoustic standards and guidance, and hence practice (Drever 2015, 2017). This is exemplified with the prescription of the ‘otologically normal’ hearer derived equal loudness contours (ISO 226:2003), giving form to ubiquitous A-weighted decibel – the ‘otologically normal’ characterising the hearing of 18 to 25-year-olds, arguably the healthiest sub-group of society. This paper will critically review this assumption through reviewing the current set of acoustics standards in the UK. Crucially it will probe at some of the methods underpinning historic and foundational studies and concepts that are referenced in current standards, such as the reliance on WEIRD (Western, Educated, Industrialized, Rich, and Democratic societies) samples to stand in for the whole of the human population. (Henrich, Heine, Norenzayan 2010; Cobianchi & Rosas Pérez, 2021). Through interviews with acoustic professionals, the paper will then look at how this is carried through into practice and finally, discuss the consequences of slavishly following these models, which studies have shown (Drever 2017), results in distress, negative impact on health and well-being and societal exclusion for some.

[Link to paper]
Vibration Characteristics Optimization of a Rectangular Plate Embedded with Two-dimensional Acoustic Black Holes

Xiaofei Du¹, Qing Gu²
¹School of Mechanical Engineering, Nanjing Institute of Technology, Nanjing, China, ²Nanjing Institute of Technology, Nanjing, China

The acoustic black hole (ABH) structures have the potential to achieve structural vibration suppression and noise reduction through the effect of the ABH on concentration and manipulation of flexural waves. In this paper, FEM models of the damping ABH plate with different geometric parameters of acoustic black holes and damping layers are established to investigate the comprehensive effect of the 2-D ABHs and the damping layers on the vibration characteristics of the plate through vibration response analysis and establish a surrogate model for the vibration characteristics of ABH rectangular plate. Based on the constructed surrogate model, the vibration response of the four monitoring points of the ABH rectangular plate is optimized, so that the weighted average value of the vibration acceleration of the four monitoring points is the lowest. This paper can provide guidance for the optimal design of acoustic black hole structure in engineering applications.

[Link to paper]
BS 4142:2019 – Methods for rating and assessing industrial and commercial sound – the past, the present and future developments – a history.

Philip Dunbavin\textsuperscript{1}
\textsuperscript{1}PDA Ltd, WARRINGTON, United Kingdom

BS 4142 is the UK’s principal assessment method for quantifying industrial / commercial noise impact. It is surprising to realise that this standard is nearly sixty years old. The first draft of the document that was to become BS 4142 was being prepared in 1962 and was first published early in 1963 as the final report of the Wilson Committee on the problem of noise.

As a young acoustician, I like many others, regarded British, and all standards in general, as tablets of stone that were immutable. As I gained in experience it became obvious that this was not true. In fact all standards are periodically reviewed, every five years in the case of a British Standard, to determine if they still reflect the current available evidence that underpins them.

The current version of BS 4142 would be virtually unrecognisable to those esteemed authors of the Wilson Report all those sixty years ago. This paper traces the history of BS 4142 from its birth in the Wilson Report, through its revisions, many of which were extremely controversial at the time, to its current iteration.

Change is coming with a review and potential revision in 2024 and this paper examines the current developments, both in research and standardisation, that may have significant impacts on this review process and the future development of BS 4142.

*Philip Dunbavin is the Chairman of BSI Committee EH/1/3 on residential and industrial noise, Chairman of EH/1/3-02 the drafting panel for the revision of BS 4142 1997, and EH/1 - the BSI overarching committee on Acoustics.
Context and Representation: Data Gathering Methodology for Soundscape Contextual Factors

Albert Dwan¹
²Arup Deutschland GmbH, Joachimsthaler Straße 41, Germany

The contextual dimension of subjective perception plays a crucial role in moderating listener evaluations of soundscapes. While Soundscape indicators are directly measured and have numerically determinable measurement uncertainty, the surveying of subjective perception via soundscape descriptors presents methodological challenges pertaining to an indeterminate range of situational moderators which influence descriptor selection. Variations in subjective assessments by listeners have been shown to be correlated with factors such as perceived relevance of a sound source, whether the acoustic environment meets their pre-existing expectations, and familiarity.

This paper addresses these methodological challenges by detailing a new data gathering strategy and analysis process for assessing the “interrelationships between person and activity and place, in space and time” (ISO 12913-1:2014). The methodology explored in this paper lends clarity to the dynamics of subjective evaluation within the surveyed population, by instrumentalizing a multi-level model of individual perception of physical environments, drawn from related studies in workplace sociology, anthropology, and organizational studies. This model of perception enables numerical analysis of written responses from listeners about their environment, revealing contextual factors which can moderate subjective perception of the sounds within the environment. This additional data can be applied to the development of conceptual frameworks during soundscape analysis.
Noise in restorative environments – Perceptions, positive and negative environmental components in Tyrolean children

Angel Dzhambov¹, Peter Lercher², Johannes Rüdisser³

¹Department of Hygiene, Faculty of Public Health, Medical University of Plovdiv, Plovdiv, Bulgaria, ²Institute for Highway Engineering and Transport Planning, Graz University of Technology, Graz, Austria, ³Department of Ecology, University of Innsbruck, Innsbruck, Austria

Background: Annoyance is regarded as the most common adverse reaction to environmental noise, and yet, relatively little is known of noise annoyance in children, even though children find themselves in a vulnerable developmental period. Noise perception is usually studied as a unidimensional phenomenon with an emphasis on annoyance, disregarding positive appraisals of the acoustic environment. This study aims to explore the joint relationships between traffic noise, other built and natural environment indicators and children’s perception of noise and associated environmental restorative quality.

Methods: Data are gathered from a cross-section survey among 1251 children (8 – 12 years old) in the cross-border Tyrol area (Austria/Italy). Children and their mothers completed questionnaires on sociodemographics, living conditions, perceived neighborhood quality, and noise annoyance in different situations. Children’s residential locations were assigned traffic noise, air pollution, and built environment/natural landscape indicators, including imperviousness density, greenness, and the composite indicator distance to nature (D2N; Rüdisser et al., 2012), which are aimed to allow an integrated prediction of noise perception and restorative quality in these children.

Results: This paper will present findings on the association between contextual influences and noise perception in children, with a focus on both positive and negative appraisals of the environment.

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Objective and perceived acoustic environments during the COVID-19 lockdown: An overview of evidence

Angel Dzhambov

Medical University of Plovdiv, 15A Vassil Aprilov Blvd., Plovdiv 4002, Bulgaria

The COVID-19 pandemic took a heavy toll on population health directly, but also triggered profound changes to social life, daily mobility patterns, and activity spaces. At the beginning, public health measures for limiting the spread of the virus mandated home confinement and limited outdoor activities, which in turn reshaped typical acoustic environments for many people. Traffic noise levels reportedly declined across various settings, allowing for nature sounds, hitherto masked, to become more prominent. On the other hand, prolonged home confinement made indoor sounds, such as mechanical sounds, human voices, and noise generated by neighbors, even more relevant for the well-being of building occupants. This overview will provide a synopsis of the evidence of changes to residential noise exposure and perceived soundscape quality and components across different contexts, with implications for residents’ well-being. The observed changes will be discussed through the lens of stress and restoration theories.

Link to paper
Design of virtual binaural manikins and auditorium acoustic system

Eusébio E.¹, Ines Conceição², Manuela J. Lúcio¹, João M. Gomes¹, Hazim Awbi³
¹University of Algarve (Vat Number: 505 387 271), Faro, Portugal, ²IST - Universidade de Lisboa, Lisboa, Portugal, ³University of Reading, Reading, Reino Unido

In this work a numerical model is applied in the development of the design of virtual binaural manikins and auditorium acoustic system. The binaural acoustic manikins is based in human body methodology and is developed using empirical and geometrical equation numerical model also coupled with the CAD system. The auditorium geometry is based in a conic methodology and is developed using a geometric numerical model coupled with a CAD system. The binaural manikin geometry, using the Human Thermal Response and the Sound Propagation numerical models, is used in the human acoustic evaluation. The virtual binaural manikin evaluates the direct and indirect sound and calculates the reverberation time.

In this preliminary study an auditorium with a group of rows and columns, occupied with 140 virtual manikins, is developed. Three virtual binaural manikins was selected to be evaluate the reverberation time. The acoustic level, in the left and right ears, that the virtual manikins are subjected are evaluated. In accordance the obtained results, the manikins acoustic level evolution, with the reverberation time in accordance with the international standards, presents slight differences between left and right ear and differences between the different binaural manikins.
Application of a thermo-biomechanical virtual manikin used in transient systems

Eusébio E. 1, Ines Conceição 2, Manuela J. Lúcio 1, João M. Gomes 3, Hazim Awbi 3

1 University of Algarve (Vat Number: 505 387 271), Faro, Portugal, 2 IST - Universidade de Lisboa, Lisboa, Portugal, 3 University of Reading, Reading, UK

In this paper is developed and applied a thermo-biomechanical virtual manikin used in transient systems. This numerical model, under transient conditions, is applied in the thermal and vibrations of the different sections of the human body. The thermal numerical model, based in energy and mass balance integral equations, considers the first order equations systems, while the vibration numerical model, based in Newton equation, considers the second order equations systems converted in first order equation system. The resolution of the numerical model is made through the Runge-Kutta-Fehlberg method with error control. The thermal numerical model is used in the study of the periodical and randomized airflow fluctuations applied to the human body section and the biomechanical numerical model is used in the study of the periodical and randomized vibrations applied to the feet, that a standing person is subjected. The signals of the stimuli, the power spectrum, the equivalent frequencies and the Draught Risk (DR) of the same signals will be presented. In accordance with the obtained results, is verified that: in the thermal component the DR is evaluated and in the vibration component the body structure reduces the power spectra energy frequency and the equivalent frequency analysis.

Link to paper
A large-scale, long-term experimental campaign for the investigation of wind turbine noise fluctuations and amplitude modulation phenomena.

David Ecotiere¹, Benoit Gauvreau, Isabelle Schmich-Yamane, Albert Alarcon, Marie-Cécile Nessi, Fabrice Junker, Gwenaël Guillaume, Vincent Gary, Laurent Brendel, Guillaume Litou, Régis Boittin, Lionel Ségaud, Hubert Lefèvre

¹Cerema, 11 Rue Jean Mentelin 67210 Strasbourg, France

The understanding and prediction of wind turbine noise (WTN) remain a subject on which progress is needed to better address the concerns of residents of some wind farms and to help wind farm operators to better optimize their wind farms. A large-scale and long-term measurement campaign was conducted by partners of the PIBE project (https://www.anr-pibe.com/en) near a French wind farm during 430 days, in order to study the emission and propagation of WTN. The campaign provided 100ms sound levels and acoustic spectra, together with periodically recorded 2 min audio samples, at 5 locations ranging from 350m to 1.3km from the wind farm, in different propagation directions. Meteorological data were simultaneously collected by a 80m meteorological mast, one or two Lidars and sonic anemometers, in order to characterize vertical profiles of wind speed, wind direction, temperature, and wind turbulence. 2 distinct weeks of intensive measurements (one in summer and one in winter) completed the data by including 15 additional acoustic points at other locations. The database will mainly be used within the project for the investigation of an uncertainty model of WTN, and of WTN amplitude modulations. This communication presents the database and first results about temporal variabilities of WTN.

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Towards Wayside Wheel Flat Detection and Classification Based on Psychoacoustic Quantities

Jonas Egeler¹, Melissa Forstreuter¹, Christine Huth¹, Manfred Liepert¹
¹Moehler + Partner Ingenieure AG, Augsburg, Germany

Somewhat similar to the acoustic problems that were uncovered with the replacement of combustion engines with electric motors in cars, the retrofitting of all DB Cargo freight wagons with low-noise brakes caused other disturbing noise emissions to become more prominent. Among these, the periodic beating sounds originating from flattened wheel treads attract most attention. As there is no sufficiently validated solution for wayside wheel flat detection which meets the requirements of precise detection, focus on acoustic relevance and economic feasibility, the German Federal Environmental Agency has initiated a research project to determine an acoustic maintenance criterion for flat spots. In this contribution, we present the results of psychoacoustic analyses performed on a dataset comprising audio recordings of 200 cargo train passings. Regions with perceptible flat spots are labelled by trained ears. Common acoustic and psychoacoustic quantities are calculated for signal windows of classes “flat spot” and “no flat spot” and statistical analyses are performed to find quantities which qualify best for a separation of both classes. The effects of window size and sample rate are examined. Based on the results of listening tests, an acoustic classification criterion for the annoyance of wheel flats is proposed.

Link to paper
The impact of changing fleet makeup on airline noise emission

Karina Einicke¹, John Kennedy¹
¹Trinity College Dublin, Dublin, Ireland

With the advent of the Environmental Noise Directive (END) population level modelling of exposure to aircraft noise has increased within Europe. Present noise exposure legislation focuses on airports whereas the greatest potential to implement noise reduction technologies lies with the airlines and aircraft manufacturers. This work focuses on the modelling the noise emission of the fleet of Europe’s largest airline by passenger numbers, Ryanair. The noise reduction achieved at a fleet level will be evaluated and the impact of changing fleet makeup assessed. The airline’s current fleet consists of 409 Boeing 737-800 aircraft and 29 Airbus A320-232 aircraft, while 210 new Boeing 737-8200 max aircraft are on order. The new aircraft have a 40 % smaller footprint in the 85dB(A) noise contour during take-off than the existing 737-800. The 85dB(A) contour of 737-800 stretches out around 4.5km along the runway, while the contour of 737-8200 max was reduced to ca. 2.5km. This is achieved by implementing new winglet design and more efficient power units, which operate with lower fuel consumption (and thus lower aircraft weight), less carbon emissions, and lower noise emissions. The impact of this change to the fleet is evaluated using a representative airport modelled in SoundPLAN. Noise contours generated with SoundPLAN show the noise effects of the different aircraft types of the historic, current and future Ryanair fleet under realistic operating conditions. Different departure profiles are investigated, depending on the aircrafts weight, altitude, speed, and thrust profile. The generated noise contours provide an evidence base for decision making within the airline for investments aiming to reduce noise levels around airports. The potential for reducing population exposure to noise under the framework of the END is presented.

[Link to paper]
Numerical and experimental analysis on helicopter’s main rotor transmission for predicting structure-borne noise (SBN) using CB-TPA methods

Wafaa El Khatiri¹, Raef Cherif², Khalid El Bikri³, Noureddine Atalla¹
¹University Of Sherbrooke, 2500 Boulevard de l’Université, Sherbrooke, QC, J1K 2R1, Canada, ²University of Quebec in Rimouski, 300 All. des Ursulines, Rimouski, QC G5L 3A1, Canada, ³Université de Mohammed V Rabat, Ensam, B.P. 6207 Av. of the Royal Armed Forces, Rabat 10100, Morocco

A large number of a vehicle’s mechanical systems are responsible for tonal vibrations, which propagate through the connected structures to radiate structure-borne noise into the cabin. In the literature, transfer path analysis (TPA) methods make it possible to solve vibro-acoustic problems using sub-structuring applications. This paper presents a case study of a heavy-active component connected to a plate backed cavity, using Component-Based transfer path analysis methods. The studied academic system is representative of a helicopter’s main transmission. Both numerical and the experimental characterization are used to discuss the effect of several parameters, such as coupling (in-situ) vs decoupling (sub-structuring), completeness of the used transfer function matrix, the accuracy of the inversion method, as well as the rigidity of the test bench used to identify the equivalent forces. It is shown both numerically and experimentally that by using part of the frequency response functions matrix, one can reconstruct the response of both vibration and acoustic targets locations, even by decoupling the system and characterizing the equivalent forces on a test bench.

Link to paper
Active control of acoustic scattering from a passively optimised spherical shell

Stephen Elliott¹, Mihai Orita, Erika Quaranta, Jordan Cheer
²ISVR University Of Southampton, Southampton, United Kingdom

At low frequencies, the sound power scattered from a spherical shell can be minimised by designing its material properties and thickness so that the mass and compressibility are the same as that of the displaced fluid. The scattered power is then dominated at higher frequencies by that due to the resonances of the structural modes of the shell, particularly the ovalling mode. The peaks in the scattered power due to structural resonances can be reduced somewhat by material damping but are more effectively attenuated with active control using structural actuators as secondary sources. Simulations are presented of the scattered sound power of such a shell when subject to feedforward control, which assumes knowledge of both the incident and scattered acoustic sound fields, and structural feedback control, which only assumes that the velocity on the surface of the sphere can be measured. The performance of the feedback controller is also examined if the structural actuators and sensors are distributed over the surface of the sphere, rather than just acting at single points.

Link to paper
Acoustic Comfort in Hybrid Learning Spaces: Students Perspective

Hussein Elmehdi¹, Ania Tato²
¹University Of Sharjah, PO Box 27272, United Arab Emirates, ²University of the Basque Country, Leioa, Spain

In this paper, we assess the acoustic environment comfort at the University of Sharjah after classes have been reconfigured in response to COVID-19 pandemic protocols, which included reducing the number of seats to comply with social distancing to support the hybrid teaching model. First, we measured the background noise and reverberation times for the different types of classrooms. The results showed classrooms do not comply with international standards where acoustic comfort indicators are higher than the recommended values. For example, the background noise levels were found to range from 43.9 – 49.6 dB(A), which is higher than the recommended WHO limits. To evaluate the acoustic comfort from the perspective of the main stakeholder; the students, we conducted a subjective survey to evaluate students’ perception of the acoustic conditions at the classrooms. The results indicate that the majority of the students surveyed, (88%) felt that noise in classrooms affected their understanding of the material and communication with the instructor and peers. Noise sources were mainly identified to originate from corridors, maintenance work, and construction sites within close proximity to the classrooms. Better designs are highly recommended to improve acoustic comfort to ensure an excellent student experience and the best learning environment.
Assessing Acoustic Conditions in Hybrid Classrooms with COVID-19 Social Distancing at the University of Sharjah

Hussein Elmehdi¹, Ania Tato²
¹University Of Sharjah, PO Box 27272, United Arab Emirates, ²University of the Basque Country, Bilbao, Spain

In response to COVID-19 global pandemic, the University of Sharjah (UAE) implemented a flexible hybrid teaching approach where the capacity of the classrooms is reduced to 50% and installed additional audiovisual equipment to support the hybrid teaching model. The aim of this study is to assess the acoustic parameters in the hybrid classrooms with focus on reverberation time, sound clarity (C50) and strength (G). Measurements were taken in six different classrooms using sound analyzer and ROOM EQ Wizard software in accordance to the guidelines set by ISO 3382. In addition, we compared the experimental data with that obtained from Sabine’s diffuse field theory and from a model developed by E. Nilsson, which considers the absorption in classrooms to be mainly due to the absorbing ceilings. Reverberation times results show that Leq (dBA) to vary from 43.0 – 50.9 dBA for acoustically untreated classroom, and 32.3 for classrooms with the air condition off. Results obtained from the theoretical model showed the same overall behavior over the investigated frequency range. Sound clarity and strength measurements indicated that the acoustic conditions in hybrid classrooms do not satisfy the international standards with the exception of one classroom, which was acoustically treated.
Ray tracing is an established method for computing the late-time part of room impulse responses. But it has the drawback that only very crude Monte Carlo models of boundary scattering and diffraction are possible to include without losing its attractive computational cost scaling. This happens because higher-resolution models of these processes output multiple child rays for every parent ray received, making the number of rays grow with reflection order. An emerging solution is so-called ‘Surface-Based’ Geometrical Acoustics.

Here the distribution of rays arriving at a boundary is mapped onto a predefined set of spatial elements and angular interpolation functions, producing a vector of coefficients. Re-radiation of subsequent reflections is then a matrix multiplication, with the steady state solution being solvable via a Neumann series. Since rays only every propagate one reflection order before being collected, diffraction and scattering process that cause them to multiply can be included without issue. Here we present a new formulation based on a Galerkin Boundary Element Method (BEM). A unique feature is its ability to readily change interpolation functions, so their effect on accuracy and convergence can be assessed. In this preliminary work, it is verified against an Image Source Model for a rectangular room.

[Link to paper]
Cabin noise analysis of an H120 B helicopter for ANC applications

Florian Ernst¹, Delf Sachau¹
¹Helmut-Schmidt-Universität - University of the Federal Armed Forces Hamburg, Hamburg, Germany

Helicopter pilots are exposed to high noise levels during flight induced by the rotor, engine and airflow. To reduce this noise exposure, headsets with active noise control functions are increasingly being used. In addition to the passive noise reduction these systems reduce low frequency noise by local destructive interference of the sound waves. The development of active noise control systems requires detailed analysis of the acoustic environment, which is rarely available for helicopters. For this reason, sound measurements were taken for different flight parameters on board an H120 B helicopter. Multiple microphones were placed at the crew and passenger positions and in the center of the cabin. In addition, a head and torso simulator (HATS) was placed in the copilot seat to measure the passive attenuation and the ANC performance of a commonly used commercial ANC headset in flight. The results of the analysis provide useful information about the noise characteristics for different flight conditions of the H120 B and identify the most critical noise components.
Assessment of The Acoustic Scattering Matrix of a Heat Exchanger Using ssCFD-LNSE Simulation

Hamed F. Ganji¹, Viktor Kornilov¹, Jeroen van Oijen¹, Philip de Goey¹, Ines Lopez Arteaga¹,²
²Eindhoven University Of Technology, Eindhoven, Netherlands, ²KTH Royal Institute of Technology,, Stockholm, Sweden

The risk of thermoacoustic instability is present in any combustion appliance. The instability results from a closed loop feedback between unsteady combustion, heat-transfer and acoustic modes of the system. To predict the system acoustics all constituting elements of the appliance need to be modelled. A heat-exchanger is the element where the gas faces complex fluid dynamics and heat transfer processes. Therefore, modelling of (thermo)-acoustic properties of a heat exchanger is challenging. In this paper, a computational approach is proposed to characterize the acoustic properties of a generic heat exchanger in both laminar and turbulent flow regimes. A hybrid Computational Fluid Dynamics - Computational Aero-Acoustics (CFD-CAA) method is used based on full linearized Navier-Stokes equation, called ssCFD-LNSE. The fundamental idea in this approach is to efficiently model acoustic wave propagation with inclusion of mean flow and temperature fields. ssCFD-LNSE is performed by splitting the quantities of the total field into a mean part (obtained from CFD) and a (acoustic) perturbation part modelled within the LNSE solver. The goal of this research is to assess the two-port acoustic scattering matrix of an array of tubes, as a generic model of heat-exchanger, with a hot cross flow.

Link to paper
Characterization and Identification of Thermoacoustic behaviour of flames anchored on burner decks with multiple perforation; Transfer Function (de)composition approach

Hamed F. Ganji\(^1\), Viktor Kornilov\(^1\), Philip de Goey\(^1\), Ines Lopez Arteaga\(^1\), Jeroen van Oijen\(^1\)

\(^1\)Eindhoven University Of Technology, Eindhoven, Netherlands

The appearance of thermoacoustic instability in combustion systems depends on thermoacoustic property (e.g., Transfer Function (TF)) of used burner/flame. Therefore, an attractive approach to cope with the instability is the purposeful design of the burner thermo-acoustics. One of the ideas of how the flame TF can be altered.designed is based on the heuristic idea that the acoustic response of one flame can be counteracted by the appropriately phased response of another flame. For the particular case of premixed, burner deck anchored conical flames, the TF depends on the diameter of perforation. It suggests the concept of combining different size and shape of perforations in one burner deck. In the present work, the acoustic response of sintered ceramic fibre burners with mixed perforation is investigated using the TF (de)-composition principle. By this approach, the cumulative flame TF can be represented as a weighted sum of elemental TF’s of the groups of flames on the basis of the additive nature of the individual flame heat release rate. The capability of this principal to offer a designing framework for optimization of burner deck patterns aiming desirable acoustic characteristics will be tested by a course of measurements. Possible simplifications and extensions of the TF (de)composition principle will be discussed.
Equivalent Circuit Method Based Double Layer Micro-perforated Panel (MPP) Design to Widen the Sound Absorption Bandwidth

Ela Faslija¹, Semiha Yılmazer², Cengiz Yılmazer³
¹Department of Interior Architecture and Environmental Design, Bilkent University, Ankara, Turkey, ²Ray W. Herrick Laboratories, Purdue University, West Lafayette, U.S.A, ³CSY R&D and Architecture Engineering, Ankara, Turkey

Acoustical solutions that occupy minimum space and simultaneously allow for flexibility in interior spaces are not feasible by using thick absorbers like conventional porous and fibrous materials. Micro-perforated panels are an excellent alternative to those classical materials due to their environmental friendliness, design flexibility on various materials, and easy installation. However, they come with the handicap of having a very narrow absorption frequency bandwidth. This study explores two inhomogeneous microperforated layers arranged in a cascade with different back cavities in order to widen the sound absorption bandwidth. This serial-parallel architected MPP system is investigated by mathematical models using Maa’s model for a single MPP and the Equivalent Circuit Method (ECM). The numerical results were validated through experiments for normal sound incidence in the impedance tube using the transfer function method. Increasing the back cavity length of the MPP having a higher perforation ratio and larger holes results in a higher absorption in the high-frequency range. In contrast, combinations of larger cavity lengths and smaller perforation ratios are more effective in the low-frequency spectrum. By tuning the design parameters of those structures, it is possible to achieve wideband absorption by fibreless materials for room acoustic applications.
On the decay of entropic-compositional sources of indirect noise in combustors

Abolfazl Fattahi, Ebrahim Rahmani, Nader Karimi, S. Mostafa Hosseinalipour

1University Of Kashan, Ghotbe Ravandi blvd, Kashan, Iran

For nearly half a century, indirect combustion noise in gas turbine combustors was entirely attributed to entropy waves, as the convecting hot spots. However, recent studies identified another source of indirect noise called compositional waves, which consists of convecting chemical blobs. Understanding the evolution of this new source during its journey throughout the combustor requires attention due to the unknown physics of the turbulent, heat transferring flow in which it moves. In the current study, a hot chemical blob including a mixture of combustion products is introduced at the channel inlet. During its convection along the channel, degeneration of various thermal and chemical components of the entropic-compositional wave is investigated in the frequency domain using large-eddy simulations. It is shown that the wave annihilation due to wall cooling, as found in real combustors, can exceed those imposed by the flow hydrodynamics. Through a coherence analysis, it is found that mixture fraction is mainly responsible for deteriorating the chemical sources and that the contribution of potential function is comparatively smaller. Overall, it is concluded that compared to entropy waves, compositional waves are up to 20% more prone to decay.

Link to paper
Noise mapping from above

Endre Fay¹
¹Herman Otto Institute Nonprofit Ltd., Budapest, Hungary

In the case of noise modelling preparation of industrial plants, if the client does not have the required quantity and quality of information and data for the proper outcome, we have to produce them for ourselves. In such instances, field survey is essential to obtain the desired data. In this paper, it is shown how to create the necessary digital terrain (DTM) and surface (DSM) models for the noise modelling in case they are not available. The implementation of the task was solved by photogrammetric survey obtained as the result of a drone (UAV) flight operation and its data processing. The aim is to produce a file that can be imported into the noise mapping software used in the project. On the generated orthographic photo of the study area the exact position of the noise sources can be marked in the horizontal plane. In vertical plane terms, the surface model will help us to determine the height of the noise sources and the relevant objects. Then, using an appropriate software, a shape file can be generated and imported into the noise mapping software and as the goal, the noise modelling can be performed.
A comparative study of semi-empirical noise emission models based on the PANAM and sonAIR aircraft noise simulation tools

Gil Felix Greco¹, Felix Wienke², Lothar Bertsch³, Christoph Zellmann³, Beat Schäffer³, Tobias P. Ring¹, Sabine C. Langer¹

¹Institute for Acoustics (InA), Technische Universität Braunschweig, Langer Kamp 19, 38106 Braunschweig, Germany,
²Institute of Aerodynamics and Flow Technology, German Aerospace Center (DLR), Bunsenstraße 10, 37073 Göttingen, Germany,
³Laboratory for Acoustics/Noise Control, Swiss Federal Laboratories for Materials Science and Technology (Empa), Überlandstrasse 129, 8600 Dübendorf, Switzerland

In the context of aircraft noise simulations, an accurate representation of the aircraft noise sources is crucial so that reliable predictions can be obtained. In this contribution, we present a comparative study between the predictions provided by the emission models based on the DLR in-house code PANAM and the sonAIR simulation software. Both are based on semi-empirical descriptions of the engine and airframe noise contributions, meaning that the emission levels are modeled separately for each noise source according to the operational conditions of the aircraft. This allows the comparison of the emission models not only in terms of the aircraft's overall noise levels, but also regarding its different noise sources. The comparative study considers models representing the noise emissions of an A319 aircraft, which are provided by both simulation tools but further simulated within the sonAIR software environment in order to yield noise immission levels on a large calculation area. In general, a good agreement is observed for the departure procedure due to the similar performance of the engine noise models. In contrast, larger differences are observed during the approach procedure and at larger distances from the runway, which might be explained by differences in the airframe noise models.

[Link to paper]
An update to the WHO 2018 Environmental Noise Guidelines exposure response relationships for annoyance from road and railway noise

Benjamin Fenech\textsuperscript{1}, Georgia Rodgers\textsuperscript{1}, Sierra Clark\textsuperscript{1}
\textsuperscript{1}Noise and Public Health Team, Radiation Chemical and Environmental Hazards, Science Group, UK Health Security Agency, London, United Kingdom

The systematic review on environmental noise and annoyance commissioned by the World Health Organization (WHO) to inform its 2018 Environmental Noise Guidelines proposed new aggregate exposure response relationships (ERRs) for transportation noise, based on studies published between 2000 and 2014. A subsequent scoping review commissioned by the UK’s Interdepartmental Group on Costs and Benefits Noise Subject Group identified 12 new studies for road and nine new studies for rail, published between 2014 and 2019, and recommended that an update to the WHO ERRs may be warranted. This paper presents updated aggregated ERRs for the percentage of people highly annoyed (%HA) from road and railway traffic noise incorporating data from a subset of the recent studies that met certain eligibility criteria. In light of the ongoing debate on the temporal stability of community annoyance (observed or modelled), we also discuss some of the important considerations that need to be taken into account when deciding if and how often a reference exposure-response relationship is updated for policy and practice.

[Link to paper]
A Multiple Target Data Association Method for TDOA Passive Localization

Miao Feng¹, Zhaoning Gu¹, Shiliang Fang¹
¹Key Laboratory of Underwater Acoustic Signal Pro, Nanjing, China

In order to solve the multiple target data association problem in underwater acoustic passive localization system, a new algorithm focus on data association in Time Difference of Arrival (TDOA) is studied. Firstly, the zero-sum condition is used to select TDOA measurements according to the continuous measurement values within a certain period of time. Then, the selected TDOA measurements are associated with the multiple targets and the correct correlation probability is measured by the correlation degree. The algorithm is used in sea trial. Processing results show that the method proposed in this paper can effectively solve the TDOA measurement association problem, and can locate multiple targets at the same time.
Sound.Wood.Austria - selected measurement results of building components for multi-storey timber construction in Austria

Heinz Ferk¹, Selina Vavrik-Kirchsteiger¹, Leh Christopher¹, Markus Mosing¹, Bernd Nusser²
¹Graz University of Technology, Graz, Austria, ²Holz Forschung Austria, Wien, Austria

With the increasing use of wood also for multi-storey dwellings, a wide variety of timber construction systems have been developed in Austria, of which in particular timber post and beam construction and solid timber construction in cross-laminated timber have become established. During the Internoise 2005, the first session on sound insulation in timber construction was initiated by Jean-Luc Kouyoumj. At that time, I was able to present first examples of multi-storey CLT dwellings in Austria. Today building with wood is a worldwide topic and there are still a lot of research questions, especially in the low-frequency range, in flanking transmission and optimization. Within the Sound.Wood.Austria research project, acoustic laboratory measurements of typical Austrian wood based building components were carried out in order to determine the effect of various design measures on sound insulation in a systematic approach and to identify possible optimization potential. Exterior and apartment partition walls as well as apartment partition ceilings were investigated. In this talk, selected measurement results will be presented and discussed. The results stress the fact, that further research work and developments, preferably internationally networked, are desirable in order to exploit the acoustic potential of timber buildings in the sense of "Green Deal".

[Link to paper]
Engine Order Cancelation in a supersports car cabin

Cesare Lupo Ferrari¹, Jordan Cheer²

¹Department of Mechanical Engineering, Politecnico di Milano, Milano, 20156, Italy, ²Institute of Sound and Vibration Research, University of Southampton, Southampton, SO17 1BJ, UK

Active noise control (ANC) has been used in several systems to improve acoustic performance while avoiding increases in the size and weight required by passive noise control solutions. This paper considers an ANC application aimed at controlling the sound field in the cabin of a supersports car with a naturally aspirated engine. This work studies the performance of a system that employs microphones and loudspeakers in the car cabin and uses a reference signal obtained from CANbus data. The controller exploits a multichannel, multi-order Fx-LMS algorithm to control the sound only in the region surrounding the driver’s ears. Due to the nature of the car, this ANC application provides an interesting and challenging case study due to the rapidly changing acoustic excitation provided by the engine. The paper therefore describes a system for noise reduction, focusing on engine order reduction, aiming at achieving control during the most representative manoeuvre known as the “Wide-Open Throttle” (WOT). The investigated controller - acting locally and only on some orders simultaneously - shows good sound attenuation over the entire spectrum, with peaks of reduction exceeding 10 dB, and achieving a 5% overall decrease in the loudness, which is calculated according to ISO 532-1.

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Psychoacoustic properties of tire-road noise and the relation to noise annoyance

Andre Fiebig¹, Christoph Jakobs¹
¹Technische Universität Berlin, Berlin, Germany

Rolling noise as the interaction between tire and road contributes strongly to the total road noise in particular as engines become quieter due to more strict noise regulations and the emergence of electric motors. Thus, road traffic noise can be effectively reduced by optimizing vehicle tires and the pavement. Over the last decades, different pavements were developed to reduce tire/road noise as for example a porous asphalt surface or stone mastic asphalt reduce significantly rolling noise over a period of about 10 years.

In the past the noise reduction due to different pavement types and layers were validly determined, several measurement methods established and level reduction values incorporated in noise directives like the German guidelines for noise protection at roads. However, little attention was paid to assess the annoyance reduction effect of different pavements in detail. As the road tire noise is not only reduced in level but is also affected in spectrum, road traffic noise annoyance might not be accurately predicted by considering the level reduction only. In the following paper diverse road traffic noise measurements related to different pavements are analyzed from a psychoacoustic point of view and the resulting noise annoyance investigated.

[Link to paper]
Experimental design of an active vibration control device used to protect cultural heritage objects.

Loïc Forma¹,²,³, Nicolas Wilkie-Chancellier¹, Sandie LeConte², Henri Boutin³, Marguerite Jossic⁴,⁵
¹Systèmes et Applications des Technologies de l'Information et de l'Energie (SATIE), CY Cergy-Paris Université, 5 mail Gay Lussac, 95000 Neuville-sur-Oise, France, ²Institut National du Patrimoine (INP), 124 Rue Henri Barbusse, Aubervilliers, France, ³Sciences et Technologies de la Musique et du Son (UMR9912), Sorbonne Université, Ircam, (CNRS) Centre National de la Recherche Scientifique, 1 place Igor Stravinsky, Paris, France, ⁴Équipe Conservation Recherche, Musée de la Musique, Cité de la Musique, Philharmonie de Paris, 221 Avenue Jean Jaurès, Paris, France, ⁵Centre de Recherche sur la Conservation, CNRS-USR3224, Muséum National d'Histoire Naturelle, Ministère de la Culture, 36 rue Geoffroy Saint-Hilaire, Paris, France

While light, temperature and humidity on cultural heritage objects are drastically controlled to assure their better conservation, it is not the case of the vibrations and their impact on the objects have received little consideration. Most of the proposed solutions to protect objects from vibrations suffer from a lack of adaptability and poor performances in the lowest frequency range. To tackle this issue, the development of a new kind of protection devices based on active control is proposed. The main challenge is to respect the cultural heritage ethics: non intrusiveness and reversibility.

To adapt to a wide variety of cultural heritage objects, the proposed solution aims to minimize the vibrations of a museum’s shelf in real time. A replica of museum’s shelf is excited by a vibration exciter and a feedforward control configuration is used to monitor the shelf vibrations, by a reference signal measured on the shelf structure and actuators and error sensors placed on the shelf plate. This bench offers the opportunity to experiment multiple PAA (parameter adaptation algorithms) for which a parameter analysis can be performed. A comparative study based on criterions such as amplitude attenuation and time convergence is performed to find an optimized control configuration.

Link to paper
Effect of urban morphology and greening on noise and air pollution – case studies including disease burden estimates

Jens Forssén¹, Marie Haeger-Eugensson²,³, Meta Berghauser Pont¹, Andreas Gustafson¹, Christine Achberger², Niklas Rosholm⁴

¹Chalmers University of Technology, Göteborg, Sweden, ²COWI AB, Sweden, ³Gothenburg University, Department of Earth Sciences, Sweden, ⁴City of Gothenburg, Environmental Office, Sweden

Exposure of both noise and air pollution due to road traffic in urban environments has been calculated and evaluated for multiple cases assuming constant total traffic flow. A model study in an urban setting used 31 cases of building morphologies and traffic concentration. An evaluating second set was based on a real case of an arterial road transformed into a boulevard. Besides the effect of building morphology, the effects of driving speed, electric vehicles and urban greening were studied. The levels of noise exposure (Lden and Lnight at housing facades) and air pollution (NO2 and PM10 at sidewalks and yards) were calculated as input to estimating the health impact using DALY (Disability-Adjusted Life Years) per person. Openings in building blocks were shown to impair the noise situation but improve air quality. Nonconflicting positive results were shown for several solutions including densification by complementing the blocks with towers, transitioning to electric vehicles in combination with reduced vehicle speed, and traffic concentration by locating all local traffic to a single, widened road. Urban greening was shown to improve the noise situation whereas air quality varied due to the interaction between wind speed, dispersion, and filtering effect of leaves.

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Using Non-wave based modelling to explore how much acoustic diffusion is too much in a concert hall.

Michael Fort

London South Bank University, London, United Kingdom

This paper explores the relationship between acoustic surface diffusion and acoustical character in concert halls by using non-waved based modelling. Measurements were undertaken in a small concert hall to use as a baseline, which is then transferred into ODEON to experiment with the acoustic parameters further. Using the ODEON modelling results, the relationship between amount of diffusion vs scattering coefficient to achieve optimal objective parameters in a concert hall according were visualised. These trends were then tested on existing famous concert hall models, e.g. Musikvereinssaal. The experiments showed that when considering how much diffusion is too much in a concert hall, the statistical amount of diffusion is less of a factor, when compared to retaining strong early reflections from side walls and ceilings and the amount of scattering provided by diffuse surfaces. For example, a hall with a high amount of diffusion, can still be a subjectively “good” hall, if it still has strong early reflections on the side walls and ceilings when compared to a hall with geometry that does not provide strong lateral reflections.

Link to paper
Characterisation Testing of Floating Floor systems under Impact Conditions

Adam Fox¹, Doug Valerio²
¹Mason U.K. Ltd, Unit 6 Abbey Business Park, United Kingdom

Characterising the nature of vibration produced by impact events from sporting activities remains a challenge. The variables of the impactor, isolation measures and response of the supporting structure inherently make this and prediction of resultant noise levels a significant challenge.

This paper presents research into the performance of floating floor systems. Under several excitation events such as weight drops and treadmill activity, the behaviour of the floating floor was characterised through generation of a validated finite element model. The insertion loss of the system was confirmed through extensive testing for a wide range of typical gymnasium activities. The effect of floor dampers and use of covering layers was also investigated.

This paper presents these results which provide a validated understanding of how varying the nature of the impact generating activity affects floating floor insertion loss and how the floating slab responds dynamically to impact. This information provides data suitable for extrapolation to other installations, which is highly sought by industry to predict the implication of gymnasium installations.

[Link to paper]
Informing sound art design in public space through soundscape simulation

Valérian Fraisse\textsuperscript{1,2,3}, Nadine Schütz\textsuperscript{1,4,5}, Catherine Guastavino\textsuperscript{3,6}, Marcelo Wanderley\textsuperscript{2,3}, Nicolas Misdariis\textsuperscript{1}

\textsuperscript{1}STMS IRCAM-CNRS-SU, Paris, France, \textsuperscript{2}Schulich School of Music, McGill University, Montreal, Canada, \textsuperscript{3}Centre for Interdisciplinary Research in Music Media and Technology, Montreal, Canada, \textsuperscript{4}Institute of Landscape and Urban Studies, ETH Zurich, Zurich, Switzerland, \textsuperscript{5}((Echora)), Paris, France, \textsuperscript{6}School of Information Studies, McGill University, Montreal, Canada

Urban sound management often amounts to reducing sound levels with the underlying assumption of sound/noise as a nuisance. However, a reduction in sound level does not necessarily lead to a more pleasant auditory experience, especially in urban public spaces where vibrancy can be sought after. A proactive design approach that accounts for the human experience of sound environment is needed to improve the quality of urban spaces. Recent studies in soundscape research suggest that added sound and particularly sound art installations can have a positive influence on public space evaluations. Yet, the role of added sounds in urban context remains understudied and there is no existing method to date to inform sound art composition in public space through soundscape simulation. We present here a research-creation collaboration around the design of a permanent sound installation in an urban public space in Paris: Nadine Schütz’s Niches Acoustiques. We report on a series of listening tests involving High-Order Ambisonic soundscape simulations of different prototypes to inform the sound artist’s composition in order to optimize the quality of public space experience in the presence of the sound installation.
Mixing materials in false ceilings to increase sound diffusion in education spaces

Giulia Fratoni¹, Dario D'Orazio¹, Luca Barbaresi¹, Massimo Garai¹, Luca Cappellini²

¹University Of Bologna, Bologna, Italy, ²Saint-Gobain Italia S.p.A., Milano, Italy

According to the International standards on education spaces, in situ acoustic tests should achieve specific reverberation time targets. Since the match between predictive formulas and measurements increase with the sound field diffuseness, it is extremely important to pursue such condition through proper design choices. For example, false ceilings can play a key role in controlling room acoustic features; however, the use of such elements is generally considered only for absorption purposes. For this reason, the present work concerns mixing materials in false ceilings within a group of teaching spaces here taken as case studies. The alternation of materials with different acoustic impedances has been investigated through experimental acoustic measurements and numerical models in order to assess the related sound diffusion increase. The ceiling treatment here proposed proved to be an efficient and smart method to exploit diffraction effects along material discontinuities junctions. The match between early design predictive formulas and the results of the acoustic measurements enhanced the reliability of the acoustic design process and set up a potential new guideline for indoor acoustic treatments.

Link to paper
Acoustic source localization in ports with different beamforming algorithms

Luca Fredianelli¹, Marco Bernardini², Lara Ginevra Del Pizzo³, Francesca Tonetti⁴, Francesco Fidecaro⁵, Gaetano Licitra⁶

¹IPCF-CNR, Via Moruzzi 1, Pisa, Italy, ²INM-CNR, Via di Vallerano 139 - 00128 Roma, Italy, ³Ipool S.r.l., Via Enrico Fermi 75, Pisa, Italy, ⁴SPSC - TU Graz, Inffeldgasse 16c Graz, Austria, ⁵University of Pisa, Physics Dpt., Largo Bruno Pontecorvo 3 - 56127 Pisa, Italy, ⁶ARPAT, Via Vittorio Veneto, 27, Italy

Acoustic cameras are used to investigate the origin of a noise and localize it on video for a couple of decades. This was made possible by applying beamforming techniques to the acoustic signals simultaneously acquired by a microphone array. The number of scientists working on improving the efficiency and accuracy of this technique increased over the years, leading to the design and production of different shapes for the antenna and microphone array. Moreover, in the last years many different algorithms for beamforming techniques have been published to improve the original “Delay and Sum” method. This field is evolving rapidly and, unfortunately, there is no clear view on the advantages of one method over another, both from a theoretical and a practical point of view. This work shows the different results obtained by different algorithms when applied to the same input acoustic signals, i.e., they can localize the noise source in different points of the screen. The input signals were acquired with acoustic camera measurements to investigate port noise, a topic that has been neglected for too long and on which only few studies have been carried out. The various sound sources acting on ships’ pass-by and the predominant emitters in a multi-source environment have therefore been localized using the different algorithms.

[Link to paper]
Effect of neighbours sounds in wooden residential buildings on restorative EEG rhythm (Alpha waves)

Alessia Frescura¹, Pyoung-Jik Lee¹, Jeong-Ho Jeong², Yoshiharu Soeta³

¹University Of Liverpool, Liverpool, United Kingdom, ²Building acoustics laboratory, Fire Insurers Laboratories of Korea (FILK), Yeoju-Si, Korea, ³Biomedical Research Institute, National Institute of Advanced Industrial Science and Technology (AIST), Osaka, Japan

The present study aimed to explore the effect of neighbours sounds commonly heard in wooden residential buildings on restorative EEG rhythm represented by Alpha waves. Thirty participants took part in a listening test which was performed to collect EEG data in distinct acoustics scenarios. Noise sensitivity and attitude toward neighbours were introduced as non-acoustic moderators and assessed through questionnaires before the experiment. A series of impact and airborne sounds were presented through loudspeakers and subwoofer, while participants sat comfortably in the simulated living room wearing the EEG headset (B-alert X24® system). The impact sound sources were two types of footsteps, adult walking and child running, recorded in a laboratory on different floor configurations and thus, varying in sound pressure level and frequency characteristics. The airborne sound sources were a lively conversation and a piece of classical piano music, digitally filtered to represent good and poor sound insulation performances of vertical partitions. The effect of sound stimuli and non-acoustic factors on restorative EEG rhythm corresponding to Alpha waves (8-13 Hz) was then analysed. Differences in response to distinct acoustic scenario were observed. Additionally, Alpha band activity showed to be affected by noise sensitivity and attitude toward neighbours of participants.
Overview of the acoustic quality of dwellings in Ukraine and CIS countries

Eugen Fridlib

1 Acoustic Group Ukraine, Kyiv, Ukraine

At least 10 million square meters of dwellings have been built in Ukraine per year. Most of them are residential complexes in cities. What is the level of acoustic comfort in these buildings? What are the main complaints of residents? We will answer these questions in this report. The most popular partitions and floors types, their main problems and methods how to improve sound insulation will also be shown. We will analyze the requirements of national standards and assess how modern houses meet these requirements. This article shows the acoustics characteristics of many structures measured on site, taking into account various flanking transmission pathways. Particular attention is paid to additional insulation structures that are used in apartments, to the differences between laboratory measurements and field measurements.
Broadband potential optimisation of a full scale acoustic metawindow performance.

Gioia Fusaro\textsuperscript{1}, Massimo Garai\textsuperscript{1}, Jian Kang\textsuperscript{2}

\textsuperscript{1}Applied Physics, Department of Industrial Engineering, University of Bologna, Bologna, Italy, \textsuperscript{2}Institute for Environmental Design and Engineering (IEDE), The Bartlett, University College London, UK, London, UK

Noise control and airflow in duct-like systems are among some of the most interesting applications to conjugate AMMs innovation and sustainability. Specifically applied to the built environment, they opened up a new field of research supporting indoor wellbeing, sanitised environments, and public activities. Previous research conducted by the authors has proved AMM based window to be a resourceful way to address both natural ventilation and reduce the incoming noise propagation; however, the effective spectral range did not cover lower frequencies (50-350 Hz). For this reason, in the presented paper, implementation in the AMM unit geometry was performed over a full-scale acoustic metawindow (AMW). The resonating volume has been enhanced (by 200\% of the original one) and coupled with a set of lateral flanks. Numerical analysis through FEM proved that on a range of opening ratio from 3 to 33\%, the TL related to the window is improved overall of the 70\% on the frequency range from 50 to 350 Hz. Such results encourage the use of new AMMs ergonomic windows in place of standard ones to achieve both natural ventilation and noise attenuation from 50 to 5k Hz, being resourceful for domestic, sanitary, and public applications.

Link to paper
Differences in acoustic characteristics of hitting sounds in baseball games

Ryohei Futamura

Kanagawa Institute of Technology, 1030 Shimo-ogino, Atsugi City, Kanagawa, 243-0292 Japan, Japan

In sports, athletes use visual and auditory information to perform full-body exercises. Some studies reported that auditory information is an essential cue for athletes: They utilized auditory information to predict ball behavior and determine body movements. However, because athletes instinctively use situation-related sounds, there is no systematic methodology to improve auditory-based competitive ability. Few studies attempted to approach the utilization of sound in games from the perspective of acoustics, and the functional acoustical features have not been quantitatively revealed. Therefore, the objective of this study is to clarify the acoustical characteristics of auditory information to maximize its utilization in baseball games. In particular, to analyze the acoustical features of batted ball sounds that enhance defensive skills, we conducted acoustic measurements of batted ball sounds in realistic situations. The results showed that the peak gain values of fly and liner batted balls were greater than those of grounder, and the frequency components included in the hitting sound were also different among them.
Using data-driven techniques to provide feedback during material characterisation

Mathieu Gaborit¹, Luc Jaouen²
¹LAUM CNRS UMR 6613, Le Mans, France, ²Matelys, Vaulx-en-Velin, France

The aim of the work is to study the feasibility of using machine learning techniques to design a decision helper to assist the characterisation of acoustic materials (porous media for instance). The tool is intended to alert the human operator about specific physical phenomena occurring during the measurements or common mistakes in handling the characterization rig or its parameters. Examples of classical issues include leakage around the samples, unintentional compression during the sample mounting, errors in input parameters such as the static pressure or temperature, etc.

The proposed helper relies on a physical analysis and a k-nearest neighbours classifier using the Fréchet distance to score the measurements. This approach allows to measure the similarity between curves, independently from sampling. The training phase is performed on a labelled dataset created from actual impedance tube measurements and possibly some computer generated results to bridge gaps. The inputs are frequency-dependent quantities including normal sound absorption curves, surface impedance, dynamic mass density and dynamic bulk modulus.
Vibrational damping properties of finite microperforated plates

Lucie Gallerand¹, Mathias Legrand², Thomas Dupont¹, Philippe Leclaire³
¹École De Technologie Supérieure, Montréal, Canada, ²McGill University, Montréal, Canada, ³Université de Bourgogne, Nevers, France

Microperforated plates (MPP) are traditionally used to advantageously absorb acoustic waves in sound control technologies. However, less is known concerning the additional structural damping they can induce. The latter is activated through exchanges in the viscous and thermal boundary layers near the fluid-structure interface of the microperforations. MPPs therefore offer an alternative to, or can be used together with, viscoelastic materials, commonly implemented to damp vibrations at medium and high frequencies.

In this work, the structural damping capabilities of MPP are investigated. To this end, the damping performance of a finite size MPP is explored analytically through an alternative form of the Biot model, classically devoted to porous plates, and considering energy dissipation through viscous friction mechanisms. Analytical results are compared to experimental measurements of structural damping factors on various MPP samples. The model is validated and confirms the damping effect added by the microperforations in the low frequency range. A sensitivity analysis on the perforation rate and perforation diameter provides a condition for which additional damping is maximized.

Link to paper
Acoustical Effects of Surgical and N95 Masks on Speech Perception in Open-Plan Offices

Pooja Ganatra\textsuperscript{1}
\textsuperscript{1}Buro Happold, Dubai, United Arab Emirates

Wearing face masks provides some protection against infection from COVID-19. Face masks can also change how people communicate and subsequently affect speech signal quality. This study investigated how two common face mask types affect acoustic analysis of speech perception. Quantitative and qualitative assessments were carried out in terms of measuring the sound pressure levels and playing back to a group of people, respectively. The responses gauged proved that masks alter the speech signal with downstream effects on speech intelligibility of a speaker. Masks muffle speech sounds at higher frequencies and hence the acoustic effect of a speaker wearing a face mask is equivalent to the listener having a slight high frequency hearing loss. When asked on the perception of audibility, 83\% of the participants were able to clearly hear the no mask audio clip, however, 41\% of the participants thought it was moderately audible with the N95 and face shield masks. Due to no visual access, face masks act as communication barriers with 50\% of the people finding to understand a person because they could not read their lips. Nevertheless, based on these findings it’s reasonable to hypothesize that wearing a mask would attenuate speech spectra at similar frequency bands.

\textbf{Link to paper}
High frequency modelling of electric motor vibration in the presence of adhesive bonded components

Boyang Gao¹, Dan O'boy¹, Georgios Mavros¹
¹Loughborough University, Epinal Way, Loughborough, UK LE11 3TU, United Kingdom

Electric motors often include adhesive joints to bond magnets to shells. In this paper, the variability of the frequency response function is assessed with regards to high frequency, finite element modelling and validation. The adhesive bond is used to fix the permanent magnets to the motor shell for the typical PMDC motor as it provides a smoother, more continuous surface than fixings without discontinuity of the magnetic field. To obtain the dynamic response of the motor housing at specified settings of the adhesive layer, which include variations in thickness and stiffness, a finite element model is established in ABAQUS. Given the relative stiffness of the adhesive is lower, this has a significant effect on the overall stiffness of the casing, for a fixed mass and thus the response frequencies and loss factor. When using frequency response functions to couple motors to components, this variability can be significant and thus this work is useful for the e-motor noise optimization at its design stage.

Link to paper
Influence of Environmental Sensitivity on Soundscape Evaluation in Urban Open Public Spaces

Weifu Gao\(^1\), Jian Kang\(^2\), Hui Ma\(^1\)
\(^1\)School of Architecture, Tianjin University, Tianjin, China, \(^2\)Institute for Environmental Design and Engineering, University College London, London, UK

Urban open public spaces play a vital role in contemporary cities, and the quality of the soundscape in these environments affects people's psychological and physiological restoration. Previous soundscape research has shown that environmental sensitivity is a crucial factor affecting psychological responses to the acoustic environment, but many of these findings are restricted to the interpretation of “negative” dimensions’ variance of evaluations. In this experiment, we examined the effects of individuals' different aspects of environmental sensitivities such as vulnerability sensitivity (noise sensitivity, etc.) and vantage sensitivity (aesthetic sensitivity, etc.) on soundscape evaluation through experiencing audio-visual environments of various urban open public in laboratory. The participants, 20-45-year-old college students and staffs with normal hearing (N=30), experienced ten common urban open space scenarios (parks, plazas, pedestrian streets) for at least 10 minutes each, and finished the questionnaire which consisted of two parts: items from the Soundscape Quality Protocol and the Environmental Sensitivity Survey includes Weinstein’s Noise Sensitivity (WNS) Scale and Highly Sensitive Person (HSP) Scale. The results show that people with high noise sensitivity tended to overestimate the “negative” dimensions of soundscape evaluations, whereas people with high aesthetic sensitivity tended to overestimate the “positive” dimensions. These environmental sensitivities were found to be statistically independent. In other words, environmental sensitivity affects the soundscape evaluation significantly in urban open public spaces. This suggests that attention should be paid to the diverse needs of different people, in policy-making and urban planning.

Link to paper

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Thermoacoustic stability prediction using Deep Learning

Renaud Gaudron¹, Aimee S. Morgans¹
²Imperial College London, London, United Kingdom

Thermoacoustic instabilities are an undesirable physical phenomenon that can occur in a wide range of combustors such as gas turbines, rocket engines, and boilers. These instabilities are typically loud, vibration-inducing, and can increase parietal heat transfer in the combustion chamber. As a consequence, mechanical fatigue increases and can sometimes lead to a catastrophic failure of the combustor. A well-established formalism to predict thermoacoustic stability is based on network models where the combustor is represented by a sequence of connected acoustic modules. The frequency of the modes appearing inside the combustor are then given by the eigenvalues of a characteristic equation obtained using conservation equations. This approach has been successfully used to predict the stability of a variety of combustors. However, this operation needs to be repeated many times in order to optimise the shape of an unstable combustor at an early design stage. One option to reduce the computational cost of predicting the thermoacoustic stability of a given configuration is to use a data-driven approach as opposed to a physics-based approach. In the former approach, a Machine Learning algorithm is trained to discriminate between thermoacoustically stable and unstable combustors using examples generated by a (physics-based) acoustic network model. The ML model is then able to predict the thermoacoustic stability of an unknown configuration much faster than a traditional acoustic network model and with a very high accuracy. This approach has been validated in a previous study using classical Machine Learning algorithms, but it is restricted to somewhat simple geometries. The objective of this study is to investigate whether Deep Learning architectures can be used to generalise those results to complex geometries with a large number of elements.
Impact of railroad switches on rail noise exposure near stations

Anders Genell¹, Mikael Ögren², Erik Nyberg¹, Andreas Gustafson⁴, Tomas Jerson¹

¹Swedish National Road And Transport Research Institute, Gothenburg, Sweden, ²Department of Occupational and Environmental Medicine | School of Public Health and Community Medicine Institute of Medicine, Sahlgrenska Academy, University of Gothenburg, Gothenburg, Sweden, ³ELTON Acoustics Consultant, Höviksnäs, Sweden, ⁴Gärdhagen Akustik AB, Gothenburg, Sverige

According to Common NOise aSSess methOdS in EUrope (CNOSSOS-EU) in Annex II of Directive 2002/49/EC, noise from road, rail and airplane traffic, as well as noise from industries, shall be assessed using this common method. For railway noise in Sweden, noise assessment has previously been done using the Nordic Assesment Method for Train Noise, revised 1996 (NMT96). NMT96 includes a simple correction for rail joints of +3dB and for rail switches of +6dB. CNOSSOS-EU instead introduces a speed dependent correction based on a third octave band wavelength spectrum adding up to 20dB rolling noise energy in lower frequencies and down to -40 dB in higher frequencies. Measurements recently performed for two different rail switch types along the Swedish rail system indicate that the frequency distribution corresponds well to the CNOSSOS-EU correction for one type of rail switch but not for the other, and for the overall level difference the opposite is true. In order to investigate to what extent this deviation is affecting noise exposure an inventory of more than 11000 rail switches along the swedish railroad network has been performed to identify what types are situated in densely populated areas such as railway stations.
Inverse Design of Linear and Nonlinear Cylindrical Metamaterial Rod

Pravinkumar Ghodake

Indian Institute of Technology Bombay, Mumbai, India

Continuum elastic metamaterials can be used to reduce system-generated 2nd harmonics and they should also pass the fundamental harmonics during nonlinear ultrasonic testing. Linear metamaterials are designed based on the bandgap structure of the periodic layered materials showing contrast in acoustic impedances. Design parameters such as widths of the periodic layered elastic materials are calculated by a parametric sweep by solving eigenvalue problems, and the transfer matrix method. Most of the design studies assume infinitely long periodic elastic layers, but in practice length of metamaterial is limited by the reduction in fundamental amplitude of input short pulse. Though the linear metamaterials are designed for nonlinear ultrasonic applications, considering geometric and material nonlinearity of the layered elastic materials which contributes to harmonic scattering, the sensitivity of widths of layered materials to amplitudes of the 2nd harmonics, along with the linear interference is the most realistic modeling approach. In this study, linear and nonlinear metamaterials are designed using shape optimization techniques by solving transient finite element studies considering realistic geometric and material models. Gradient-free algorithms such as co-ordinate search and Nelder Mead are used during optimization. Effective design approaches are proposed and demonstrated to control longitudinal modes in a cylindrical rod.

Link to paper
Topology optimization of single and double panels for improved sound insulation in specific frequency bands

Daniele Giannini¹, Mattias Schevenels², Edwin Reynders¹

¹Department of Civil Engineering - Structural Mechanics Section, KU Leuven, Leuven, Belgium, ²Department of Architecture - Architectural Engineering Research Group, KU Leuven, Leuven, Belgium

Single and double panels are commonly employed in noise control, e.g., as partitioning elements between rooms and to enclose noisy machines. In presence of narrowband disturbances, related for example to rotating machines, further improvements in sound insulation can be obtained by properly distributing the material within the area of the panels. This allows maximizing the sound Transmission Loss (TL) in the frequency band of interest by controlling structural resonances and antiresonances. In order to achieve this goal, in this work, we apply numerical topology optimization to find the optimal material thickness distribution for single and double panels. In the iterative design process, single panels are schematized through a simple mechanical Finite Element (FE) model, while double panels are modelled considering the vibroacoustic coupling between the two mechanical plates and the internal acoustic air cavity. The sound insulation properties of the designed solution are evaluated by TL computations through hybrid Finite Element-Statistical Energy Analysis (FE-SEA) simulations. The method is applied targeting different frequency bands in the audible range and focusing on practically relevant design cases, such as single and double PMMA and glazing panels.

[Link to paper](#)
Measuring the impact force from the ISO impact ball and comparison with the tapping machine and alternate input method

Sunit Girdhar¹, Jason Blough¹, Andrew Barnard², John LoVerde³, Wayland Dong³

¹Michigan Technological University, Hancock, United States, ²Pennsylvania State University, State College, United States, ³Veneklasen Associates Inc., Santa Monica, United States

The impact ball was recently standardized within the ISO standards as a low-frequency input impact source for impact testing of floor-ceiling assemblies. The input force due to an impact ball is not measured during the tests. A force measurement plate was created with three force transducers to measure the impact force due to ball drops on six different floor assemblies. The input force showed a really good comparison for heavy and lightweight floors in lower frequency but poor force excitation for all the floors above 100 Hz. The input force values were compared with a modified tapping machine’s force input levels showing the tapping machine has poor low-frequency excitation (in comparison) but an improved high-frequency excitation. An alternate input method was developed where a force transducer is added to the impactor to make live measurements of the input force and the impact tip can be changed to modify the range of targeted frequencies for any test.

[Link to paper]
A method to quantify the noise annoyance in an airport community

Truls Gjestland¹, Idar L N Granøien
²Sintef, Trondheim, Norway

Exposure-response curves showing the prevalence of high annoyance as a function of the long-term noise exposure level DNL/DENL is the preferred way of presenting the results from surveys on noise annoyance. However, such curves give very little information about the actual extent of the negative impact in a specific noise situation. The number of impacted people is not known and people that are annoyed to a lesser degree than “highly annoyed” are not counted.

A method to quantify the magnitude of noise annoyance in an airport community has been developed.
The Sonic Identity Model: one interdisciplinary approach for qualitative urban soundscape analysis, management and design

Sophie Gleeson
Arup; RMIT University, Melbourne, Australia

Urban soundscapes are predominantly understood through the use of quantitative environmental noise management and traditional acoustic design approaches. These approaches, while valuable, do not capture the subjective qualities of sonic environments as experienced by its users. The Sonic Identity Model, developed by Pascal Amphoux of the Centre for Research on Sonic Space and Urban Environment (CRESSON), offers one interdisciplinary approach for qualitative urban soundscape analysis, management and design. The interdisciplinary Model is intended to be used by large research teams to study a city’s soundscape. Since its publication in 1993 it has received little attention in urban soundscape research and practice. In this paper I provide an introduction to, and overview of, the Sonic Identity Model. I review practitioner uses of the Model, with a focus on its demonstrated applicability in conjunction with traditional acoustic design approaches. I then present my contemporary adaptation of the methodology, developed for individual researchers to study indoor and outdoor urban soundscapes in situ, and describe its use in a limited urban study. This paper serves to position the Model as a guiding framework for future urban soundscape practice, offering practitioners a toolkit of qualitative methods for soundscape documentation and conceptual tools for soundscape analysis.
The Effects of User Experience on the Questionnaire to Detection of the Soundscape of Historical Areas - Example of Eskisehir Factories Region

Özlem Gök Tokgöz
Chair of Acoustics and Haptics, TU Dresden, Dresden, Germany

Soundscape studies carried out in historical areas need extensive research and analysis in the processes from the past to the present. It is determined by taking into account many variables such as historical process, the character of area, events and people. In this study, it is aimed to investigate the past experiences of the people carried out in historical areas affect the evaluation of the present data. Eskisehir was chosen as the study area. Eskisehir is an Anatolian city in the Central Anatolia region, on the trade routes and at the intersection of railway transportation. Due to its proximity to railway transportation, many factories established. Nowadays it is under protection as an industrial heritage. In the study, a questionnaire was conducted to evaluate the soundscape of the region with people living in the region for a long time, and people newly settled in Eskisehir. In the survey, the sounds in the region, the pleasantness of the people and the adjective pairs to describe the acoustic environment were asked. As a result of the study, the importance of the user's experience was investigated and evaluated for the survey studies carried out in the evaluation of the soundscape of historical areas.

Link to paper
Soundscapes Research in Multicultural Market Areas - Example of Berlin Kreuzberg

Özlem Gök Tokgöz\textsuperscript{1}, André Fiebig\textsuperscript{2}
\textsuperscript{1}Chair of Acoustics and Haptic Engineering, Institute of Acoustics and Speech Communication, TU Dresden, Dresden, Germany, \textsuperscript{2}Department of Engineering Acoustics, Institute of Fluid Dynamics and Technical Acoustics, TU Berlin, Berlin, Germany

Market areas are places where sellers and buyers come together periodically. Throughout its history, market areas have always been places that allow rich cultural interaction. At those places usually, people from different cultural backgrounds and speaking different languages come together. Due to this rich cultural and social potential promoting social relations, it has been the subject of many studies from different disciplinary points of view. However, no study deals in detail with the soundscape of those areas where the human voice is often the main sound source and leads to unique acoustic environments. The study determines the role of market area soundscapes by means of user assessments and acoustic measurements.

A field study was carried out in different market areas in Berlin Kreuzberg. This district is a culturally diverse and multilingual area and in the street markets many products, mainly fruit and vegetable sales, are sold. In this study, comparative sound measurements and surveys were conducted. The field survey, which was held in Turkish, German, and English language, was applied to the group of sellers and buyers. The soundscape of these areas including its perception was systematically investigated and the role of sound as a mediator between cultures explored.

[Link to paper]
Further application of the 1/3 oct band heavy/hard impact prediction method

Matthew Golden¹, Tim Patzke
²Pliteq, 131 Royal Group Crescent Vaughan, Canada

Previously, the author presented a 1/3 octave band heavy/hard impact prediction method based on force pulse measurements from a drop tower. Since then, we have been applying the method with a variety of success. The previous paper was based on concrete structures in North America. This paper will be looking at the validity of the method on lighter weight mass timber buildings primarily located in the United Kingdom as well as traditional concrete buildings. The discuss will be focused on the accuracy of the method across several structures and describe why the method was less accurate in some applications. The primary cause of disagreement between predicted and in-situ measurements was high levels of background noise and other site conditions.

Link to paper
An ocean acoustical ray-tracing tool based on Fermat’s least time principle in real a environment

João Duarte Gonçalves
\textsuperscript{1}
\textsuperscript{1}Escola Naval, Lisboa, Portugal

Recently the Underwater Acoustics Modelling and Sonar Prediction – SeaRider tool was developed by the Portuguese Naval Academy. Based on Fermat’s least-time principle, 2D and 3D models of propagation of acoustic rays in the ocean were developed. These models consist of an algebraic differential system of equations. In this work we considered additionally the possibility of calculating the trajectory, addressing the occurrence of acoustic ray reflections either on the water surface or on the ocean floor. The reflections in the boundaries were assumed specular and were modelled based on Snell’s law. We also considered the possibility of calculating the trajectories, taking into account the actual data of the speed of sound in the ocean as well as the bathymetry of the bottom. For this purpose, the 2D and 3D ocean-acoustic ray tracing developed can use existing data bases (GEBCO, NOAA, WOD18 and TEOS-10), extracting information on the topography and climatology to compute the acoustic ray trajectories in a real environment. This tool allows us, for example, to identify positions of ecosystems subjects to the effects of different sources of noise. The developed algorithms were submitted to several numerical simulations and compared with other ocean-acoustic modelling programs.

Link to paper
Large Eddy Simulation of compositional indirect noises generated in a non-isentropic nozzle

Yu Gong¹, William Jones¹, Fred Marquis¹
¹Imperial College London, London, United Kingdom

The present work describes the results of a numerical study of the noise generation by compositional perturbations in a non-isentropic nozzle. An in-house compressible LES code, Boundary Fitted Flow Integrator-LESc, is utilized to simulate the noise generation in the system. The compositional inhomogeneities are generated by a cross-flow pulse injection. Different operating conditions are investigated, including different injection gases and air mass flow rates. The results revealed that the processes of direct and indirect noise generation are successfully reproduced in the LES, with the noise magnitudes in good agreement with those in the measurements. Injection of gases with smaller (He) and larger (CO2) molar masses compared to air is found to generate negative and positive indirect noises, respectively, in the LES, which is consistent with the experimental findings. The effect of different air mass flow rates is also investigated and discussed, and the direct noise and indirect noise amplitudes are both found to be closely related to the air mass flow rate. The indirect noise amplitude and upstream pressure are found to be closely related to the losses in the system, which are higher in the simulation when the Mach number in the nozzle approaches unity and shocks may exist. Under these circumstances, the accuracy of the numerical method is uncertain and requires further investigation.
Association between aircraft noise levels and deprivation

Xiangpu Gong\textsuperscript{1,2}, Nicole Itzkowitz\textsuperscript{3}, Kathryn Adams\textsuperscript{1}, Calvin Jephcote\textsuperscript{1}, Marta Blangiardo\textsuperscript{3}, John Gulliver\textsuperscript{1,2}, Anna Hansell\textsuperscript{1,2}

\textsuperscript{1}Centre for Environmental Health and Sustainability, University of Leicester, Leicester, United Kingdom, \textsuperscript{2}National Institute for Health Protection Research Unit in Environmental Exposures and Health at the University of Leicester, Leicester, United Kingdom, \textsuperscript{3}Department of Epidemiology and Biostatistics, Imperial College London, London, United Kingdom

There is limited evidence on socioeconomic distribution of noise exposure. Noise data (Lden, Laeq24, Lnight, Levening, and Lday) were available for London Heathrow airport for 2014-18. These were linked with different measures of deprivation: the Carstairs deprivation index (UK Census-derived), fuel poverty rate and the avoidable death rate.

Using Carstairs, mean noise levels were slightly higher in more deprived areas for most noise metrics, especially for Lnight (~2dB between least and most deprived Carstairs quintiles). However, Leve had slightly lower mean noise levels in the most deprived quintile (~0.5dB difference). A clear pattern of higher mean noise levels with deprivation was seen using avoidable death rates (~4dB difference between lowest and highest quintile for Lnight). Conversely, mean noise levels were slightly lower in more deprived quintiles of fuel poverty.

Differences have been further quantified using a random-effects model, accounting for year.

Heathrow airport is situated close to highly populated areas, some of which are very wealthy, so may not be representative of other airports. Results will be discussed with community groups near Heathrow prior to Internoise 2022. As air transport increases post-pandemic, information on noise exposures as well as views from community groups can inform future airport policies.

[Link to paper]
An Approach to Designing and Specifying Audibility Requirements of Train Activated Warning Systems

Christabel Goode¹, Seckin Basturk¹, James Block¹, Alex Southern¹
²Aecom, United Kingdom

Train Activated Warning Systems (TAWS) use an audible warning to alert track-workers of an oncoming train. TAWS emits a safe-tone sound to indicate the system is active. When a train approaches, the safe tone switches to a warning-tone in enough time to allow track workers to reach a position of safety. There is currently no specific methodology for designing a new TAWS system to achieve the required audibility over a defined area of track. This paper presents an approach to the design and specification of TAWS audibility over lengths of track where different prevailing acoustic environment conditions need to be considered. The challenges encountered and the limitations of the resulting approach are discussed.

[Link to paper]
State of the art about solutions for tram noise reduction in the framework of the Life SNEAK project

Lapo Governi¹, Monica Carfagni¹, Francesco Borchi¹, Luca Puggelli¹, Francesco Buonamici¹
¹University of Florence - Department of Industrial Engineering of Florence, Via Di Santa Marta, 50139, Firenze, Italy

The LIFE SNEAK project, started in September 2021, aims at the reduction of noise from road traffic that mainly affects densely populated urban areas where the noise and vibrations produced by the tram overlap with noise produced by road traffic. Applicative measures will be designed and tested in a pilot case of the city of Florence, such as low-noise and vibration surfaces, with life cycle costs comparable to those of traditional surfaces, and measures to reduce tram noise aiming to obtain substantial reductions in noise and annoyance.

Referring to tram noise, in the first phase of the project, specific attention has been dedicated to the state-of-the-art analysis concerning possible measures to perform noise reduction with specific attention to noise due to wheel-rail contact and “squeal noise” phenomena that mainly occur in urban environments close to curves with small radius.

In this paper, the results of the state-of-the-art analysis are presented with particular attention to the use of sound-absorbing panels to be applied on the tram (bogie skirts).

[Link to paper]
A new procedure to carry out noise and vibration measurements oriented to support an annoyance evaluation in the framework of the Life SNEAK project

Lapo Governi\textsuperscript{1}, Andrea Bracciali\textsuperscript{1}, Gianluca Megna\textsuperscript{1}, Matteo Bernardini\textsuperscript{1}, Chiara Bartalucci\textsuperscript{2}, Raffaella Bellomini\textsuperscript{2}, Gianfrancesco Colucci\textsuperscript{2}, Sergio Luzzi\textsuperscript{2}

\textsuperscript{1}University of Florence - Department of Industrial Engineering, Firenze, Italy, \textsuperscript{2}Vie en.ro.se. Ingegneria, Firenze, Italy

The LIFE SNEAK project, started in September 2021, aims at the reduction of noise from road traffic that mainly affects densely populated urban areas where the noise and vibrations produced by the tram overlap with noise produced by road traffic. Applicative measures will be designed and tested in a pilot case of the city of Florence, such as low-noise and vibration surfaces, with life cycle costs comparable to those of traditional surfaces, and measures to reduce tram noise aiming to obtain substantial reductions in noise and annoyance.

In the first phase, specific attention was dedicated to the state-of-the-art analysis concerning prediction and monitoring of the level of noise and ground-borne vibrations in urban environments.

Moreover, the impacts of road traffic and tramway in terms of noise and vibrations on people annoyance in urban context have been investigated in order to design appropriate questionnaires for citizens. In fact, the exploration of any combined effect of vibration and noise on annoyance is also suggested by recent guidelines for designing dedicated social surveys.

In this paper the procedure to design a noise and vibration measurements campaign oriented to support an evaluation of effective reductions in terms of both levels and annoyance is presented.
Assessment of the Noise Reduction Impact from Application Restrictions on Rail Dampers

Christoph Gramowski¹, Roxana Donner²
¹Schrey & Veit GmbH, Sprendlingen, Germany, ²Acouplan GmbH, Berlin, Germany

In the last decades, rail dampers had become a commonly used rolling noise abatement measure at several mainline and metro networks. Rolling noise reductions outdoor/indoor up to 4/8 dB had been found. While the beginning of damper application was started with multiple test sections, infrastructure managers had raised installation restrictions from other related technology departments like signaling and communication. This is leading to defined sections where one rail has to remain partially free from dampers or the track has to remain completely free from dampers.

These sections become relevant when the damper application is caused by noise tackling action plans. Therefore, the acoustic impact was assessed by a) laboratory test track analysis (partially free) and b) environmental noise prognosis software (completely free).

It is shown, that also for a partially free rail, a cancellation of the noise reduction can be expected for single 1/3 octave frequencies. This can be relevant for the overall noise emission. The effect from the completely free rail is much larger due to noise increases at several immission points. Railway noise mitigation has to consider these results or, if possible, the rail damper technology has to be improved to avoid these restricted sections.
Classroom acoustics design beyond BB93 - refurbishment of a hearing impaired unit in a mainstream primary school

Emma Greenland

1Anderson Acoustics, 1 Trafalgar Mews 15-16 Trafalgar Street, United Kingdom

Benchmark acoustic testing was carried out for an existing hearing impairment unit within a mainstream primary school, as part of a feasibility study investigating potential for refurbishment vs. rebuild/relocation. Acoustic measurements comprised reverberation time, internal airborne sound insulation and indoor ambient noise level. Although the benchmark testing largely demonstrated compliance with the minimum acoustic performance standards outlined in Building Bulletin 93 for refurbishments, it was also important to consider the results in the wider context of individual school operation and management, and beyond the scope of Building Bulletin 93 performance standards. Interviews with staff and students were carried out to supplement the acoustic measurements and evaluate performance in use. This process revealed additional acoustic problems which were outside the scope of BB93 but were nonetheless challenging for the children and staff learning in the space. Results will be discussed against the scope of BB93 and findings will be useful to inform future design standards, given the Department for Education’s refocus on refurbishment of school buildings as part of its target to achieve net zero carbon by 2050.
Verification of Railways Noise Mapping Using CNOSSOS-EU: Case Study on Freight Trains

Alvaro Grilo Bensusan¹, Javier Mitjavila¹
¹Inerco Acústica, Calle Tomas Alba Edison, 2 41092 Seville, Spain

Freight trains are a relevant source of environmental noise and require an acoustical assessment to quantify the exposure of the population using noise mapping. Once the results of the noise calculations have been developed, it might be necessary to adopt mitigation strategies that can be validated using these noise models. It is becoming increasingly common to undertake some form of validation exercise to cross-reference the calculated levels with measurements to reduce the uncertainty in the action planning. Based upon the results of the monitoring, the measured data may then be stratified regarding the source data and meteorological data and introduced into the calculation model, to enable the model to replicate the situation during the measurement windows (meta-models). The results from the calculations of each of these meta-models may then be compared with the noise measurement results as the basis for the validation study. This paper presents an overview of a verification project undertaken in South America where such a process was followed using the CNOSSOS-EU as the basis of comparison.
Acoustics for a Sustainable Future

Richard Grove

Inhabit, London, United Kingdom

Sustainability is now at the core of everything we do, from our personal daily lives to how we engineer the built environment and treat it in operation. The need for acousticians to consider sustainability is now, more than ever, a critical element in having acoustic interventions included in a design. The wide ranging terminology and acronyms associated with sustainability, abstract concepts of physiology and psychology around Health and Wellbeing, and passing references made in wider policy, standards and guidance, can be difficult to navigate and resolve with technical acoustic performance when applied in practice. Since much of an acousticians work centred on technical acoustic performance, much needed consideration to sustainability can often be overlooked. This paper seeks to provide a review of the current position in relation to sustainability, including references to the UN Sustainable Development Goals, Life Cycle Analysis, The Circular Economy, and Whole Life Carbon including Embodied and Operational Carbon impacts that my arise from recommendations made by acoustic designers. Health and wellbeing impacts are also discussed, through reference to the Genius Loci and acoustic design as an integral element in the building design process, demonstrating how carefully considered acoustic design can contribute positively to Sustainable Communities.
Incoherent Integration of Hyperbolic Frequency Modulated Pulses by the Radon Transform

Zhaoning Gu\textsuperscript{1}, Chuanqi Zhu\textsuperscript{1}, Shiliang Fang\textsuperscript{1}
\textsuperscript{2}Key Laboratory of Underwater Acoustic Signal Processing, Ministry of Education, Southeast University, Nanjing, China

We herein investigate the incoherent integration of hyperbolic frequency modulated (HFM) pulses for improvement of detection performance under heavy ocean noise. In active sonar systems, combining wideband transmit signals and matched filtering offers considerable processing gain. However, when relative motion exists between the target and sonar system, the processing gain decreases due to the mismatch caused by the Doppler distortion. As a Doppler invariant signal, the HFM waveform gets the property at the cost of a bias in the matched filter output. We propose an incoherent pulse integration method based on the Radon transform to take advantage of the property of HFM signals and handle the bias in outputs of matched filters. In the proposed method, return pulses are first matched filtered, and the Radon transform is performed on the outputs afterward. After that, range bias compensation is performed based on the transform results. The proposed method offers reliable detection performance under heavy ambient ocean noise thanks to the processing gain obtained by both pulse integration and matched filtering. Also, with the help of the Radon transform, detection, bias compensation, and target parameter (range and radial velocity) estimation could be carried out simultaneously.

[Link to paper]
Experimental study on electromechanical performance decoupling and vibration suppression of crystal oscillator

Zhangqi Gu\textsuperscript{1}, Qingqing Yu\textsuperscript{1}, Xuelin Peng\textsuperscript{1}
\textsuperscript{2Nanjing Research Institute Of Electronics Technology, Nanjing, China}

In the mechanical vibration environment, the phase noise of crystal oscillator would deteriorate sharply, which would lead to the decline of the stability of crystal oscillator and affect the comprehensive performance of the whole electronic equipment. In this paper, the mechanism of electromechanical coupling between mechanical vibration and phase noise is analysed theoretically. The relationship between phase noise and vibration magnitude and the sensitivity of phase noise to different vibration frequencies and directions are studied experimentally, then the decoupling of mechanical performance and electrical performance is realized. Based on this, a vibration isolator for crystal oscillator is designed, which can achieve 15-2000Hz full frequency band random vibration attenuation, the vibration acceleration RMS value is reduced by 95%, and the phase noise degradation of crystal oscillator is less than 5dB. The research has a certain reference value for the vibration isolation design of electromechanical coupling vibration sensitive devices.

[Link to paper]
We experimentally investigate the collective behaviour of four turbulent lean-premixed combustors coupled in a ring network. We adopt a complex systems approach, treating each combustor as an individual self-excited thermoacoustic oscillator and examining how a minimal network of such oscillators can self-organize into synchronous and asynchronous states. Using proven synchronization metrics, we identify a broad range of collective behaviour, including a weak anti-phase chimera, a breathing chimera, intermittent frequency locking, and three-frequency quasiperiodicity. The discovery of chimera states in a minimal network of coupled thermoacoustic oscillators suggests that chimera control techniques could be exploited for the suppression of thermoacoustic oscillations in can-annular combustion systems.
Sound Radiation Estimate from Vibration Measurements With Multiple Cameras

Gianluca Guernieri¹, Paolo Gardonio¹, Roberto Rinaldo¹, Andrea Fusiello¹, Emanuele Turco¹
¹Università Degli Studi Di Udine, Udine, Italy

This paper presents experimental results on the estimate of the sound radiation by a thin flat plate from flexural vibration measurements taken with multiple cameras. The study considers the sound radiation into free-field by a baffled rectangular plate fixed on a rigid frame. The plate is excited by a tonal point force exerted by a shaker at the first three resonance frequencies of the plate flexural response. The resulting vibration field is measured with a set of six cameras suitably synchronised. More specifically, 3D point tracking is implemented on a regular NxM grid of small circular points marked on the plate. The transverse displacements at these points are thus reconstructed from triangulation with multiple (i.e. more than 2) view-points. The transverse displacements are then used to derive the sound radiation from a direct boundary integral formulation. More specifically, for the flat rectangular plate at hand, the sound radiation is derived from the Rayleigh integral, which is approximated into a finite sum over the mesh of rectangular elements centred at the NxM grid of points depicted on the plate. The flexural vibration field and the sound radiation field derived from the camera measurements are contrasted with measurements taken with a laser vibrometer and microphone-scanner probe. The initial results presented in this paper demonstrate the feasibility of the proposed measurement approach at low audio frequencies.
Apparent wood elements and acoustic performance – Feedback from Adivbois CLT building mockup

Catherine Guigou Carter¹, Nicolas Balanant², Jean-Luc Kouyoumji³
¹CSTB, Saint Martin d'Hères, France, ²CERQUAL Qualitel Certification, Paris, France, ³FCBA, Bordeaux, France

The acoustic performance of a CLT based building mockup was investigated within the scope of AdivBois acoustic technical commission with the objective of defining wood building constructions fulfilling requirements. The CLT based building is a three floor construction, with four rooms on each level. Acoustic measurements from junction characterization to air-borne and impact sound insulations have been performed. Apparent wood is supposed to have positive effect on health and well-being on building occupants. This paper concentrates on the effect of apparent wood on the acoustic performance: the apparent wood can be either the underside of the CLT floor (i.e., no suspended ceiling) or posts and beams possibly continuous between different rooms. The measured results are discussed with respect to prediction. A simple approach to take into account the through beams or posts is proposed. Recommendations concerning apparent wood elements in buildings are imparted.

[Link to paper]
Building acoustic performance prediction – Feedback from Adivbois CLT building mockup

Catherine Guigou Carter1, Nicolas Balanant2, Jean-Luc Kouyoumji3
1CSTB, Saint Martin d’Hères, France, 2CERQUAL Qualitel Certification, Paris, France, 3FCBA, Bordeaux, France

The acoustic performance of a CLT based building mockup was investigated within the scope of AdivBois acoustic technical commission with the objective of defining wood building constructions fulfilling requirements. The CLT based building is a three floor construction, with four rooms on each level. Measurements from junction characterization to air-borne and impact sound insulations have been performed. Furthermore, acoustic measurements have been performed before and after linings and floor coverings were implemented. Moreover, several acoustic teams have carried out measurements in the building. This paper concentrates on the comparison between measured acoustic performance and the predicted one. Predictions are based on the EN ISO 12354-1 and -2 standards, using floor and wall acoustic performances measured in laboratory conditions. The effect of inserting resilient layers in junctions, floor covering and receiving room size is discussed.

Link to paper
Sound generation by entropy waves accelerated by blades

Juan Guzman-Inigo, Aimee Morgans

1Imperial College London, London, United Kingdom

Entropy noise is the sound produced by the acceleration of convective temperature fluctuations (entropy waves) by non-uniform flows and is a major contributor to indirect combustion noise. Entropy waves are accelerated by nozzles in rocket engines or by the turbine blade rows in the combustors of gas turbines. While several analytical models have been developed for entropy noise generated by nozzles, not many efficient models exist for the case of blade rows. This is due to the more complex physical mechanisms involved: when entropy waves pass through cascades of blades, sound is produced due to the acceleration and turning of the entropy waves in the interblade region, but also unsteady forces are created in the blades and vorticity is shed from the trailing edge of the aerofoils. All these mechanisms are strongly coupled and affect the generated entropy noise.

In this work, we explore numerically the importance of these mechanisms. To this end, we present time- and frequency-domain simulations of entropy waves interacting with several canonical aerofoils. Finally, a simple model is presented to estimate the entropy noise generated by each configuration.

[Link to paper]
The tyre/road noise comparison of SMA 11 and cobblestone pavement

Ing. Blanka Hablovičová¹, Ing. Petra Marková¹, Vítězslav Křivánek¹
¹Transport Research Centre CDV, Líšeňská 33a, 636 00 Brno, Czech Republic

Noise has a big influence to human health. The major source of noise in residential areas is traffic, especially the contact between tyre and pavement of road (tyre/road noise). Asphalt is the most used pavement in residential areas, but cobblestones, for example, are used in historic parts of cities. There are relatively a few road surfaces with cobblestones, but with regard to noise, it is very important to monitor their acoustical behavior. Article compare the tyre/road noise of the stone mastic asphalt with the maximum grain size 11 mm and cobblestones measured by the Close-Proximity method in 2021. The measurements were performed on the same road within the following sections at velocities from 30 to 90 km/h. The results are presented as values of sound pressure level and frequency spectra.

Link to paper
Testing the active minimization of the total radiated sound power of a vibrating plate

Mehran Hajilou\textsuperscript{1}, Delf Sachau

\textsuperscript{1}Helmut Schmidt University, Holstenhofweg 85, 22043 Hamburg, Germany

This paper presents an experimental investigation of an Active-Noise-Control (ANC) system for reducing unwanted so-called primary sound by destructive interference with sound generated by so-called secondary sources (loudspeakers). In this work the primary source is a vibrating simply supported plate which is radiating sound into the free field. The loudspeakers are placed in front of the plate. The ANC-system utilizes the measured signals of the primary accelerometers which are placed on the surface of the plate. The number of the primary accelerometers corresponds to the number of the loudspeakers. Also, one secondary accelerometer is fixed onto each loudspeaker cone. Furthermore, a microphone in front of each loudspeaker measures the near field sound pressure. An adaptive feed-forward-controller is used to calculate the optimal control signal for each secondary source. The optimal control is achieved by minimizing the radiated active sound intensity in front of each loudspeaker in order to minimize the total radiated sound power of the primary and secondary sources. The ANC-system is tested in different configurations with one or two loudspeakers in front of the plate. Also, an approach for the system calibration is developed to compensate the phase deviation between the true and the measured sound intensity.
Practical Tutorial on cylindrical structure vibro-acoustics Part 1 – Vibrations

Stephen Hambric¹
¹Penn State University, State College, United States

The mathematics which describe the vibroacoustic behavior of cylindrical structures are imposing to say the least. Part 1 of this practical tutorial demystifies cylindrical shell vibration theory by using measured data from actual shells and pipes to explain key concepts. For any shell, you can estimate frequency ranges where shells behave like simple beams and flat plates, greatly simplifying calculations of modes of vibration and mobilities. The key is first calculating the ring frequency – the frequency where membrane waves can propagate fully around the shell circumference. Simple infinite structure theory may then be used to compute mean mobilities for beam, shell, and flat plate behavior. Modes of vibration for a cylinder depend on both longitudinal and circumferential harmonics, or a helical wavenumber. Cremer’s simple approximate resonance frequency formula is used to show examples for a large diameter short shell and a small diameter long shell (a pipe). Finally, the measured modal densities of an elbowed pipe are compared to estimates from an empirical expression for modal density of a shell. In all cases in this tutorial, measurements and simple estimates agree well, showing that cylindrical shell vibrations may be estimated without difficult math or complex computer models.

[Link to paper]
Systematic review and meta-analyses of association between transportation noise and Ischaemic heart disease based on studies published between 1994 – 2022

Sophie Hamilton¹, Benjamin Fenech¹,², Xiangpu Gong², Danielle Vienneau³,⁴, Anna Hansell²,⁵
¹Noise and Public Health Team, Radiation Chemical and Environmental Hazards, Science Group, UK Health Security Agency, UK, ²Centre for Environmental Health and Sustainability, University of Leicester, Leicester, UK, ³Swiss Tropical and Public Health Institute, Allschwil, Switzerland, ⁴University of Basel, Switzerland, ⁵National Institute of Health Research (NIHR) Health Protection Research Unit (HPRU) in Environmental Exposures and Health at the University of Leicester,

There is a growing body of evidence that exposure to transportation noise can increase the risk for ischaemic heart disease (IHD). However, there are significant variations in the pooled exposure-response relationships (ERRs) derived by recent meta-analyses. These discrepancies lead to uncertainties in health impact assessments and in public health policy decision-making. Updated analyses are needed to better understand this relationship.

This paper presents an update to recent systematic reviews and meta-analyses investigating the effects of transportation noise exposure on IHD mortality and morbidity. Specific aims are to understand if studies published since 2019 affect pooled ERRs and assess if evidence for aircraft and railway noise exposure has strengthened. We included studies from two meta-analyses and one literature review covering the years 1994-2020. We then conducted an updated literature search in PubMed, Scopus, Web of Science and Medline for the period October 2020 and January 2022, following the same protocol as the WHO Environmental Noise Systematic Review Group. 30 studies were included from the previous reviews, and nine further studies were identified via the updated literature search. The studies present risk estimates for IHD incidence (n=36), prevalence (n=5) mortality (n=26). The updated evidence and exposure response analysis is presented for Lden.
Resonance mode analysis of finite plate strip with acoustic black holes: the gap between bandgap and attenuation band

Bing Han¹, Hongli Ji¹, Jinhao Qiu¹, Li Cheng²
¹Nanjing University of Aeronautics and Astronautics, Nanjing, China, ²Hong Kong Polytechnic University, Hong Kong

Acoustic Black Hole (ABH) lattice structures show promise for achieving broadband bandgap in lightweight design. Existing ABH lattice research usually assumes that the bandgaps of infinite periodic structure are roughly the same as the attenuation band with strong energy attenuation in the finite counterpart. This work is concerned with comparison of the real attenuation bandwidth of finite periodic ABH structures and the bandgap of the infinite counterpart. The plate strips consisting of different numbers of periodic ABH elements are considered. It is observed that the bandgap-predicted attenuation band is split into two narrow attenuation bands, so that the periodic ABHs fails to ensure a broadband and continuous attenuation in the finite scenarios. Results show that there are resonance modes of finite plate strips with ABHs falling into the bandgap due to the boundary reflection and would result in high transmission peaks within the bandgap-predicted attenuation band. This unexpected phenomenon suggests the gap between the attenuation bandwidth of finite periodic structure and the bandgap of the corresponding infinite one. Analysis shows that the resonance mode of finite plate strips, which reduces the bandgap-predicted attenuation bandwidth, can be tuned by geometrically disturbing the periodicity and symmetry of the finite periodic configuration.

Link to paper
The effect of main stage flow velocity on thermoacoustic instability of stratified swirl burner

Meng Han¹, Xiao Han¹, Jianchen Wang¹, Yuzhen Lin¹
²Beihang University, Beijing, China

In this paper, two group experiments were conducted to study the effect of the main stage flow velocity on thermoacoustic instability and flame macrostructure. The experiments were carried out under atmosphere condition, and namely the pilot stage flame mode and the stratified swirl flame mode. The experimental results show that in the pilot stage flame mode, the thermoacoustic oscillation amplitude remains constant (around 1000 Pa) with the decrease of the main stage flow velocity. But when the velocity is zero (without main stage air), the thermoacoustic instability disappeared. In the stratified swirl flame mode, the amplitude of thermoacoustic instability is the largest (around 300 Pa) when the main stage flow velocity is 6.2 m/s, and the amplitude is slightly smaller in other working conditions. The time-averaged flame shape under the two flame modes is recorded and discussed. This paper highlights the effect of interactions between the pilot stage flame and main stage air or flame on thermoacoustic instability.
Analysis of community departure noise exposure variation using airport noise monitor networks and operational ADS-B data

R John Hansman¹, Jacqueline Huynh², R. John Hansman³
¹MIT International Center For Air Transportation, Cambridge, United States, ²UC Irvine Department of Mechanical and Aerospace Engineering, Irvine, United States, ³MIT International Center for Air Transportation, Cambridge, United States

Advanced operational flight procedures have been proposed to reduce the impact of aircraft operations on community noise. Recent work has led to the development of noise abatement procedures like the delayed-deceleration approach for arrivals. Causes of variation in airport noise monitor network measurements due to departures remain an important source of uncertainty in the development of departure noise abatement procedures. Understanding this variation, found to be up to 20 dB at individual monitors for multiple departures, can be accomplished by analyzing aggregate departure noise and flight procedures so statistically-significant factors that correlate with measured noise can be isolated. This paper aims to identify these factors. Operational flights at Seattle-Tacoma International Airport conducted in March and August of 2019 are examined using a framework that includes ADS-B data from the OpenSky Network, a force balance kinematics model to model aircraft performance, and the Seattle-Tacoma International Airport noise monitor network. Variation in measured departure noise throughout the entire monitoring network is examined as a function of aircraft weight, thrust, velocity, specific energy, and flight path angle. Variables that are found to correlate with increased noise are isolated and can be used to inform the development of future departure noise abatement procedures.
Acoustic Shielding and Scattering Effects of a Propeller Mounted Above a Flat Plate

Liam Hanson¹, Kabilan Baskaran¹, Bin Zang¹, Mahdi Azarpeyvand¹

¹University Of Bristol, Queen's Building, University Walk, Bristol, BS8 1TR, United Kingdom

To reduce the overall noise pollution generated by aircraft, design choices often attempt to incorporate acoustic shielding often using aircraft wings to minimise the noise generated by engines and propellers. By mounting a propeller above a wing, increasing the noise shielding, acoustic scattering effects can be introduced which change the directivity and magnitude of the noise generated. Experiments were carried out to investigate the acoustic shielding and scattering effects of a propeller mounted above a flat plate trailing edge. Two propellers were tested at constant rotational rates of 5000 RPM and 7000 RPM respectively. The tests were conducted within an anechoic wind tunnel facility with loading and far-field noise data collected by microphone arrays at a parametric set of propeller locations relative to the flat plate trailing edge. Analysis of the spectral content of the noise along with the tonal content of the signals are presented. The levels of coherence and cross spectrum phase are considered to give greater insights into the levels of noise attenuation due to shielding and scattering effects. Analysis of the acoustic data shows locations with notable levels of noise attenuation for both the tonal and broadband noise content.

Link to paper
Challenges in delivering effective noise management at gas compressor stations

Carl Christian Hantschk1, Marco Geisler1
1Müller-BBM, 82152 PLANEGG, Germany

The basic principles applied in gas compressor stations to manage noise and demonstrate compliance with statutory acoustic requirements are not different from those used with most other industrial activities. Well-known and proven standard procedures involve sound emission assessment, acoustic modeling, model verification, development of a noise control concept and its optimisation until compliance can be demonstrated. However, noise control for some of the typical equipment in gas compression is extremely demanding in terms of both acoustic and operational/safety aspects so that it requires special attention. Examples are the exhausts of the gas turbines driving the compressors and the extensive network of gas piping. Because of their high and strongly varying sound emissions the exhausts pose a significant challenge in designing effective silencers. In addition, flow-generated self-noise in the silencers is a risk that needs to be avoided. For the piping sound attenuation by acoustic lagging is in conflict with corrosion and maintenance/accessibility problems and makes an optimised lagging concept an ambitious task. The present contribution illustrates typical problems encountered and possibilities to deal with them. It is based on data and experiences with gas compressor stations with very stringent acoustic requirements.

Link to paper
Subjective evaluation for sharp sound image construction based on reverberation control with surround sound system using parametric and electro-dynamic loudspeakers

Yuna Harada¹, Yuting Geng¹, Kenta Iwai², Masato Nakayama³, Takanobu Nishiura²

¹Graduate School of Information Science and Engineering, Ritsumeikan University, Kusatsu, Japan, ²College of Information Science and Engineering, Ritsumeikan University, Kusatsu, Japan, ³Faculty of Design Technology, Osaka Sangyo University, Daito, Japan

3-D sound field reproduction systems can provide a high presence. These systems commonly use electro-dynamic loudspeakers. Electro-dynamic loudspeakers tend to construct diffuse sound images due to its wide directivity and high reverberation. In contrast, parametric array loudspeakers can construct sharp sound images due to its sharp directivity and low reverberation. On the other hand, it is difficult to provide reverberation presence by parametric array loudspeakers because of the sharp directivity.

We have previously proposed a sharp sound image construction based on reverberation control with surround sound system using parametric and electro-dynamic loudspeakers. In this method, the sharp sound image is rendered using parametric array loudspeakers, and the reverberation presence is provided by electro-dynamic loudspeakers, emitting reverberation signals synthesized with reverberation control filters. Through the objective experiments, we have confirmed that this method can construct the sharp sound image with reverberation presence.

In this paper, we conduct subjective experiments to confirm if the listeners can perceive the reverberation presence provided by the proposed method. In particular, we evaluated the sharpness and direction of the sound image, and the reverberation presence with objective and subjective evaluation experiments. From the subjective evaluation, we confirmed that the reverberation presence can be perceived.

Link to paper
A comparison between the high-frequency Boundary Element Method and Surface-Based Geometrical Acoustics

Jonathan Hargreaves
1University of Salford, Salford, United Kingdom

The audible frequency range covers many octaves in which the wavelength changes from being large with respect to dominant features of a space to being comparatively much smaller. This makes numerical prediction of a space’s acoustic response, e.g. for auralisation, extremely challenging if all frequencies are to be represented accurately. Different classes of algorithm give the best balance of accuracy to computational cost in different frequency bands – ‘wave solvers’ such as Boundary Element Method (BEM) at low frequencies and Geometrical Acoustics (GA) methods at high frequencies. But combining their output data can be an awkward process due to their very different formulations. This is particularly important for early reflections, which give crucial spatial perceptual cues. Hence there is a need for a unified full audible bandwidth algorithm for early reflections. This paper will describe ongoing research to develop such an algorithm by exploiting synergies between high-frequency BEM and GA. It will describe how appropriately chosen oscillatory basis functions in BEM can produce leading-order GA behaviour at high frequencies and explore how interactions between these compare to the same interactions arising in a surface-based Geometrical Acoustics scheme.
Analysis and Control of Acoustic Modes in Cylindrical Cavities with application to Direct Field Acoustic Noise (DFAN) Testing.

Jonathan Hargreaves

1University of Salford, Salford, United Kingdom

It is well known that acoustic cavities have frequencies at which certain free-response ‘modes’ of propagation respond especially strongly. In the absence of significant damping, these cause peaks of high SPL in the frequency response as well as spatial non-uniformity and temporal ringing. The spatial non-uniformity is especially problematic since it means the room cannot be ‘EQ’d’ to compensate, since the SPL is different in different positions. This phenomenon has been studied extensively in the room acoustics literature and various strategies for mitigation proposed. Many of these make use of the theoretical mode shapes for a cuboid with a rigid boundary condition, since this is a common shape of room and a reasonable approximation for a solidly constructed wall. But modes exist for other shape spaces too. Of particular interest is the cylindrical cavity that is formed when large enclosing arrays of loudspeakers are used to perform high-intensity acoustic tests on space hardware. These possess problematic modes that can cause over-testing in some positions and under-testing in others. In this work, it is investigated how a simple FEM simulation can compute Q-factors for these modes and identify which will be problematic. How this might inform control system design is discussed.

Link to paper
The three methods of calculating population exposure according to CNOSSOS-EU

Erwin Hartog Van Banda

DGMR Software, The Hague, Netherlands

In December 2020, the EU commission published amendments on CNOSSOS-EU in report ‘C(2020) 9101 final’. In this report an additional method for the calculation of population exposure is described, based on a Median value. In the original CNOSSOS document, 2 methods are described, Method 1 – Most exposed façade and Method 2 – Length of representative façade. Method 1 is used for buildings that represent a single dwelling or 1 dwelling per floor. Method 2 is used for apartment buildings that have dwellings with a single façade exposed to noise. The new Method 3 can be used for apartment buildings that have more than 1 façade exposed to noise, or for apartment buildings where no information on how many facades are exposed to noise is available. It will be difficult for authorities to create a dataset that distinguishes between a single façade and multiple façades exposed to noise. Therefore, it seems likely that Method 3 will be more frequently used. When comparing Methods 2 and 3, it is found that Method 3 leads to a higher number of exposed people and dwellings. In this paper the 3 methods are explained and compared using noise and population data for a city in Europe.

Link to paper
Acoustic measurement around the pinna in very high frequency region using a dummy head

Koki Harusawa

Kanagawa Institute of Technology, 1030 Shimo-ogino, Atsugi City, Kanagawa, 243-0292 Japan, Japan

We investigated the azimuth angle characteristics of head related transfer function (HRTF) at very high frequency region using two kinds of head and torso simulators (HATS). In the measurement of hearing thresholds, there are two ways using a headphone or a loudspeaker. In general, it will be carried out using a loudspeaker because sound pressure calibration and measurement are simple. However, the hearing threshold which measured using a loudspeaker at very high frequency region may contain some errors because sound pressure level (SPL) reaching the ear are seriously affected by a small movement of the head. Also, the SPL near the pinna seriously depends on both shapes of a pinna and a head because excess attenuation by diffraction of VHF sound is very large. To provide assurance for the accuracy measurement of hearing threshold, it is important to make clear the relationship between the SPL and shape of head and/or ear. In this paper, we reported the HRTFs calculated from the SPLs measured at three different positions of left ear – a tragus, an auricle and an eardrum and discussed the influence of head and/or ear of HATS from the azimuth angle characteristics of these HRTFs.

Link to paper
A new Building Regulation for overheating: practical considerations for the acoustic constraints

Jack Harvie-Clark\textsuperscript{1}, Nick Conlan\textsuperscript{1}, Nicholas Dobinson\textsuperscript{1}, Rupert Kazlauciunas\textsuperscript{2}

\textsuperscript{1}Apex Acoustics Ltd, Gateshead, United Kingdom, \textsuperscript{2}Zehnder Group UK Ltd, Camberley, United Kingdom

A new Building Regulation to mitigate overheating applies in England from June 2022. A requirement of the regulation is that the strategy to mitigate overheating must be usable, considering occupants’ safety and comfort. If internal noise levels exceed 40 dBA L\text{night}, or 55 dB L\text{Amax} more than 10 times a night, then windows cannot be assumed to be open during the night time period.

This paper discusses a triage process to consider the noise risk, the practical methods and uncertainties in the noise survey, environmental noise modelling, calculation of facade sound insulation with windows sufficiently open to mitigate overheating, and demonstrating compliance. Potential solutions for natural ventilation and mechanically assisted ventilation are outlined.

Until now, the environmental noise impact on new dwellings has been controlled through the planning regime, where environmental health officers have acoustics expertise. The Building Regulations are enforced by building control officers, who may have little or no training in acoustics. More than 30\% of existing dwellings in the UK are exposed noise levels that may preclude reliance on opening windows to mitigate overheating in future dwellings.

[Link to paper]
Confidence in Room Acoustic Design: an Empirical Approach for Classrooms

Weigang Wei¹, Jack Harvie-Clark¹

¹Apex Acoustics Ltd, Design Works, William St, Gateshead, NE10 0jp, United Kingdom

Methods to predict reverberation time range from the simple Sabine or Eyring relation to more elaborate means such as geometric and numerical acoustic modelling. Classrooms often have a very uneven distribution of sound absorption; measured reverberation times can exhibit a much wider range of values between equivalent rooms than prediction methods would generally indicate. The analytical tools can commonly fail to provide what the designer actually needs: a simple and robust method to advise on solutions for sound absorption that can routinely achieve the stated reverberation time criteria. This paper presents an empirical approach to room acoustic design for classrooms with free-hanging absorbent rafts, wall panels and furniture. Statistical analysis of the measured reverberation time in over a hundred rooms is used to determine confidence intervals for design. With this approach, the acoustic designer can not only describe the proposed requirements to the design team, they can also identify with a stated confidence the anticipated compliance rate. Although this empirical approach is based on measurements in school classrooms, it may be also used to predict the reverberation time for other spaces with similar acoustic characteristics.

Link to paper
Perception of tire-pattern noise

Takeo Hashimoto¹, Shigeko Hatano¹
¹Seikei University, Tokyo, Japan

Due to the increase of electric motor cars for preventing spread of carbon dioxide, noise atmosphere inside the car compartment is more important for the perception of tire-pavement noise. This paper describes the impression of pattern noise created by the tire thread pattern under real running condition. Our impression on tire-pattern noise is more prominent if the peak level of the pattern noise together with its frequency location and width of the peak. This paper deals with our impression on tire pattern noise how our impression vary with its peak level and frequency location.

Link to paper
Railway Noise Reduction at the Source only. Is this possible or mandatory?

Markus Hecht¹
¹Tu Berlin, Berlin, Germany

Climate change urges CO2 reduction also in traffic. Electrified Railways are a powerful CO2 free and energy and space efficient traffic mode already today. Modal shift is demanded but environmental noise of railway hinder rail traffic growth significantly. Noise tunnels are not only expensive but also reduce energy efficacy and increase interior noise. Noise barriers are very costly and optical obstacles. TSI-Noise values have many criticisms. They do not cover the most bothering situations, curve running and severe other critical operation conditions are missing. The noise limit values are very high. Many standard measures in all other technical fields, construction machines or road vehicles do not exist in the railway context. Even worse is the situation of the track noise. There are nearly no measures except the demand for smooth surfaces.

But the noise radiation of rails and sleepers is not constant but can be reduced significantly. Even good railway practice in other countries does not push the noise reduction without legislative demands. Example are quiet high speed pantographs and tamping machines in Japan. With general measures and low noise barriers and skirts on each track side the immersion limit even at densely operated lines of LDEN 55 dBA is possible.

[Link to paper]
Impact Sound Insulation of thermally insulated Balconies

Lucas Heidemann¹, Jochen Scheck¹², Berndt Zeitler¹

¹University of Applied Sciences Stuttgart, Stuttgart, Germany, ²STEP GmbH, Winnenden, Germany

With the increasing urban densification, balconies are gaining in popularity as they improve the living quality in homes. Thermal insulation between balconies and the building’s façade is state of the art. In Germany the most popular balcony construction is a reinforced concrete balcony, separated from the building by a thermal insulation element (TIE), which is meant to reduce the thermal energy loss and thus ensure the sustainability of buildings. The impact sound transmission from balconies, however, is a problem that has not been addressed enough to date. The main goal of the project is to provide acoustic quantities, e.g., an impact sound reduction, for a TIE that can be used to compare the acoustical quality of products and to predict the impact sound pressure levels within the building using the standard EN ISO 12354-2. Experimental and numerical studies have been carried out on various ceiling-balcony mock-ups without and with TIEs e.g., by means of experimental modal analysis and finite element models. This paper will show the effect that various parameters have on the impact sound insulation. Additionally, the measurements on the test set-up will be compared to measurements on building sites.

Link to paper
Simplification of ISO 3744 – Making the Most Important Standard for Determination of Sound Power Levels Easier to Use

Fabian Heisterkamp¹, Jeff Schmitt², Joey Hook²
¹BAuA, Dortmund, Germany, ²Viacoustics, Austin, USA

Sound power level (L_W) is the key quantity to describe the noise emission of products and is needed to reduce noise at work, at home, and in the environment, e.g. for promoting and selecting low noise products (Sell and Buy Quiet). ISO 3744:2010 is the main standard referred to by most product test codes and regulatory requirements for determining L_W. It is used by laboratories, noise control engineers, and manufacturers.

Due to its structure and length, the usability of the current document is limited. The main body of ISO 3744:2010 contains so much information that the basic concept of sound power is obscured.

To improve usability of ISO 3744:2010 three projects were launched: 1. A revision and restructuring of ISO 3744 with a simplified main body and a series of annexes for special cases; 2. A new standard: ISO/CD 5114-1 on the uncertainty of L_W determined from sound pressure levels; 3. A new standard: ISO/CD 26101-2 to determine the environmental correction used in determining L_W.

These new standards contain specific information needed by some users while ISO/CD 3744 focusses on determining L_W. We present key aspects of all three committee drafts and explain how and why ISO 3744 should be revised.
Interdisciplinary collaboration to identify challenges and opportunities in urban sound planning

Josh Hernandez¹, Marion Burgess², Deo Prasad¹

¹University of New South Wales, Sydney, Australia, ²University of New South Wales, Canberra, Australia

Urban sound planning aims to integrate soundscape approaches within existing planning frameworks to create sound environments which are conducive to health and wellbeing. It recognises that the best soundscape outcomes are achieved when acoustic environments are considered from the outset of the urban planning and design process—and that this must be done with the interdisciplinary involvement of professionals from a range of fields. While the benefits of soundscape approaches in urban design have been demonstrated, positive soundscapes and public health outcomes have been limited by a gap between theoretical understandings of sound as a manageable resource versus implementation in planning and the built environment. This is especially true in jurisdictions that lack quality-based environmental noise policies, as their regulatory actions are confined to the mitigation of “noise” as a waste or pollutant. This paper explores the challenges for implementation of quality urban sound planning within the regulatory system of New South Wales, Australia. Barriers and opportunities for soundscape approaches in planning are discussed, based on experiences from professionals in relevant domains and examples of successful soundscape and health outcomes in other jurisdictions.

Link to paper

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Full Multiphysics Electro-Vibroacoustic Analysis of a Balanced Armature Transducer

Mads Herring Jensen

1COMSOL, Kgs. Lyngby, Denmark

A balanced armature transducer, also known as a receiver in some industries, is a high-performance miniature loudspeaker that is often used in hearing aids but also in other in-ear audio products like earbuds. The electrical and vibroacoustic performance of a balanced armature transducer is analyzed using a full multiphysics analysis. The model includes acoustics and associated thermoviscous losses, structural components such as diaphragm and armature (made of magnetic steel), and as the electromagnetic components including permanent magnet and coil. The vibrating armature enters a magnetic circuit with alternating magnetic flux, generated by an AC coil, which has a strong interaction with the DC magnetic field of a magnet. The electromagnetic forces are included through volumetric and surface contributions of the Maxwell stress. The analysis is performed in a commercial finite element analysis software and predicts the linear response modeled in the frequency domain and nonlinear effects modeled in the time domain. The latter include nonlinear thin-film damping and nonlinear magnetic force contributions captured using a moving mesh.

[Link to paper]
Runway determination using two-point time difference method

Taichi Higashioka¹, Yoshio Tadahira¹, Manabu Sugiura¹, Etsushi Fujita¹, Osamu Kohashi¹
¹Nihon Onkyo Engineering Co., Ltd., 1-21-10 Midori Sumida-ku, Japan

Around airports having multiple runways, aircraft noise affected areas vary depending on the runway operation because the flight path changes by the operation. Therefore, it is important to figure out exactly which runway was used for analyzing the noise impact on the surrounding area. For this purpose, runway information included in flight data provided by the airport operator can be used in most commercial airports. However, for some airports, the data is unavailable or not always accurate.

We developed “Takeoff/landing runway determination system; DL-TLS” for determining runway operations and have been utilizing it to aircraft noise analysis. However, that system requires to place measurement stations at the end of each runway to ensure the high level of accuracy. To solve this issue, we focused on difference in acquisition time of the same transponder signal at two measurement stations. This new approach achieved satisfactory level of runway determination accuracy, by matching the time difference changes with template for each runway. We proved that this method can be used in combination with the current DL-TLS with even higher accuracy. In addition, we showed the possibility of reducing number of measurement stations and eliminating the measurement location constraint.

[Link to paper]
Subjective studies on floor impact sound using headphone

Susumu Hirakawa¹, Hayato Sato², Manabu Chikai³, Atsuo Hiramitsu³, Hiroshi Sato³, Jeffrey Mahn⁴, Markus Mueller-Trapet⁴, Iara Batista da Cunha⁴

¹National Institute of Advanced Industrial Science and Technology and Building Research Institute, Tsukuba, Japan, ²Kobe University, Kobe, Japan, ³National Institute of Advanced Industrial Science and Technology, Tsukuba, Japan, ⁴National Research Council Canada, Ottawa, Canada, ⁵National Institute for Land and Infrastructure Management, Tsukuba, Japan

Due to the pandemic situation, it become complex to conduct subjective experiments in the anechoic chamber as a result of the lockdown. For this situation the procedure for the subjective experiments without accessing to the anechoic chamber needs to be considered for an alternative approach. The previous study has shown that there are good correlation between the laboratory and online listening test on impact sounds in residential buildings using ambisonic microphone recording with headphone. Hence, further subjective experiments were carried out with monaural and binaural microphone recordings in an experimental buildings in Japan. The subjective experiment using a headphone in anechoic chamber was held in AIST, Japan. The 3 different floor types, 2 different types of microphones (mono and binaural), at 12 different combinations of impact sources, excitation positions and microphone positions were tested. This study also provided some evidence, and suggested there are potential of the online/remote subjective experiment using headphone.
Effect of concrete topping on floor impact sound insulation performance of CLT floor

Atsuo Hiramitsu¹, Susumu Hirakawa²

¹National Institute For Land And Infrastructure Management, Tsukuba, Japan, ²Building Research Institute, Tsukuba, Japan

The use of wood is being promoted to achieve the goals of the SDGs (Sustainable Development Goals) around the world. In Japan, “the Act on Promotion of Utilization of Wood in Buildings” and “Other Structures to Contribute to the Realization of a Decarbonized Society” promotes the use of wood in buildings in general. In addition, CLT (Cross Laminated Timber) is being promoted in order to make effective use of domestic timber. There have been many requests to show wooden structural materials when CLT is adopted to the building (i.e., without ceiling and CLT panel itself is exposed). This paper examined the approach to increase the sound insulation performance of CLT floor without ceiling. The measurement of the floor impact sound insulation performance and driving-point impedance was carried out in the experimental building using concrete floating floor on top of the CLT floor panel with and without floor finishing. As a result, the performance of the concrete floating floor on the CLT floor showed that the performance was almost the same as the concrete floor itself. Moreover, the effect of the floor finishing on the concrete floating floor was investigated.

Link to paper
Distance control of virtual sound source based on switching electro-
dynamic and parametric loudspeaker arrays

Ayano Hirose¹, Haonan Wang¹, Masato Nakayama², Takanobu Nishiura¹
¹College of Information Science and Engineering, Ritsumeikan University, Kusatsu, Japan, ²Faculty of Design Technology, Osaka Sangyo University, Daito, Japan

High presence sound field reproduction technology has recently gained attention. We have previously proposed a virtual sound source (VSS) construction method based on wave field synthesis (WFS) using parametric loudspeaker array (PAL array). The previously proposed method can construct the VSS at any position without relocating the PALs. However, the previously proposed method has difficulty constructing the VSS near the PAL array. In this paper, we propose a new method to control the distance of a VSS based on WFS using an electro-dynamic loudspeaker (EDL) array and a PAL array. The EDL array is suitable to construct VSSs near the loudspeaker array. In contrast, the PAL array is suitable to construct VSSs far away from the loudspeaker array. Therefore, in this method, we place an EDL array and a PAL array parallel to each other and switch the loudspeaker array for VSSs construction depending on the desired position to realize VSS distance control. The threshold of switching loudspeaker array is determined by a subjective preliminary experiment. We demonstrated the effectiveness of the proposed method through evaluation experiments.

Link to paper
Extension of frequency range of the sixteen-microphone method in normal-incidence sound transmission loss measurement.

Nakagawa Hiroshi¹, Akira Sanada²

¹Nihon Onkyo Engineering Co., Ltd., 1-21-10 Midori Sumida-ku, Tokyo, Japan, ²Industrial Technology Center of Okayama Prefecture, 5301 Haga, Kita-ku, Okayama, Japan

This study deals with development of a high-frequency measurement method of normal incidence sound transmission loss using acoustic impedance tube. On ordinary transfer-function method, measurable frequency of the method is limited by the diameter of the tube. Authors have developed 8 microphone method to measure normal incidence absorption coefficient. This technique lays 4 microphones on the same cross section and cancels rotational acoustic modes. This makes it possible to measure normal incidence absorption coefficient up to 3 times the upper frequency of the ordinary 2 microphone method. In this study, authors apply the same technique to normal incidence transmission loss measurement.
Main flow oriented vorticity noise experiments

Lionel Hirschberg¹, Friedrich Bake¹, Karsten Knobloch¹, Steven Hulshoff¹
¹Imperial College London, Imperial College London, South Kensington Campus, London Sw7 2az, United Kingdom

Entropy inhomogeneities and vorticity spots induce so-called indirect combustion noise when passing through a choked nozzle; referred to as entropy noise and vorticity noise, respectively. We note that vorticity noise depends on the orientation of the vorticity; viz., oriented normal or parallel to the axial main flow. An experimental investigation of parallel component vorticity noise is presented. In the experiment a time-dependent swirling flow was induced by unsteady tangential injection in the pipe upstream of a choked convergent-divergent nozzle. As the resulting swirling flow passes through the nozzle, the axial stretching of the fluid caused an increase in rotation energy. The steady energy conservation in an isentropic flow implies a Mach number higher than unity at the throat and an associated reduction of density. Ergo, the critical mass-flow rate (for fixed reservoir pressure and temperature) decreases quadratically with increasing swirl intensity. The acoustic waves radiated downstream of the nozzle are a direct measure for this mass-flow modulation. Using a semi-empirical model, this sound production mechanism is demonstrated to indeed be quasi steady.

[Link to paper]
Effects of noise presence and noise position on interpersonal distance in a triadic conversation.

Lubos Hladek¹, Bernhard Seeber¹
¹Technical University of Munich, Munich, Germany

People usually move in different ways during conversations but little is known whether movement behavior reflects difficulties that some people experience in communication in terms of listening and speaking. Here, we investigate movement behavior of standing participants in triadic conversations in noise with different spatial properties. In the initial analysis, we test how presence and position of noise affects interpersonal distance. The task of the interlocutors was to hold a free conversation in controlled acoustic conditions with realistic reverberation and visual scene of an underground station that was rendered in real-time in the Simulated Open Field Environment while the participants were monitored with motion tracking equipment and their voices were recorded. Two groups of people took part in the study. Different noise conditions involved presence of stationary speech-shaped noise at 70 dB SPL presented from one of four possible directions (Front, Right, Rear, Left), or from all directions simultaneously (F+R+R+L), or there was no noise (Quiet). The results show that interpersonal distance decreased when the noise was present, which confirmed previous results. Further, the preliminary analysis shows a relatively small effect of noise position on the interpersonal distance.

Link to paper
Sheet Pile Tuned Mass Damper for Construction Noise Control

Wilson Ho¹, Wylog Wong¹, Eric Chu¹
¹Acoustics Innovation Limited, Unit 106, Block A, Shatin Industrial Centre, Sha Tin, N.T, Hong Kong

Sheet piles are often used for underground retaining structures. For dense geology, vibratory driven method is more cost-effective than press-in driven method, but noisier. Conventional mitigations such as noise barrier or enclosure are not applicable due to the large size of pile wall (generally >12m high and >10m width). Acoustic camera images revealed that noise radiation was dominant at 630Hz to 2000Hz and mainly came from the sheet-pile wall rather than the vibratory exciter. Vibration response measurement showed the sheet piles had two major resonance modes at 1000 and 2000Hz. An innovative noise mitigation method was developed with 14 nos. of tuned mass dampers (TMD) distributed along a 5m long aluminum tube for vibration energy dissipation at the pile wall. Specific magnetic mounts were developed for quick and easy attachment of the TMDs at the construction site. In the site test, total 6 aluminum tubes (i.e., 84 TMDs) were mounted to the 1st, 2nd and 3rd piles adjacent to the driven pile on both sides. Vibration reduction was measured ~9 to 14dB at the pile wall. Noise reduction was measured 7 to 9dB(A) at 2 noise monitoring locations (~7m and ~22m from the pile wall).

Link to paper
Lightweight Retractable Noise Barrier in Hong Kong

Wilson Ho¹, Wylog Wong¹, Eric Chu¹
¹Acoustics Innovation Limited, Unit 106, Block A, Shatin Industrial Centre, Sha Tin, N.T, Hong Kong

Construction noise is one of the major noise pollution sources in urban area. In Hong Kong, the Noise Control Ordinance (NCO) states that construction works at night time and holiday with Powered Mechanical Equipment (PME) are only allowed if the PME noise levels are controlled within the Acceptable Noise Level (ANL) calculated at nearby Noise Sensitive Receivers (NSRs). In many cases, night works require noise barriers to minimize the PME noise levels. However, conventional noise barriers of 3m to 6m height require a heavy base in order to sustain occasional heavy gust wind loading. Those heavy bases require cranes to install and relocate which may not feasible under some site constraints. SilentUP® Retractable Noise Barrier has been invented in Hong Kong to meet this demand. It is a 7m high noise barrier without concrete foundation. The modular design and magnetic connecting mechanism allow SilentUP® to form a continuous wall. It can be installed, uninstalled and relocated by people without using any machines. The entire process is quiet enough to be completed at night. To enhance the stability and safety features, a patented automatic wind load relieving mechanism is incorporated so that the lightweight structure remains safe during occasional gusts. It reduces up to 95% structural loading requirement and hence a lightweight design can be adopted. The on-site insertion loss performance of SilentUP® Retractable Noise Barrier is varied from 11-21 dB(A) depending on the noise source and size of barrier / enclosure.

Link to paper
Railway Ground Borne Noise (GBN) Reduction by Rail Dampers

Wilson Ho¹, Ron Wong¹
¹Jabez Innovation Limited, Unit 106, Block A, Shatin Industrial Centre, Sha Tin, N.T, Hong Kong

Railway GBN impact has raised increasing concerns due to underground transportation expansion. Reducing train speed or replacing standard baseplates with high resilient ones are adopted for GBN control. Both mitigations are not satisfactory considering the installation difficulty and limited performance, e.g., only ~3dB noise reduction for 30% train speed reduction. On the other hand, FST (Floating Slab Track) are commonly used. In many cases, to accommodate the FST, tunnel diameter is enlarged for the TBM (Tunnel Boring Machine) tunnel section. Also, rail dampers are used for air-borne noise control, but never used for GBN control due to its relatively small mass.

P2 resonance is a main cause of railway GBN. It is a simple harmonic motion of a lump mass (wheel and rail combined) oscillating on top of resilient baseplates. Laboratory test was conducted with a 6m fastened rail and a ~450kg mass to simulate train wheel and track system. A retrofit rail damper with TMD (Tuned Mass Damping) oscillators was tested. The mass of TMD oscillators along the rail with ~2m effective length of P2 resonance is more than 10% of the wheel. Around 7dB vibration reduction was recorded at the rail and floor when allowing the TMD oscillation.
Track Decay Rate (TDR) Measurement Method for Reactive Damping by Tuned Mass Damper (TMD)

Wilson Ho¹, Marco Ip¹
¹Jabez Innovation Limited, Unit 106, Block A, Shatin Industrial Centre, Sha Tin, N.T, Hong Kong

TDR measures the rate of vibration decay along rail in dB/m. Higher TDR leads to lower noise radiation. However, new railways are often having low TDR due to the use of resilient fasteners (to provide vibration isolation between rail and supporting structure for ground borne noise concerns), which leads to high noise radiation. Rail damper is used to increase TDR (thus reduces railway noise), where TMD is an efficient damping mechanism dissipating the vibration energy of the rail. TMD provides reactive damping force, maximised after a few cycles of oscillations. TMD force is stronger with continuous excitation than impulse excitation. For convenient purposes in the industry, TDR measurements are primarily conducted by impulse method, which do not allow sufficient time to include reactive TMD force. Therefore, impulse excitation TDR is smaller than continuous excitation TDR. Continuous excitation TDR is considered to reflect more of the real case of wheel/rail interaction excitation during train running. Besides, TDR in terms of time decay in dB/s is an alternative approach for evaluating noise performance of the rail. This paper presents TDR measurement results under different conditions, e.g., impulse excitation against continuous excitation; freely supported short rail (~6m), short rail (~6m) with resilient fastener support as well as site measurements in continuous welded rails.

Link to paper
Five Years’ Monitoring Data on Rail Damper Performance

Wilson Ho¹, Max Yiu¹, Qian Sha¹, Ron Wong¹

¹Wilson Ho and Associates Limited, Unit 601, Block A, Shatin Industrial Centre, Sha Tin, N.T, Hong Kong

Roughness in rail surface accumulates with train operations and grows faster on curved tracks than tangent tracks. Higher roughness leads to higher noise radiation. In Hong Kong, railway noise prediction includes a 3dB correction for rail surface deterioration. Depending on rate of deterioration, different rail grinding cycles (typically between 3 and 24 months) are scheduled to ensure train operations without excessive noise radiation.

Before rail dampers installation, noise levels were monitored for 1.5 years and around the noise limit with variation +/- 3dB(A) due to rail roughness variation. After installation of rail damper, railway noise was generally maintained at 7dB(A) below the noise limit with variation +/-1.5dB(A) for more than 3 years. Noise reduction at dominant frequencies 630 Hz and 800 Hz were more than 10dB in 1/3 Octave analysis. The rail dampers were installed at alternative spaces such that additional rail dampers can be installed to double the amount in case further noise reduction is required.

This paper examines the five years’ monitoring data in detail, showing the noise levels with smaller variations over grinding cycles after rail damper installation, and explores rail damper potential ability to slow down the growth rate of rail roughness levels.

[Link to paper]
Factors influencing tyre/road noise under torque

Carsten Hoever¹, Achillefs Tsotras¹, Marie-Agnès Pallas², Julien Cesbron³
¹Continental Reifen Deutschland GmbH, Hannover, Germany, ²Université Gustave Eiffel, Lyon, France, ³Université Gustave Eiffel, Bouguenais, France

High levels of road traffic noise negatively impact public health in many parts of Europe, especially in cities. The introduction of electric mobility is often seen as one of the best measures to reduce noise exposition in urban environments. Compared to internal combustion engine vehicles (ICEV), there is an increased importance of tyre/road noise for electric vehicles (EV) because of the reduced masking by the powertrain noise. This effect increases further under acceleration. Firstly, it is known that in most cases tyre/road noise is higher under torque than for free rolling. Secondly, in situations which are characterized by increased driving torque, the lack of masking from powertrain noise for EVs is especially evident when compared to ICEVs. The aim of the LIFE E-VIA project is to reduce road traffic noise in cities by providing noise optimized road surfaces and tyres for EVs. Because of the mentioned effects, not only constant speed driving needs to be considered but also accelerated driving. Consequently, within E-VIA noise measurements from an indoor drum and a test track have been used to investigate the impact of different tyre parameters and operating conditions on the change of tyre/road noise under acceleration when compared to free rolling.

[Link to paper]
Combination of Acoustic Black Holes with point masses

Steffen Hoffmann¹, Sebastian Rothe¹, Sabine Christine Langer¹
¹Technische Universität Braunschweig, Braunschweig, Germany

Passive acoustic measures are suitable for the targeted improvement of the vibration behaviour of technical products. In this context, Acoustic Black Holes (ABH) as innovative measures have shown great effect for an efficient damping of vibrations and a simultaneous mass reduction. The vibration reducing effect, however, is primarily apparent in the higher frequency range. The thickness reduction results in a mass reduction of the system, which could worsen the vibroacoustic behaviour in the lower frequency range. The idea of the approach here is to use the saved material in form of point masses to counteract this disadvantage at low frequencies by a targeted placement or direct consideration in the manufacturing process. The result is a mass-neutral acoustic design measure. In order to investigate the effectiveness of the ABH point mass combination, finite element models of generic beam and plate structures with ABH are used in this paper. In addition, the influence of point masses in terms of their position and number on the vibroacoustic behaviour is simulated. One focus is the assessment of the advantage by combining ABH with point masses. To validate the results, experimental investigations are carried out and compared with the numerical results.

Link to paper
Multi-directional active vibration control of 1D smart structure inspired by automotive engine mounting system

Moon Hojoon¹, Yang Qiu¹, Kim Byeongil¹
²Yeungnam University, 280 Daehak-ro, Gyeongsan, Gyeongbuk 38541, South Korea

Recently, active mounting system is being gradually applied to automotive engine mounts for mitigating structure-borne vibration effectively throughout the whole vehicle chassis. This paper presents modeling, analysis, and control of a source structure with an active mounting system in multi-directions, considering position and direction of actual automotive engine mounts. The active mount consists of a piezoelectric stack actuator in series with an elastomeric (rubber) mount. When harmonic excitation forces are employed, secondary force required for each active mount is calculated mathematically and the control signal can reduce the vibration through the destructive interference with input signal. In addition, the horizontal vibration can also be mitigated by setting a variable parameter through the dynamic relation of source structure. A series of simulation results demonstrate that the excitation vibration could be reduced along with this multi-directional (vertical and horizontal) active mounts. Based on this result, it can be expected that noise vibration harshness (NVH) performance can be improved by controlling the vibration of the actual automotive engine structure with rubber mount and secondary force of actuators in both vertical and horizontal directions.
Comparison of the direct sound insulation for wooden joist, CLT and timber hollow box floors

Anders Homb1, Simone Conta1
1SINTEF Community, 7465 Trondheim, Norway

Timber buildings are now present worldwide, and their market is growing rapidly, pushed by sustainability and environmental arguments. Several technological options for engineered wood systems are available and well developed, the most common being wooden joist, CLT and timber hollow box. In this paper, we present a comparative study of the airborne and impact sound insulation of the three options. The analysis is based on data collected from laboratory measurements. The results include the comparison of the bare floor construction and examples of assemblies with additional floating floor, suspended ceiling or a combination of the two. We identify the characteristic trends and highlight the effect of selected parameters as for instance mass per unit area, assembly thickness and properties of the resilient layers. The comparison attempts to show the constructive consequences of the different options on the sound insulation properties. It could help selecting the most suitable floor system in future projects and contribute making timber construction more efficient and affordable.
Validation of target tracking performance through signal feature extraction method based on 1D convolutional neural network

Dongwoo Hong¹, Junhee Kwon¹, Byeongil Kim¹
¹Yeungnam University, 280 Daehak-ro, Gyeongsan, Gyeongbuk 38541, South Korea

In order to perform active vibration and noise control, a variety of adaptive algorithms have been investigated and developed. Especially, neural network-based signal tracking algorithms, such as the radial basis function neural network (RBFNN), are being widely utilized. For signal tracking problems, a reference signal has a significantly important role, while it is difficult to determine the reference signal when it has relatively complex spectrum. Thus, this study focuses on the signal feature extraction for manipulating appropriate reference signals easily and validation of signal tracking performance with it. In order to carried out the signal feature extraction, 1D convolutional neural network (1D CNN) is implemented and trained based on the CWRU bearing dataset. In addition, multi normalized least mean square (NLMS), neural network-based signal tracking algorithm, and diagonal recurrent neural network (DRNN) is employed to confirm the signal tracking performance. The proposed method shows that the 1D CNN-based signal feature extraction method could find the signal feature properly and the reference signal obtained from this methodology is employed to a target tracking problem, which shows a great performance.
Interlaboratory comparison of testing the level reduction of booths and furniture ensembles by ISO 23351-1

Valterri Hongisto¹, Jukka Keränen¹
¹Turku University Of Applied Sciences, Joukahaisenkatu 3-5, FI-20520 Turku, Finland

International standard ISO 23351-1:2020 describes a laboratory method for declaring the speech level reduction $D_{S,A}$ of furniture ensembles (such as partially enclosed pods or workstations) and enclosures (such as phone booths). Such products are increasingly used in lounges, hospitals, education buildings, open-plan offices, and similar places to provide local places of improved speech privacy or concentration. $D_{S,A}$ describes how much the product reduces the A-weighted sound power level of standard speech to the exterior space. The method is based on repeated application of ISO 3741 standard. The purpose of our study was to determine the precision of the ISO 23351-1 method for two extreme kinds of products that the method covers: a workstation and a phone booth. Eight independent laboratories from six countries participated in the accuracy experiment. Two specimens were circulated in these laboratories and tested according to ISO 23351-1. Measured $D_{S,A}$ values varied from 3.7 to 5.5 for the workstation and from 27.2 to 30.3 dB for the booth. The corresponding reproducibility standard deviations were 0.6 and 1.1 dB, respectively. The results have been exploited in the ISO 23351-1 standard.

Link to paper
Acoustic properties of commercial thermal insulators

Valtteri Hongisto¹, Pekka Saarinen¹, Jarkko Hakala¹, Reijo Alakoivu¹
¹Turku University Of Applied Sciences, Joukahaisenkatu 3-5, FI-20520 Turku, Finland

Material manufacturers give very limited or no information of the acoustic properties of thermal insulators in broad perspective. The purpose of our study was to compare the acoustic performance of commercially available thermal insulators. Thirteen insulator types produced by several manufacturers were studied. The acoustic performance was determined holistically by measuring six acoustic quantities: sound reduction index of bare insulator, sound reduction index of encapsulated insulator (insulator between two boards), normal incidence sound absorption coefficient, airflow resistivity, dynamic stiffness per unit area, and reduction of impact sound pressure level in a floating floor. All measurements were conducted according to prevailing ISO standards in an experienced test laboratory. The acoustic performance differed significantly between insulator types for each acoustic quantity. The ranges were 10⁻²⁷ dB, 33⁻₅₂ dB, 0.2₀⁻⁰.₇₈, 3.₀⁻₂⁷₀₀ kPa·s/m², 1.₅⁻₇₃₀ MN/m³, and 1₅⁻₃₆ dB, when the thickness of the insulator was 1₀₀ mm. Closed-pore insulator types usually carried worse acoustic properties than open-pore insulator types. Lower thermal conductivity was associated with worse acoustic performance of two acoustic quantities. Insulator manufacturers should consider to better declare the acoustic properties of insulator products, because this knowledge is needed in the acoustic design of building constructions and other applications.
Health effects of environmental noise in a wind power area

Valtteri Hongisto¹, Jenni Radun¹, Henna Maula¹, Pekka Saarinen¹, Jukka Keränen¹, Reijo Alakoivu¹
¹Turku University Of Applied Sciences, Joukahaisenkatu 3-5, FI-20520 Turku, Finland

We examined the effects of both wind turbine noise and road traffic noise on symptoms and diseases close to wind turbines and in a control area. Wind turbine sound levels were between 17–39 dB LAeq and met the Finnish regulation (40 dB). Daytime road traffic noise levels were 32.5–63.5 dB. Altogether 676 residents responded to the questionnaire. Higher wind turbine sound level was associated with more likely reporting wind turbine noise annoyance and not with reporting of symptoms or chronic diseases. Higher road traffic sound level was associated with higher probability of road traffic noise annoyance, migraine or headache, dizziness, impaired hearing, pressure in ears, tachycardia or heart palpitations, and heart disease. The health effects of wind farms seem to be limited to noise annoyance in areas where all residents are exposed to sound levels under 40 dB. The study has strong practical relevance since new wind power areas always fulfill this 40 dB regulation in Finland. On the other hand, more than 600,000 inhabitants are exposed to road traffic noise levels above 55 dB in Finland. Because high road traffic noise is associated with elevated prevalence of symptoms and a disease in our study, and several previous international studies have found even more serious health effects of road traffic noise, this issue deserves higher concern in the future.

[Link to paper]
Prediction of combustion noise for a swirling flame with low order network model

Zhu Hongzhi¹, Zhu Min¹
¹Department Of Energy And Power Engineering, Tsinghua University, Beijing, China

Combustion noise has become an important noise source for gas turbines and aero engines. Efforts are needed in understanding mechanisms of combustion noise and developing prediction methods. In this work, direct combustion noise for a swirling premixed flame is predicted by low order model (LOM) and compared with experiments. In LOM, model combustor is simplified to a plenum, a swirler and a combustion chamber. Unsteady heat release rate is set to a constant value and pressure perturbation is calculated. Thermoacoustic transfer function defined by the ratio of pressure perturbation and unsteady heat release is calculated to describe noise spectrum distribution. Results show that peaks in thermoacoustic transfer function increase with the gain of downstream reflection coefficient while corresponding frequencies maintain unchanged. The phase of downstream reflection coefficient affects both peak frequency and amplitude. In experiments, unsteady heat release and pressure perturbation are measured. Thermoacoustic transfer function calculated by experimental results presents several peaks associated with thermoacoustic instability modes. With proper reflection coefficient, predicted thermoacoustic transfer function is compared with experiments and achieves reasonable agreement. Thermoacoustic transfer function provides a basic understanding for energy transfer from heat release to acoustic waves and could be used to predict combustion noise.
A key physical mechanism that controls the sound absorption of aerogel powders

Kirill Horoshenkov, Y Xue, S. Bolton, K.V. Horoshenkov

1University Of Sheffield, Sheffield, United Kingdom, 2Midea Corporate Research Center, Foshan, Guangdong, China, 3Herrick Laboratories, Purdue University, West Lafayette, Indiana, USA

A key physical mechanism that controls the acoustic absorption and attenuation in a loose, air-saturated aerogel granular mix with the grain diameter being in the order of a few microns is not well understood. A particular challenge here is to understand sound propagation in an aerogel powder composed of highly porous, low-density particles with sub-micron pores. Experimental evidence suggest that a relatively thin layer of an aerogel powder can provide a very high narrow band acoustic absorption at relatively low frequencies. This study presents an attempt to explain this physical phenomenon with two well-known analytical models for the acoustical properties of porous media. The results of this study suggest that an aerogel powder behaves like a viscoelastic layer and its absorption coefficient depends strongly on the sound pressure level in the incident wave, i.e., this acoustic behaviour is non-linear. The loss factor seems to be a key parameter which predicts the observed acoustical behaviour. The loss factor is found higher than physically reasonable at low frequencies and decreases with the frequency exponentially. This behaviour is likely to relate to the frictional interaction between the particles in the powder and acoustic fluoridisation effect.
Estimation of insertion loss for noise barrier with multichannel sound reproduction technology

Satoshi Hoshika\textsuperscript{1}, Tetsuya Doi\textsuperscript{1}, Masaaki Hiroe\textsuperscript{1}, Takahiro Iwami\textsuperscript{2}
\textsuperscript{1}Kobayasi Institute of Physical Research, Tokyo, Japan, \textsuperscript{2}Kyushu University, Fukuoka, Japan

A method based on the wave field synthesis is proposed to estimate the insertion loss of a noise barrier under the complex diffracted sound field due to the characteristics of the noise source and the transmitted sound through the barrier. This method is equivalent to evaluating the acoustical performance of the noise barrier in a reproduced sound field. There are two advantages of the proposed method. First, by storing the radiated sound of various noise sources as a database in advance, the insertion loss for them can be obtained. Second, the impulse responses from multipoint can be measured by changing one loudspeaker position sequentially, so it does not necessarily require many loudspeakers. In order to validate this method, numerical simulation was performed for a diffracted sound field consisting of a point source and a rigid barrier. Moreover, the insertion loss of simple noise barriers for one loudspeaker was estimated under the primary and synthesized sound field conditions experimentally. As a practical example, the insertion loss of the same noise barriers for a moving automobile was also estimated. The results show that the estimation error is within a few decibels in the frequency band where spatial aliasing does not occur.

[Link to paper]
The effects of workstation arrangements on the acoustical performance of the architecture design studios.

Hany Hossam Eldien¹, Umaru M. Bongwirnso¹, Seraj Alzaher¹
²Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia

Architecture design studios spaces needs special treatment for its acoustical environment. Interaction, communication, meetings, and various activities could influence concentration, which in turn, affects other aspects as quality of the architectural concepts and creation level. Workstation arrangement could consider as one of the elements which can improve the design studio acoustical conditions. In this paper, we evaluate the impact of 5 types of workstation arrangement with two different partitions heights (1.10m and 1.60m). The measurements were conducted in the College of Architecture, Imam Abdulrahman Bin Faisal University, KSA. Speech Transmission Index, STI in the nearest workstation, Distraction distance rD, privacy distance rP, A-weighted background noise level Lp, A, B and A-weighted SPL of speech at 4 meters Lp,A,S,4m have been measured according to ISO 3382-3. We found that U-shaped workstation arrangement can improve the acoustical environment the design studio. Furthermore, good results were observed using 1.60m partition height for all types of arrangements.

Link to paper
Impact of Mihrab geometry on the acoustics of the mosque

Hany Hossam Eldien¹, Umaru M. Bongwirnso¹, Emad Hammad²
¹Department of Building Engineering, College of Architecture and Planning, Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia, ²Department of Interior Architecture, College of Architecture and Planning, Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia

Mihrab is a niche in the wall of a mosque that indicates the qibla, the direction of the Kaaba in Mecca towards which Muslims should face when praying. The wall in which a mihrab appears is thus the "qibla wall". Mihrab geometry has an impact on daily prayer recitation and others. This paper investigates the impact of new type of the Mihrab geometry on the acoustics of the mosque. Flat wall and 7 types of mihrab were modeled. Polar response measurements were carried out using 1:10 scale model. Measurements had been realized using 1:10 omni-directional sound source and Dirac room acoustics software. It is found that flat wall and Mihrab with trapezium and triangle shapes can generate a uniform polar response over the frequency range we are interested in (500-2000 Hz).
Unlock the myth of low-frequency footstep thumping noise in lightweight wood floors

Lin Hu1, Anes Omeranovic1, Fabrice Roussiere1, Christian Christian1, Sylvain Gagnon51
1FPinnovations, Quebec city, Canada

Major occupants’ complaints received in lightweight wood floors of Impact Insulation Class (IIC) above 55, are low-frequency footstep thumping noise. Lack of understanding of fundamentals and solutions motived this study. A series experiments were conducted to answer the following questions: 1) what are the frequency range of the low-frequency footstep thumping noises heard by the occupants in mass timber slab floor and in light frame wood joisted floor when the floors are impacted by the ISO tapping machine, footsteps of a person walking with shoes, and with bare foot? 2) how look like the impact sound spectrums below 50 Hz (ISO) or below 100 Hz (ASTM)? 3) Can the tapping machine excite the low-frequency noise down to the range of wood floor natural frequency around 15 Hz? 3) Can the current measurement system measure the sound signals at such low frequency range reliably? 4) can the measured spectrums of impact sound signals reveal the low-frequency impact noise issues? 5) what are the special construction details of the wood floors contributing to the low-frequency impact noise problem? 6) what are the solutions for the problem? Our experiments answered the questions. The findings and solutions will be shared in the full-length paper.

Link to paper
Aural Diversity: noise control and a sustainable future.

Andrew Hugill 1
1University Of Leicester, Leicester, United Kingdom

The unquestioned assumption of a "normal" pair of standard healthy ears underpins most sound-related disciplines, from acoustics to engineering, from music to sound studies, from medicine to hearing science. Yet, the reality is that everybody hears differently. Our ears are uniquely shaped. We all experience temporary changes in hearing, such as during a cold. Everybody goes through presbyacusis (age-related hearing loss) at varying rates after the teenage years. More specific aural divergences are the result of an array of hearing differences or impairments which affect roughly one sixth of the world's population (Lancet, 2013). These include noise-related, genetic, ototoxic, traumatic, and disorder-based hearing loss, some of which may cause full or partial deafness. Moreover, "loss" is not the only form of difference: auditory perceptual disorders such as tinnitus, hyperacusis and misophonia involve an increased sensitivity to sound. This paper presents findings from the AHRC-funded Aural Diversity Network, which explores the consequences of these differences for noise-related engineering and many other fields. How may we ensure a sustainable future that acknowledges aural diversity?
Two-step optimization design of a periodic beam with acoustic black holes

Sheng Hui¹, Hui Sheng¹
¹Tianjin University, 92 Weijin Road, Tianjin 300072, China

This paper presents a two-step optimization method to design the acoustic black holes (ABH) profiles according to local property in the target frequency region. In the first step, the concept of ‘local index’ is used to identify the position of local vibration. Then, as the second step, the ABH parameters are multi-objective optimized. The numerical examples indicate that the two-step optimization provide a set of Pareto solutions for lightweight ABH design with board bandgaps. To reveal the mechanism of the attenuation band, the vibration modes of the structure are analyzed and the local property of the ABH is shown. Using dynamic and static characteristics as objective functions, the proposed method provides a way to merge physical meaning in the process of data-based optimization.
Green transition and noise transition – Europe's first Living Lab on traffic noise

Karolina Huss¹, Sif Enevold
¹Gate 21, Liljens Kvarter 2, Albertslund, Denmark

Around Copenhagen, in the most noise emission plagued areas in Denmark, nine municipalities have joined forces to improve citizens' health and quality of life.

Traffic noise is one of the largest environmental problems in our society. In Denmark, over 1.3 million people are estimated to be affected by traffic noise. Silent City works on several levels with political influence, opinion-making, competence development and the establishment of a Living Lab.

Since the start in 2015, the partnership has managed to put traffic noise on the agenda, and on that basis implemented several concrete initiatives, including a public consultation at the Danish parliament, preparation of a white paper, targeted press efforts and concrete demonstration projects in a single Living Lab.

Together we are stronger, and wiser. When municipalities, companies, citizens, regions, and research institutions work together to reduce traffic noise, promote citizens' quality of life. In the next couple of years, we will use the growing attention on traffic noise and continue to test and develop innovative solutions for combating traffic noise on a 1:1 scale in natural urban environments.
Speech perception and deaf and hard of hearing children in the classroom: A multidisciplinary effort in the United States to bring data and standards to architects, school districts, and into building codes

Frank Iglehart

1Educational Audiology Assoc. Classroom Acoustics Coalition, Leverett, United States

This presentation will discuss efforts by a multidisciplinary team to overcome the notable lack of progress in the United States in acoustic accommodations for deaf and hard of hearing children in the classroom. Data collected through research efforts by members of this team, and by others, demonstrate the benefits of appropriate acoustics for all children and especially those deaf and hard of hearing. These efforts have resulted in a voluntary standard in classroom acoustics specifically for deaf and hard of hearing children by the American National Standards Institute. This standard, however, is not reaching built classrooms. This team representing the fields of acoustics, architecture and audiology is using speech perception data and new computer simulations to increase awareness of the need for classroom acoustic standards in building codes to accommodate deaf and hard of hearing children.

Link to paper
Research on Sound Power Levels of Structure-Borne Noise of Viaducts Roads

Kimikazu Ikeya¹, Tatsuaki Mori, Tomoyuki Itiki, Akinori Fukushima
¹Nexco Research Institute Japan, Tokyo Matida City, Japan

The authors studied the power levels of structure-borne noise of viaducts generated when tyres of running vehicles excite the road surface.

The Acoustical Society of Japan’s Research Committee on Road Traffic Noise describes the power levels of structure-borne noise are influenced by viaduct type, running speed, and vehicle weight.

This paper reports on the results of organizing the power levels per running speed and number of axles, measured by grouping large vehicles by their number of axles.

The study confirmed that power levels tend to larger as the speed and number of axles increase.

Based on this result, the power-level setting equation applied in the prediction method of road traffic noise was revised.
Parameter extraction of 3D acoustic images using a nonlinear optimization technique

Lara Del Val¹, Alberto Izquierdo¹, Juan J. Villacorta¹
¹University Of Valladolid, Valladolid, Spain

In biometrics, classification techniques are based on parameter extraction from a large data set, such as fingerprints. Specifically, when using 3D acoustic images, it is necessary to extract a set of meaningful parameters. This work assumes that each significant target will have an acoustic image characterized by the 2D radiation pattern of the array and the envelope of the transmission pulse used. Under this assumption the final acoustic image can be synthesized by a linear combination of the significant targets in the scene. The work uses a non-linear optimization algorithm that obtains the parameters (power, range, elevation and azimuth) for each of the significant targets from a 3D acoustic image. Specifically, the algorithm is applied to the parameterization of 3D images of people, as a prior step to the use of classification algorithms based on machine learning.

Link to paper
New aircraft noise monitoring system introduced at the three airports in the Osaka area

Junshi Izumi, Yoshio Nishino, Kenji Matsubara, Junshi Izumi, Etsushi Fujita, Taichi Higashioka

1Kansai Airports, 1 Senshu-kuko Kita, Izumisanoshi, Japan, 2Nihon Onkyo Engineering Co., Ltd., 1-21-10 Midori Sumida-ku, Japan

There are three airports in the Osaka area and each of them has been analyzing and evaluating aircraft noise and publishing its results. However, since these three airports are adjacent to each other, the airspace is complicated, and the monitoring range is wide, which caused so much manual work for data review before obtaining an accurate noise impact assessment. This paper introduces a new aircraft noise monitoring system that has been constructed to reduce the human workload and accurately and integrally monitor aircraft noise at the three airports with flight-track measurement.

The new system reduces the time for noise analysis and evaluation using artificial intelligence, and it has become possible to publish accurate noise conditions more quickly and at a lower cost. In addition, since it is difficult for an airport operator to obtain air traffic control data, we constructed a system that can monitor the position coordinates of aircraft as recent as 15 seconds ago. By operating this system integrally with the noise system, we can now visually confirm the noise level at the measurement point and the position of aircraft on a map, and publish the real-time noise data online for residents living near the airports.
High sensitivity of indirect noise predictions in non-isentropic nozzles

Animesh Jain\textsuperscript{1}, Luca Magri\textsuperscript{2,1}
\textsuperscript{1}University Of Cambridge, Cambridge, United Kingdom, \textsuperscript{2}Imperial College London, London, United Kingdom

In aircraft engine combustors, incomplete mixing and air cooling give rise to flow inhomogeneities. When accelerated through the nozzle guide vane downstream of the combustor, these inhomogeneities give rise to acoustic waves. This is commonly known as indirect combustion noise. When these sound waves are reflected off the outlet and travel upstream of the combustor, they can lead to thermoacoustic oscillations. To predict indirect noise, models proposed in the literature assume the frequency of impinging disturbances to be small (compact nozzle assumptions). However, in reality, the assumption might not hold; hence, a mismatch in the predicted and experimental results can be observed. First, we present a semi-analytical solution to a non-isentropic nozzle indirect noise model using asymptotic expansion. Second, we show that the indirect noise predictions are sensitive to a small change in the Helmholtz number for a nearly compact nozzle, especially in the subsonic flow regime. We also show the predictions become lesser sensitive as the non-isentropicity increases. This study highlights the importance of non-compact assumptions for the accurate prediction of indirect noise transfer functions and thermoacoustic instability in aeronautical gas turbines.

[Link to paper]
Sound Insulation Performance of Composites Developed using Waste Carbonaceous Materials

Sunali Jaish¹, Jonty Mago¹, Ashutosh Negi¹,²,³, S. Fatima¹

¹Automotive Health Monitoring Laboratory, Centre for Automotive Research & Tribology, Indian Institute of Technology Delhi, India, ²Renewable Energy and Chemicals Laboratory, Department of Chemical Engineering, Indian Institute of Technology Delhi, India, ³School of Interdisciplinary Research, Indian Institute of Technology Delhi, India

Mitigating vibration in a system has many advantages, from decreasing noise output to increasing component life. Therefore, it is necessary to eliminate the mechanical vibration and sound through appropriate measures. State-of-the-art techniques seek the utilization of sustainable carbonaceous resources for the development of sound insulating materials to reduce the environmental externalities of the synthetic materials. It is noteworthy to mention that sustainable carbonaceous resources such as biochar, also assist in atmospheric carbon sequestration (capturing and storing CO₂) and ultimately limit CO₂ concentration in the environment. In the present work, carbonaceous material obtained from biomass waste was utilized as a filler with natural rubber as matrix to develop sound insulating materials. Furthermore, the physical, mechanical, and acoustical properties of developed composites were studied. The sound transmission loss of the composites was measured as per ASTM-E2611 using a four-microphone impedance tube. Noticeably, with the increase in biomass waste filler in the composite, significant improvement in the physical (density), mechanical (tensile strength) and acoustical (sound transmission loss) properties has been observed.

[Link to paper]
Experimental Noise Characterisation of Different Pitch Propellers in Static and Forward Flight.

Nur Syafiqah Jamaluddin¹, Alper Celik¹, Kabilan Baskaran¹, Djamel Rezgui¹, Mahdi Azarpeyvand¹

¹University of Bristol, Bristol, United Kingdom

The present study investigates the influence of blade pitch on propellers' aerodynamic load and noise characteristics during static and forward flight operations. A series of experiments were carried out on an isolated propeller configuration in the aeroacoustics facility at the University of Bristol. Thrust, torque and far-field noise were measured at varying propeller advance ratios. Spectral and directivity analyses were performed to understand the distribution of acoustic radiations with frequency and emission angles, respectively. The results are presented in terms of propeller thrust and torque variation, power spectral density of acoustic pressures, and overall sound pressure level directivity. The results reveal that with an increase in pitch, the overall sound pressure level radiation increases across all polar angles for all measured velocities. Additionally, free-run PIV measurements for the same testing parameters were conducted to understand the variation in velocity fields. Qualitative and quantitative results are presented to illustrate the flow visualisation and the distribution of variables in the flow field, respectively.

[Link to paper]
An investigation of classroom sound levels as a function of class size

Adrian James¹
¹Adrian James Acoustics, Norwich, United Kingdom

It is generally acknowledged that students with special hearing and communication needs should be taught in classrooms with relatively short reverberation times. There has been a great deal of research into the effect of room acoustics on the signal-to-noise ratio experienced by pupils. There is, however, much less research into the effect of class size on ambient noise levels during lessons, and hence on the signal-to-noise ratio and on absolute sound levels in classrooms. These absolute levels are important because many students with special needs are sensitive to high noise levels, either for psycho-acoustic reasons or because of the limited dynamic range of cochlear implants and other assistive devices. In his work as an expert witness on acoustics for Special Education Needs and Disabilities Tribunals, the author has measured in-lesson sound levels for different types of teaching and learning activity in many schools throughout England. He has analysed these to investigate the correlation, when corrected for acoustic factors, between class size and sound levels generated by teachers and pupils, and to consider whether there is a typical class size at which an effect analogous to the Lombard Effect occurs. From this the author draws conclusions as to the acoustic justification for teaching pupils with special hearing and communication needs in smaller classes.
Recent Technological Advances in Spatial Active Noise Control Systems

Ehsan Javahersaz, Samira Mohamady, Roohollah Javahersaz

Lancaster University, Lancaster, United Kingdom

This article provides a broad overview of the recent advances in the field of active noise control techniques to reduce unwanted noise over a certain spatial region of interest. By both commercial and technological advances in local active noise control systems extending the size of the quiet zone seems to be a crucial step to develop the next generation of active control systems for a more personalized and quieter audio products. In this review article, the advances over the past decade in design and development of spatial active noise control techniques to enlarge the controlled sound zone is reviewed. The focus is specifically on the adaptive control techniques and the methods proposed in the frequency domain to control the sound field. The study has paid a specific attention into the most important performance measures in designing a spatial active noise control system such as convergence rate, stability and robustness of the algorithm, and the size of quite zone and how it can be enlarged by configuring the loudspeaker and microphone array geometries. Finally, the authors will discuss the current and future challenges that should be overcome to improve the effectiveness of the recently proposed methods to expand the silence zone.

Link to paper
The Attenuation and Speech Intelligibility of the Gecko Helmet Used by the Royal National Lifeboat Institution

Stephen Jay\textsuperscript{1,2}  
\textsuperscript{1}London South Bank University, London, United Kingdom, \textsuperscript{2}Environment Agency, United Kingdom

The RNLI operates a fleet of B Class Inshore Lifeboats around the UK and Ireland. To help keep their volunteers safe, crew members wear the Gecko helmet as part of their issued personal protective equipment. Anecdotal evidence from lifeboat crew has shown that wearing the helmet interfered with the ability of volunteers to follow normal conversations and commands given under non-amplified situations. Objective measurements were undertaken at varying angles of incidence to quantify the attenuation of sound provided by the helmet at the location of the human ear along with objective and subjective measurements of the intelligibility of speech while wearing the Gecko helmet. Analysis of data showed that the Gecko helmet provides limited noise attenuation at frequencies above 1kHz. Results of objective and subjective speech intelligibility tests show a reduction in the speech transmission index score when the helmet was introduced into the experiment.

[Link to paper]
Sub-band attention CNN with feature evaluation for chatter detection

Kwanghun Jeong¹, Jonghoon Jeon¹, Junhong Park¹
¹Hanyang University, Seoul, South Korea

In chatter detection, feature evaluation is an important task to identify mechanical systems and achieve higher classification accuracy. The importance of frequency bands is useful under various operating conditions. In this study, we propose a new methodology to identify the importance of frequency bands based on sub-band attention CNN. The sub-band attention CNN is a structure that combines the sub-band CNN and the attention layer. Unlike conventional CNNs that treat all frequency components with the same filter, the sub-band CNN processes different filters for each band. The attention layer is used to evaluate the importance of each band. The time-varying variance in frequency domain is used to extract chatter characteristics that vary greatly with time and it is used as an input for chatter detection. The useful frequency bands for chatter detection are obtained from the sub-band attention CNN. The importance of the frequency band is analyzed with the frequency response of the mechanical system.

Link to paper
Measuring low noise level in dwellings

Birger Jessen

1 Danish Technological Institute, Hoeje Taastrup, Denmark

DS 490:2018 “Akustik – Lydklassifikation af boliger”, translated to “Acoustics - Acoustic Classification of Dwellings” relates to many acoustical parameters, and two of them “Noise from ventilation” and “Reverberation times” are now being tested in real life in the Danish “Voluntary sustainability classification”. (Called FBK)

Danish building regulation state a sound level limit in dwellings from all kinds of technical systems at 30 dB(A), equal to the Acoustical class C, comparable with the limit in several countries. Research shows that 30 dB(A) does not ensure acoustic satisfying comfort for most people.

The FBK have chosen to lower the noise limit to 25 dB(A), equal to acoustical class B.

We need to improve the ventilation systems in order to reach such lower level of sound emission, and to be able to measure it implemented in dwellings.

The paper describes some methods and in situ experience fighting background noise problems caused by activities around and in the dwelling, as well as in the measurement systems. Special analyses and editing of recordings based on listening and pragmatic judgements are relevant.

The goal is: Measure and document low noise without a cost in time and money being a barrier for lower noise levels in dwellings.

[Link to paper]
Study of the comfort aircraft norms

Sarah Jibodh-jiaouan\textsuperscript{1,2}, Guillaume Osmond\textsuperscript{2}
\textsuperscript{1}Insa, Villeurbanne, France; \textsuperscript{2}Airbus, Toulouse, France

"In long range aircraft, one reason of discomfort of the passengers are the vibrations and the noise induced by the rotation of the engine. This induces high-level single-frequency excitations (both for noise and vibration). The frequency (located between 25 and 55 Hz) and the amplitude of these excitations vary depending on flight parameters. This study investigates the influence of the frequency and the level of vibration and noise stimuli to discomfort. The aim is to build a global discomfort model. Subjective experiments were carried out in the laboratory, on a test bench allowing to control vibration and noise stimuli. Volunteers separately assessed the vibration, noise and global discomfort. Foot, seat, backrest and armrests accelerations were measured for each participant and each stimulus. As expected, noise or vibration discomfort depends on the excitation level; but no influence of the frequency could be detected. Finally, it appears that specific vibration discomfort strongly influences global discomfort."

Link to paper
Prediction of rattle noise in steering gear system and analysis of contributing factors through neural networks using design and manufacturing data

Hyeon-Cheol Jo¹, Jae-Yong Seo¹, Kyung-Hwan Park¹
¹Applied NVH Technology cell, Hyundai Mobis, Yongin, South Korea

In a vehicle, rattle noise may occur when driving on bumpy roads due to clearance between parts of steering gear systems. The rattle noise is perceived by the drivers’ ears and it can be the cause of a repair campaign. In order to reduce rattle noise, the dimensions of clearance between parts are optimally designed. Also, in the development stage, general auto parts companies manage rattle noise below a certain level. However, it is impossible to measure noise for all products at the production stage due to cost and time issues. In this paper, the noise prediction model using the neural network model for all products based on design factors and the data of manufacturing execution system was introduced. In addition, the main factors contributing to rattle noise were analyzed in the process of creating the model. By referring to the main factors contributing to noise, it helps in the design of the steering gear to reduce the rattle noise value.

Link to paper

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Elastic hangers for suspended ceilings – are they really needed?

Bengt Johansson

Efterklang, Stockholm, Sweden

Suspended ceilings made of several layers of gypsum boards are a common way to increase the sound insulation of slabs in buildings. The ceiling is typically hanging 100-500 mm below a slab. There are many manufacturers of the hangers and most of them supply elastic hangers, made of rubber or metal springs. The elastic hangers are very costly and there are very little scientific data of the effect of these elastic hangers, especially at low frequencies and especially for concrete slabs, which are the most common slab type. The sound insulation of normal buildings is increasing with frequency and the low frequency region is the most interesting region. The author has in more than 30 years been part of many cinema projects where elastic hangers has not been used. Still, the sound insulation at low frequencies is excellent. What are the most important parameters? Could it be that elastic hangers are even reducing sound insulation due to resonances at low frequencies? In this paper we will discuss measurement data both from laboratory and real buildings with focus on air-borne sound insulation at low frequencies. We will also discuss calculations methods.

Link to paper
Aircraft Approach Noise Trials

Anders Johansson

KTH-Center for Sustainable Aviation, 100 44 Stockholm, Sweden

This article presents the results from a series of aircraft approach trials that were conducted with the aim to investigate noise reduction procedures within the boundaries of a normal ILS approach. The significant decline in air traffic at Stockholm Arlanda, that occurred during the pandemic meant that the empty airspace and the availability of grounded aircrafts could be utilized to perform controlled flights - something that would have been difficult to achieve during normal traffic conditions. The approach trials were performed by two Airbus A321, which alternately carried out interrupted landing procedures starting 17 nautical miles (nm) from the runway threshold. During the trials, the aircraft speed and configuration (high lift devices and landing gear) were varied according to a predetermined schedule. To capture these variations, flight data (FDR) were recorded while the noise on ground was measured at positions approximately once every nautical mile along the flight track. Results suggest that speed and configuration recommendations can be effective to reduce noise, especially for the final 7 nautical miles of the flight track. However, whether a low speed is to be advocated during the entire approach is currently unclear.
Data-driven reconstruction of rough surfaces from acoustic scattering

Michael-David Johnson¹, Anton Krynkin¹, Giulio Dolcetti¹, Mansour Alkmim², Jacques Cuenca², Laurent De Ryck², Yue Li²

¹University Of Sheffield, Sheffield, United Kingdom, ²Siemens Industry Software NV, Leuven, Belgium

This work investigates the use of data-driven approaches for reconstructing rough surfaces from scattered sound. The proposed methods stand as alternatives to matrix inversion, which requires a linearisation of the dependence on the surface parameters. Here, a large dataset was formed from different surface realisations alongside the corresponding scattered acoustic field, estimated through the Kirchhoff Approximation. Limiting this work to the reconstruction of a static surface, K-Nearest Neighbours, Random Forests, and a stochastic approach are compared to recover a parameterisation of surfaces using the scattered acoustical pressure as input. The models are then validated against a laboratory experiment alongside methods highlighted in Dolcetti et. al., JSV, 2021. The models are tested at a frequency that best fits the lab uncertainties, then tested on a broad frequency range. This scheme provides relatively accurate results in comparison to the approaches tested. Estimation errors as well as robustness in the presence of noise are discussed.
Numerical investigation of sound transmission through single and double walls with periodic arrays of resonators

Milica Jovanoska¹, Todorka Samardzioska¹
¹Faculty of Civil Engineering, UKIM, Skopje, Macedonia

Lightweight partition walls are widely used in buildings, especially nowadays when sustainability is of a major interest. At the same time, noise pollution is becoming a growing problem across the globe. All this implies the need to find possible solutions for sound insulation improvement of the lightweight partitions. This paper is focused on exploring the possibilities of exploiting the dynamic effects of periodic subwavelength arrays of resonators for sound insulation enhancement. In order to improve the sound transmission loss in a specific frequency region, periodic resonant units are tuned and introduced to single and double panels. It can be shown that the resonance mode of the resonators couples with the host plate vibration in the way of breaking the mass law and overcoming some phenomena like coincidence effect and mass-air-mass resonance. The investigation of the considered panels under acoustic field excitation is conducted using different methods. Sound transmission loss curves and dispersion diagrams are calculated. Finite element method is employed for this purpose, but also the theory of threedimensional elasticity and well-known transfer matrix method (TMM). Several designs of resonators are proposed.
A Study on Improving the Robustness of Virtual Sensing Methods in ANC Systems

Yoshinobu Kajikawa\(^1\), Yoshinobu Kajikawa\(^3\)
\(^2\)Kansai University, 3–3–35 Yamate-cho Suita-shi, Japan

Active noise control (ANC) system generates anti-noise with the same amplitude and opposite phase to reduce unwanted acoustic noise based on acoustic wave superposition. In general, ANC can generate a zone of quiet (ZoQ) around the error microphone position. However, if the microphone cannot be placed at the desired position we want to realize noise reduction, the reduction effect may not be sufficient in the desired position. In such a case, we need to use the virtual sensing method to move the ZoQ to the desired position. Several virtual sensing methods have been proposed, each with different robust performance due to the different way the system is designed. It is known that the noise reduction is degraded when there are perturbations in the environment such as plant and noise. In this paper, we investigate how to improve the robust performance of the virtual sensing method.

Link to paper
Development of ventilation and sound-absorbing materials using specimens generated by the multi-objective optimization method (Part 1: The multi-objective optimization method to generate 3D model based on fluid potential flow analysis)

Keigo Kajitani 1
1Shimane University, Matsue-shi, Japan

In hot and humid tropical countries, the houses are designed to be naturally ventilated with vent louvers. However, these louvers play as direct paths for noise entering the house. It is necessary to create geometries that can maximize the noise transmission loss and the ventilation performance of the housing structure. The present study aims to develop ventilation and sound-absorbing material using the multi-objective optimization method. This material has a specific design that enables wind from the exterior of the building to pass through while reducing noise. This study is presented in two parts. This paper, Part 1, explains the multi-objective optimization method and analysis calculation result. In the following paper, Part 2, the acoustic experiment of the ABS specimens manufactured by the 3D printer and results will be reported. An optimization problem is formulated by the Digital Fourier transformation, which searches the patterns of existing and blank elements. The sum of the magnitudes of the flow velocities in all the elements and those in the bottom elements are obtained from fluid potential flow analysis and used as by-objective functions. Multi-objective optimization is performed using "Platypus," an external library of Python. As a result, models that maximized the sum of the magnitude of each flow velocities are obtained.

[Link to paper]
Prediction methodology and assessment of low frequency noise break-in for a science building

Christos Karatsovis¹, Erika Quaranta¹
²ISVR, University of Southampton, Southampton, United Kingdom

More often than not the effects of anthropogenic (or man-made) noise are evident in all facets of the built environment: from residencies and offices through to state-of-the-art R&D facilities. Often external ambient noise can penetrate the fabric of these buildings and adversely affect, for instance, human symbiosis on a socio-political level or mar the outcome of advanced technological research in scientific facilities. The principles of acoustic design of buildings are mainly limited to a specific frequency range, i.e. within the standard sonic range, and usually do not account for the effect of lower frequency noise, such as sound in the less audible range (infrasound). It is in the remit of this work to outline a practical method of estimating the impact of lower frequency noise on a science building housing particularly sensitive experiments susceptible to infrasound. An analytical model of the excitation mechanism of the external building fabric will therefore be outlined and used in tandem with a structural/acoustical numerical model of a science building in order to predict the low frequency acoustic levels within the labs. A set of measured noise data in the actual labs will also lend a level of support to the described method of predictions.
Annoyance of railway curve squeal

Christian Kasess¹, Thomas Maly², Christian Kirisits³, Piotr Majdak¹, Holger Waubke¹
¹Acoustics Research Institute, Austrian Academy Of Sciences, Vienna, Austria, ²Institute of Transportation, TU Wien, Vienna, Austria, ³Kirisits, Chartered Engineering Consultants, Pinkafeld, Austria, ⁴Medical University of Vienna, Vienna, Austria

Trains passing through a curve frequently produce the so-called curve squeal, which are salient noise components (typically either tonal or transient) covering a wide frequency range. Although the main underlying acoustical mechanisms are well known, due to the large variety of curve squeal characteristics, their effects on acoustic parameters and in particular on the perception are difficult to quantify. The work presented here aims at investigating the effects of acoustically described curve squeals on the perceived annoyance, tested in the laboratory with 30 listeners. Measurements of curve squeal at distances of 7,5, 25, and 50 m in three narrow curves were obtained. By means of so-called frame multipliers, time-variable salient features were manipulated and combined with a number of clean rolling noises to simulate squeals with parameters obtained from existing emission measurements. The annoyance ratings showed that the perception of curve squeal can be considerably altered compared to that of regular passby noises. A model was developed for the annoyance equivalent level adjustment from a clean rolling noise based on the contrast of high and mid-frequency energy. The model predictions can serve as a basis to establish rating levels predicting the perceived annoyance of railway curve squeal.
Comparing Tank Measurements Using A Calibration Panel

Scott Kasprzak¹, Matthew Craun¹, Stephen Robinson¹
¹Naval Surface Warfare Center, Carderock Division, Bethesda, United States, ²National Physical Laboratory, Teddington, United Kingdom

Researchers in the United Kingdom and the United States worked together to compare acoustic panel measurement methods and equipment using a calibration test panel. Underwater testing can be used to calibrate various transducers or to measure acoustic properties of materials, from which material properties can then be derived. The calibration panel used in this study consisted of a rubber material. Tests were initially conducted in the Acoustic Pressure Vessel (APV) at the National Physical Laboratory (NPL) in Teddington, UK and were subsequently performed in the Acoustic Pressure Tank Facility (APTF) at the Naval Undersea Warfare Center (NUWC) in Newport, Rhode Island, USA. The UK tank is a smaller-scale version of the US tank. However, the measurement approaches developed by the two groups of researchers differs. The UK utilized a parametric source with a baffle and a planar hydrophone array for reflection and transmission measurements. The US used a spherical source, a linear pseudo-array along with coherent subtraction for reflection, and a single hydrophone for transmission measurements. Early results indicated that the measurement methods showed significant discrepancies, but refurbishment of the US facility and subsequent re-testing of the panel delivered results that were in good agreement between the two groups.

[Link to paper]
A field experiment on the effect of sound absorption installed to a highly reverberant preschool classroom

Keiji Kawai1, Midori Ishizawa1, Yuuki Matsufuji1
1Kumamoto University, Kumamoto, Japan

Japanese national or local governments have not published any standard for acoustic performance of classrooms and this is reflected by the rare consideration of sound absorption in classrooms. A preschool classroom, targeted in this study, was found to be highly reverberant (V = 200 m³, RT = 1.0 s at 1 kHz) because the room was originally an outdoor space of ground floor pilotis and converted into a classroom by constructing concrete walls between the columns with the fire-resistant hard ceiling panels remained. The author proposed a temporary installation of sound absorbing material and to conduct a field experiment to examine and experience the effect of sound absorption. Sound absorbing felt was attached on the ceiling and the walls to reduce the RT to 0.5 s. By this, the slope of doubled distance reduction increased from 1.1 dB to 2.5 dB, which should mitigate the confusion of speech by children in the room. The result of sound level monitoring indicated 6.8 dB decrease at 1-2 kHz in the absorbed condition, which is greater than the 3.8 dB decrease measured in the unoccupied condition using a loudspeaker source, implying 2.9 dB decrease of the voice of the children.
Modelling the uncertainties of wind farm noise predictions

David Ecotière¹, Benoit Gauvreau¹, Bill Kayser¹
¹Cerema, Université Gustave Eiffel, UMRAE, Bouguenais, France

Representative predictions of wind turbine noise require to accurately model the main mechanisms and characteristics of acoustic emission (i.e., extended sound source with aeroacoustic noise generation) and acoustic propagation in outdoor environment (i.e., ground effects and atmospheric properties). As these phenomena fluctuate over time and space, it leads to great uncertainty on Sound Pressure Level (SPL) estimated at local resident buildings/facades. Such uncertainty is not yet properly quantified by engineering noise prediction models. Thus, this paper presents a modeling tool developed in the framework of the French project PIBE, which aims at quantifying the SPL uncertainty involved in wind farm noise predictions. Ultimately, this modeling tool will be freely available online and will help to better understand the risk of noise pollution at each stage of a wind farm's life, in order to guarantee compliance with the regulatory requirements concerning the exposure of local populations.

Link to paper
Noise mitigation of UAV operations through a Complex Networks approach

Harun Siljak, John Kennedy¹, Stephen Byrne, Karina Einicke

¹Trinity College Dublin, Dublin, Ireland

This research combines complex systems science, geographical information systems, and environmental noise modelling to analyse effects of future air mobility in urban settings and plan efficient routes for vehicles. The research used the environmental noise maps of an urban agglomeration produced under the Environmental Noise Directive (END) as input to inform the UAV operations. These maps reveal potential routes for the UAV operations where the noise impact of the vehicle can be embedded within a high background noise due to the existing sources modelled under the END. When an agent based model is superimposed on a real-world map simple strategies of the diverse agents in interaction with the environment reveal patterns, such as dominant paths, points of congestion, and suggest positioning of terrestrial infrastructure. We investigate how agents can overcome the conflicts and find trade-off solutions by interacting only with their immediate neighbours—therefore enabling autonomy, decentralization, and putting to use emergent self-organising behaviour. The potential impact of increased drone operations on urban and peri urban regions is significant. Route optimisation which does not consider the noise is likely to impact on quite areas within our residential spaces and should be considered as part of noise action planning.

Link to paper
The influence of helmets on sound localisation in motorcyclists

John Kennedy¹, Seán Byrne¹
¹Trinity College Dublin, Dublin, Ireland

Motorcyclists are among the most vulnerable road users globally, they enjoy less protection than car drivers and experience higher speed collisions than cyclists, with less mobility and spatial awareness to avoid crashes. Sound localisation (SL) while wearing military and ski helmets has been a significant area of research to improve spatial awareness, but no research has been completed thus far on the impact of motorcycle helmets on SL. This project aims to examine experimentally the impact of a motorcycle helmet on the Head Related Impulse Response (HRIR), and therefore determine the extent of the impact on SL ability of a user. A database of HRIRs as a function of position in the horizontal plane was established with and without a motorcycle helmet. The variation in the signals was evaluated, and it was found that the helmet results in significant loss of higher frequencies, important for resolving front-back confusions. It is also demonstrated that the overall sound attenuation would result in reduced SL ability of the rider. A novel system to compensate for the changes in the HRIR was developed and experimentally tested to mitigate the impact on SL ability for the wearer.

Link to paper
Precision of room acoustic modelling in open-plan offices

Jukka Keränen¹, Pekka Saarinen¹, Valtteri Hongisto¹

¹Turku University Of Applied Sciences, Turku, Finland

Room acoustic models are often used to predict parameters that describe acoustic conditions in various spaces, also in open-plan offices. An open-plan office of 81 m² was experimentally studied using 22 different room acoustic conditions. The conditions were built using typical absorption materials, office screens, and furniture. The acoustic conditions were measured according to ISO 3382-3. The measurements were modelled using two methods: A. room acoustic simulation software based on ray-tracing, and B. a simple empirical model. The precision was assessed by the difference of predicted and measured single-number values (SNVs) of ISO 3382-3. For method A, the modelled and measured SNVs were very similar in conditions with low sound absorption and low screen height. The agreement was worse in conditions with high sound absorption on the ceiling and walls, and over 1.6-m-high sound-absorbing screens. For method B, the agreement of SNVs was on the same level in most of the conditions. Consequently, SNVs with method B were more precise than with method A in conditions with high screens and high sound absorption, but less precise in conditions with low sound absorption and lower screens.

Link to paper
Measured effect of resilient edge joints on airborne sound insulation of heavyweight wall

Jukka Keränen¹, Jarkko Hakala¹, Valtteri Hongisto¹

¹Turku University Of Applied Sciences, Turku, Finland

It is common assumption that resilient joints around a heavyweight construction improve sound insulation between adjacent rooms. Effect of resilient joints on sound insulation has not been studied sufficiently. This study investigated how the joint resiliency around a heavyweight wall affected sound reduction index (SRI) measured directly through the construction. A calcium silicate block wall was built three times in a laboratory using three different joint types A–C between the wall and the building frame: A) all four edge joints rigid, B) three resilient and one rigid joint, C) all four joints resilient. SRI was determined for A–C. Total loss factor (TLF) was determined for A–C by measuring structural reverberation time using hammer impact stimulus. SRI reduced, remarkably, with increasing level of joint resiliency. For joint type A Rw was 50 dB while it was 45 dB for B and 43 dB for C. Correspondingly, TLF reduced with increasing level of resiliency. The effect of joint type was evident above the critical coincidence frequency 185 Hz of the wall. Resilient joints prevented the sound transmission to the building frame, which increased sound radiation to the receiving room. Therefore, heavyweight wall should be mounted to surrounding heavy constructions using rigid joints.

Link to paper
Modified Acoustic Black Hole Profile for Improved Fatigue Performance

Archie Keys\textsuperscript{1}, Jordan Cheer\textsuperscript{1}
\textsuperscript{1}University Of Southampton, Southampton, United Kingdom

Acoustic black holes (ABHs) are realised via modifications to a structure that effectively reduce the structural wave speed, which increases the effect of damping treatments and thus enhances the achievable vibration attenuation. ABHs are commonly designed using a tapering thickness profile and this leads to part of the ABH being very thin. Due to the focusing effect of the ABH, the thin section of the taper is also exposed to high amplitude vibrations and this raises concerns relating the vibration fatigue of the structure. This paper investigates the fatigue life of an ABH taper used to terminate a beam using a numerical model, before a modified taper profile is proposed that aims to reduce the fatigue, while maintaining ABH performance. The effect of the power law used in the taper profile on the fatigue life is investigated and the potential trade-off between performance and fatigue life is explored for both the unmodified and modified profiles.

[Link to paper]
Impact of road traffic noise on annoyance and preventable mortality in European cities: a health impact assessment.

Sasha Khomenko¹²³, Marta Cirach¹²³, Jose Barrera-Gómez¹²³, MPH Evelise Pereira-Barboza¹²³, MPH Tamara Lungman¹²³, Natalie Mueller¹²³, Maria Foraster¹²³⁴, Cathryn Tonne¹²³, Meelan Thondoo¹²³, Calvin Jephcote⁵, John Gulliver⁵, James Woodcock¹⁶, Mark Nieuwenhuijsen¹²³

¹Barcelona Institute For Global Health (ISGlobal), Barcelona, Spain, ²Department of Experimental and Health Sciences, Universitat Pompeu Fabra (UPF), Barcelona, Spain, ³CIBER Epidemiología y Salud Pública (CIBERESP), Madrid, Spain, ⁴PHAGEX Research Group, Blanquerna School of Health Science, Universitat Ramon Llull (URL), Barcelona, Spain, ⁵Centre for Environmental Health and Sustainability (CEHS), University of Leicester, Leicester, United Kingdom, ⁶MRC Epidemiology unit, University of Cambridge School of Clinical Medicine, Cambridge, United Kingdom

Road traffic noise is one of the main environmental risks to health and wellbeing. We aimed to provide an in-depth assessment of available road traffic noise data and to estimate population exposure and health impacts for cities in Europe. We analyzed 724 cities and 25 greater cities in 25 European countries. We retrieved road traffic strategic noise maps delivered under the Environmental Noise Directive (END) or available from local sources. We assessed noise exposure using the 24h day-evening-night noise level indicator (Lden) starting at exposure levels of 55 dB Lden for the adult population aged 20 and over and estimated the health impacts of compliance with the World Health Organization (WHO) recommendation of 53 dB Lden. Two primary health outcomes were assessed: high noise annoyance and Ischemic Heart Disease (IHD), using mortality from IHD causes as indicator. Almost 60 million adults were exposed to road traffic noise levels above 55 dB Lden, 11 million adults were highly annoyed and more than 3600 deaths from IHD could be prevented annually. A considerable number of adults are exposed to road traffic noise levels harmful for health. Efforts to standardize the strategic noise maps and to increase data availability at the city level are needed to provide a more accurate and comprehensive assessment of the health impacts of road traffic noise.
Clustering the residential noise in apartment house based on spectral and temporal analysis

Jeonghun Kim\textsuperscript{1}, Songmi Lee\textsuperscript{1}, Suhong Kim\textsuperscript{1}, Eunsung Song\textsuperscript{1}, Dokyeong Kim\textsuperscript{1}, Chunwon Eom\textsuperscript{1}, Jongkwan Ryu\textsuperscript{1}
\textsuperscript{1}Chonnam National University, Gwangju, South Korea

This study aimed to investigate how the residential noises cluster based on spectral and temporal characteristics of the noises in apartment houses. The type of noise was floor impact, air-borne, plumbing, transmitted outdoor unit of air-conditioner, traffic (road, rail, and air-craft noise), and construction noise. Duration of sound was edited to 5 s and sound pressure level was adjusted to be equal to be 50 dBA. K-means clustering analysis was performed to classify various sound sources, and the elbow method was used to confirm the number of clusters. As a result, residential noise sources were classified into twelves clusters according to spectral and temporal characteristics and difference in psychoacoustic parameters between clusters was also found. In addition, perceptual aspect of each cluster was investigated through semantic differential test.

[Link to paper]
Sound fields characteristics of a box-type CLT building for heavy-weight impact sources

Yong Hee Kim¹, Dae-gwan Won¹, Gyu-in Oh¹, Bon-su Koo¹, Jang-won Lee¹, Sejong Kim²
¹Y'sU Youngsan University, Junamro 288, Yangsan, South Korea, ²National Institute of Forest Science, 57 Hoegiro, Dongdaemun-gu, South Korea

This study investigated the effects of interior finishing materials on sound fields characteristics of a box-type CLT building to minimize room responses for heavy-weight impact sources. According to the requirements on ISO 10140-5, the sound fields should have reverberation time (RT) range between 1 s to 2 s with minimized deviation. Therefore, grid-type sound absorbers, reflectors and diffusers with size of 0.6 m by 0.6 m were designed and applied to the box-type building. The building has a volume of 53.8 m³, and RT of the current condition with no absorbers or diffusers was 2.56 s at 63 Hz, 1.26 s at 4 kHz. The experiments were carried out with various combination of absorbers and diffusers on lateral walls. As results, it was derived at the case of 44 reflectors with additional 4 bass traps as the optimum sound fields condition. In addition, sound fields variation as functions of interior finishing materials was discussed for driving heavy-weight impact sources such as bang machine.
Methods of Mode Generation Inside Hollow Core Photonic Crystal Fibers

Peter Seigo Kincaid¹, Alessandro Porcelli¹, Ennio Arimondo¹,², Antonio Alvaro Ranha Neves⁴, Andrea Camposeo³, Dario Pisignano¹,³, Donatella Ciampini¹,²

¹Dipartimento di Fisica “E. Fermi”, Università di Pisa, Pisa, Italy, ²INO-CNR, Pisa, Italy, ³NEST, Istituto Nanoscienze-CNR and Scuola Normale Superiore, Pisa, Italy, ⁴Universidade Federal do ABC, Santo André, Brazil

Microspheres trapped inside Hollow Core Photonic Crystal Fibers (HCPCF) could provide a way to monitor the temperature in hydrogen combustors, thereby helping to provide a warning system for flashback and thermoacoustic oscillations that can lead to expensive combustor damage. The temperature of a particle trapped in a HCPCF may be extracted by the analysis of the particles’ motion, which can be in turn controlled by opportune manipulation of the spatial intensity profile of the light in HCPCF. To this aim, an intermodal beating intensity pattern may be created inside the HCPCF using a mixture of LP01 and LP11 modes. In this work, methods of generating the optical modes, which involve the use of spatial light shaping techniques, are presented and analysed. This is an important step to producing a controllable intermodal beating pattern.

Link to paper
A review of a proposed noise quota system for Dublin Airport

Eoin King

NUI Galway, Galway, Ireland

In 2007, the airport authority for Dublin Airport (DAA) was granted planning permission to build a new runway. This permission included several planning conditions, including operating restrictions during the night-time due to noise considerations. The plans were then put on hold due to the economic downturn, but in 2016, with increasing passenger numbers, the plans were revived. In the intervening years, the planning and legislative environment related to aircraft noise changed in Ireland, particularly with the implementation of Regulation 598/2014 and the establishment of the Aircraft Noise Competent Authority (ANCA). Then, in December 2020 the DAA submitted a planning application to the Planning Authority seeking to amend those 2007 conditions associated with night-time operating restrictions. The application was referred to ANCA for an assessment of the associated noise impact, and in November 2021 they issued a draft regulatory decision report. This report proposes a number of mitigation measures for Dublin airport, including the introduction of a noise quota system. This paper reviews the proposed noise quota system.

Link to paper
Advancements in autonomous detection of high noise emitters in road traffic

Nikolas Kirchhoff¹, Maximilian Ertsey-Bayer¹, Manuel Männel¹
²Müller-BBM GmbH, 82152 Planegg, Deutschland

Noise pollution is an increasing problem in densely populated areas with high traffic flow. The NEMO project (Noise and Emissions Monitoring https://nemo-cities.eu/) is funded by the EU to develop a system that is capable of detecting high emitters in terms of noise and air pollutants to prosecute vehicle owners. To this end, a fully autonomous noise measurement system was developed and tested on several test locations, both unsupervised and supervised.

This paper describes the advancements in autonomous measuring of traffic noise and specifically addresses the problem of reliable noise source detection in dense traffic streams. While the correct localization of the source is of great importance, it is not yet enough to measure the correct sound pressure level. We therefore propose a method to estimate the influence of nearby noise sources, i.e. closely driving additional vehicles, that disturb the sound signal of the vehicle of interest and correct for it. This algorithm has been applied on several test locations. Using these insights, we will discuss the benefits and possibility of the integration of such a system in the near future.

Link to paper

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Study on sound source localization inside a structure using a domain transfer model for real-world adaption of a trained model

Shunsuke Kita¹,², Yoshinobu Kajikawa²
¹Osaka Research Institute Of Industrial Science And Technology, Izumi, Japan, ²Kansai University, Suita, Japan

Sound source localization (SSL) is important to reduce noise of products such as machinery and electrical appliances. Currently, SSL methods have been proposed that use the correlation of time-frequency signals of sound waves observed by multiple microphones. However, the application of these SSL methods are limited to the case where the acoustic signals can be directly observed. In the case of estimating the location of a sound source inside a structure from outside the structure, these methods are not applicable because the acoustic signal is observed as indirect sound.

An SSL method using deep neural network (DNN) and computer-aided engineering (CAE) was proposed to estimate sound sources inside structures. This method successfully estimates the location of sound sources inside a structure from signals observed by accelerometers installed on the outer surface of the structure in both CAE and real domains. Nevertheless, the proposed method still has the challenge of adapting DNNs trained in CAE domain to real domain.

In this research, deep convolution auto-encoder (DCAE) was used as a domain transformation model built from CAE and actual experimental data. DCAE contributed to the improvement of the SSL performance of the trained DNN over the baseline.
Numerical study of sonic boom propagation through atmospheric turbulence using open data of weather research and forecasting

Shinya Koganezawa¹, Yusuke Naka¹, Hiroaki Ishikawa¹, Ryo Shimada²

¹Japan Aerospace Exploration Agency, Mitaka, Japan, ²ASIRI Inc., Chiyoda, Japan

Sonic boom noise is a major issue to be addressed for the realization of supersonic transport, and has therefore attracted considerable attention among stakeholders as well as researchers. In particular, the deformation of waveforms and changes in noise levels due to atmospheric turbulence have been studied from the viewpoint of assessing annoyance and certification standards. Atmospheric turbulence conditions vary depending on the environmental factors (e.g. region, season, time), and it is essentially a chaotic phenomenon; therefore, statistical evaluation is necessary to understand its effect. Although many studies on the effects of atmospheric turbulence on sonic booms have been conducted, few studies have investigated realistic trends of atmospheric turbulence. In this study, numerical analysis of sonic boom propagation considering atmospheric turbulence is performed for C609, an early type of NASA’s X-59 Low-Boom Flight Demonstrator. The model equation for propagation is heterogeneous one-way approximation for the resolution of diffraction (HOWARD) and the Wilson and Ostashev model is chosen to define the atmospheric turbulence spectra. The parameters characterizing the atmospheric turbulence are set based on publicly available datasets of weather research and forecasting simulation. The sonic boom waveforms obtained by the numerical simulations and their noise level variations are statistically processed and evaluated.

[Link to paper]
Intrinsic thermo-acoustic instability criteria based on frequency response of flame transfer function

Mohammad Kojourimanesh\textsuperscript{1}, Viktor Kornilov\textsuperscript{1}, Ines Lopez Arteaga\textsuperscript{1,2}, Philip de Goey\textsuperscript{1}

\textsuperscript{1}Eindhoven University of Technology, Netherlands, \textsuperscript{2}KTH Royal Institute of Technology, Sweden

The study of Intrinsic Thermo-Acoustic (ITA) instability behavior of flames anchored to a burner deck is performed by introducing a mapping between the Flame Transfer Function, FTF(s), defined in the complex (Laplace) domain and experimentally measured frequency response, FTF(\textit{i}\omega). The conventional approach requires a system identification procedure to obtain the FTF(s) from the FTF(\textit{i}\omega); next, root-finding techniques are applied to define the complex eigenfrequencies. The purpose of the present work is to establish instability criteria which are directly applicable in the frequency domain. The particular case is considered when the acoustic boundary conditions at both sides of the flame are anechoic. At first place, the causality of the measured FTF(\textit{i}\omega) is checked. Then, the criteria of the ITA mode instability applicable to the FTF(\textit{i}\omega) phase and magnitude, are derived. Cauchy’s theorem and the path-independence Lemma are used to find the scaling factor of the mapping which allows to determine bounds of the unstable frequency and the maximum value of the linear growth rate. The proposed method is applied to study the behavior of burners with premixed burner-stabilized Bunsen-type flames. The comparison of the measured oscillation frequencies and the growth rates of observed unstable oscillations with that obtained from the derived bounds reveal good correspondence.

\textbf{Link to paper}
Leq levels of yelling audience at live shows

Marcel Kok¹, Adam Hill, Jon Burton, Jos Mulder
²dBcontrol, De Corantijn 27-J Zwaag, Netherlands

The ‘audience verbal appreciation’ for a worldwide known artist can raise the decibel levels during a show. This can lead to limit violations if there is a decibel limit for the show. In this publication the effect of a yelling audience, known by almost all sound engineers, will be described.

The research was done at 18 large live shows in Belgium and the Netherlands in the years 2015..2019. The measurement setup was a single channel measurement with a class 1 sound level meter at FOH. The data was stored as LAeq,1sec and LCeq,1sec and also the 1/3 octave band information per second was logged.

The outcome gives more information about the frequencies of yelling, but more important the effect on the decibel level of the total show.

Besides measuring at FOH (front-of-house) position, two alternative measurement methods are discussed (2-channel setup and multiple measurement points in the hall).

Link to paper
Enhancing the Dutch engineering calculation method.

Arnaud Kok¹

¹National Institute For Public Health And The Environment, Bilthoven, Netherlands

With the advent of new legislation, we have taken the opportunity to take a serious look at the Dutch national calculation method. This method, which is similar to ISO9613-2, needed enhancements to allow for the increasingly complex world outside. Objects like leaning barriers or diffracting elements on barriers are seen more and more. The 3D datasets that are available for noise models are much more complex compared to the time, many years ago, when these calculation methods were conceived.

To allow for these situations we have enhanced our method. Reflections can now occur in 3D. This allows for leaning barriers. We take the size of objects into account to determine the fraction of noise reflected. Based on the CNOSSOS implementation a direction dependent meteorological correction is now used. Methods to account for diffracting elements in the ground and on barriers have been developed. The result is a method which is more robust. Many of these enhancements could also be used in other methods like CNOSSOS or other engineering calculation methods.

In this presentation I will show you how these enhancements have improved our method and can be used to produce better noise maps and calculate more accurate noise levels.
Towards the placement of actuators and sensors for an active control of structure-borne sound in a stiffened rectangular plate

Alexander Kokott¹, Hans Peter Monner
²German Aerospace Center, Braunschweig, Germany

The active control of structure-borne sound proposes an alternative approach towards the global reduction of vibration and noise. By actively reducing or blocking the energy flow from upstream noise sources, e.g. engines or APUs of an aircraft, inside a structure, acoustically relevant downstream section of a system, e.g. the passenger cabin, may be attenuated.

This work deals with a numerical analysis towards the placement of actuators and sensors on a simple stiffened structure in order to achieve a reduction in energy flow, continuing recent research on the topic for simpler plates, where advantages of the approach could be shown already. A set of virtual error sensors is used to measure the components of structural intensity on either the shell or stiffening elements. A feed-forward control is used to drive pairs of control forces to minimize those components and, hence, overall energy transmission.

It can be shown that an inclusion of internal forces can achieve a greater global reduction in vibration compared to a simple velocity control also for a stiffened plate. By using structural intensity or its components, a greater reduction of downstream vibration can be achieved using a less dense array of sensors respective to the sound wavelength.
Control and broadening of multiple noise frequencies using an assembly of sub-metamaterials connected by membranes for aircraft noise mitigation.

Tenon Charly Kone, Sebastian Ghinet, Pr. Raymond Panneton, Zacharie Laly, Pr. Christopher Mechefske, Anant Grewal

1National Research Council Canada, Flight Research Laboratory, 1200 Montreal Road, Ottawa, On, K1A 0R6, Canada

Simultaneously attenuation of multitonal and broadband noise at low frequencies is a challenge for the aerospace, ground transportation and building industries. The technologies proposed in the literature, using layered porous materials with embedded Helmholtz resonators (HR) with a structured neck, exhibited considerable potential when tuned at tonal, multi-tonal or narrow frequency bands. However, the resonance frequencies due to the structured necks of metamaterial are narrow. Our recent investigations have shown that parallel arrangements of several structured metamaterials separated by membranes can broaden the resonance frequencies and increase the number of resonance frequencies to be controlled. This paper presents a parallel assembly of four structured sub-metamaterials separated by membranes. Each of these sub-metamaterials is also a serial assembly of a periodic unit cell (PUC) with a half-neck + cavity + half-neck configuration. The metamaterial is embedded in a layer of glass wool. Coupled fluid-structure numerical calculations in the frequency domain were used to predict the sound absorption coefficient of the metamaterial. The results obtained show a broadening of the absorption peaks and the appearance of additional frequencies due to the membranes.

Link to paper
Subwoofer array design for optimal performance and minimal noise pollution in the Roman theatre of Italica, Spain

Claus Köpplin Orrán¹, Luis Gomez-Agustina¹, Alvaro Grilo Bensusan²

¹London South Bank University, London, United Kingdom, ²NERCO Acústica S.L., Seville, Spain

Subwoofer arrays are widely used in live sound events. However, the performance of sound systems and the generated environmental noise pollution in the vicinity of Roman theatres is not well researched and documented. The investigation aimed to determine the most suitable subwoofer array configuration for an outdoor Roman theatre according to their low frequency coverage across the audience area and overspill on nearby residential areas. Performance suitability was determined by measuring the overall sound pressure (dBA) and spectrum levels of the arrays within the audience area at several locations representative of nearby residential areas. The Array Performance Rating (APR) was calculated for each array configuration to complement performance assessments. Results showed a notorious difference between coupled and uncoupled arrays, as well as between ground-based and flown subwoofer configurations. It was proven that the flown point source array offered overall less sound pressure levels and spectral variability in the audience plane and it caused the least environmental noise pollution. The conclusions drawn from this study can provide valuable guidance applicable to future sound system deployments and reconstruction projects of ancient outdoor theatres of similar architectural and environmental characteristics.
Results from The Quiet Project - UK Acoustic Community's response to Covid-19

Henry Kowalik¹, Stephen Dance¹, Lindsay McInyre²

¹London South Bank University, London, United Kingdom

The COVID-19 Lockdown created a new kind of environment both in the UK and globally, never experienced before or likely to occur again. A vital and time-critical working group was formed with the aim of gathering crowd-source high quality baseline noise levels and other supporting information across the UK during the lockdown and subsequent recovery period. The acoustic community were mobilised through existing networks (UK Acoustics Network, Association of Noise Consultants, and Institute of Acoustics) engaging private companies, public organisations, and academics to gather data in accessible places. A website was designed and developed to advertise the project, provide instructions and to formalise the uploading of noise data, observations, and Soundscape feedback. The data was collected at 99 locations by 80 acousticians (64 male, 16 female) using professional grade calibrated instrumentation with 83% of measurements including spectral data. The locations were spread across the British Isles covering 19 urban, 61 suburban, and 19 rural sites. The Lockdown 1 dataset consisted of a total of 1.6 GB of measurements and material (video, photos) covering 834 days between 1st April and 14th July 2020. This makes the award winning Quiet Project the largest ever noise and soundscape database ever recorded. As a government-funded research project the databank will be made publicly available to assist future research.

[Link to paper]
The dependence of transformer sound power measurement accuracy on microphone configurations in the anechoic chamber.

Michał Kozupa¹, Filip Kamiński¹, Robert Baranski², Tadeusz Wszolek², Paweł Pawlik²
¹Hitachi Energy Research, Krakow, Poland, ²AGH University of Science and Technology, Krakow, Poland

The paper is aimed at investigating the number and location of microphones required to accurately calculate the sound power level of a harmonic noise source. The measurement procedure performed is based on the IEC standard for the determination of transformer sound power level. The current procedure defines numerous measurement points around the tested transformer. Reducing the number of measurement points could significantly speed up the measurement procedure when a transformer is tested during the manufacturing process. Within the research work, estimations on the number and location of measurement points are identified to accurately calculate sound power level. The approach is tested and validated using specially developed software in LabView, that allows inclusion or exclusion of measurement points from the sound power level calculations. To prevent harmonic wave interference, acoustic wave reflections and background noise, the measurement procedure took place in the anechoic chamber.

Link to paper
Acoustic behaviour of CLT structures: influence of decoupling bearing stripes, floor assembly and connectors under storey-like loads

Anton Kraler¹, Paola Brugnara²

¹University Of Innsbruck, Technikerstraße 13, 6020 Innsbruck, Austria, ²Rotho Blaas srl, Via Dell'Adige 2/1, 39040 Cortaccia, Italy

Timber buildings do not have a high acoustic performance regarding vibration transmission through the structure. Sophisticated acoustic design methods are usually not applied and noise control design for wooden buildings is often merely based on the experience of engineers. To find out the peculiarity of timber transmission, an acoustic lab test with CLT was set up. Several measurement configurations were built and airborne sound measurements according to EN ISO 16283-1 and impact sound measurements according to EN ISO 16283-2 were carried out. The test results were set in relation to reference measurements on the bare CLT slab and on a floor assembly, with and without decoupling bearing stripes and with and without connectors. In addition to the standard sound measurements, the sound transmissions through the ceiling element and through the flank components (walls) were also measured with accelerometers. The results showed in an experimental evaluation method a reduction in sound transmission and standard impact sound level. All tests were carried out with the same load of 17 kN/m on the decoupling bearing stripes and the ceiling element. The load was applied by means of threaded rods and secured by strain gauges. The influence of decoupling bearings stripes, types of fastening systems and floor structures on sound transmission through the flanking components on a real scale mock-up could therefore be investigated.
Development of low-cost noise monitoring terminals (nmt) based on mems microphones

Jacek Kuczyński

SVANTEK SP. Z O.O., Strzygłowska 81, Poland

The article shows and discusses examples of Noise Monitoring Terminals (NMT) with MEMS microphones meeting class 1 and class 2 in accordance with the IEC 61672-1.

The rapid development of MEMS microphones (Micro Electro-Mechanical Systems) in last decade years made it possible to use them in noise measurement instrumentation meeting the IEC 61672-1 specifications. Fifteen years ago, the available MEMS microphones offered only the 60 dB dynamic range, whereas modern MEMS microphones offer 100 dB dynamics! Such a wide dynamic range of MEMS microphones, along with their improved repeatability and a long-term stability, enabled the development of the low-cost noise monitoring terminals for noise monitoring. In particular one of such NMTs (SVANTEK SV 307) offers the measurement range of 25dBA Leq÷128 dBA Peak which proves to be optimal for urban noise monitoring applications. Even more hardware development possibilities are offered by implementation of fully digital MEMS microphones that are offered for the cost below 5 Euro. Such a low microphone cost enables the development of innovating designs for low-cost noise monitoring terminals with features such as a multi-microphones arrangement for a dynamic system check.
Reproduction of acoustic evanescent waves using wave field synthesis by controlling phase differences between monopole secondary sources

Akash Kumar\textsuperscript{1}, Amrita Puri\textsuperscript{1}
\textsuperscript{2}Department of Mechanical Engineering, Indian Institute of Technology Jodhpur, Jodhpur, India

This paper is about the reproduction of acoustic evanescent waves using the linear distribution of discrete monopole secondary sources. The driving function for the actuation of a secondary source is derived using the theory of wave field synthesis. The analysis of the synthesized wave field is done for different source excitation frequencies. A new method of creating more precise evanescent waves based on the phase difference between the sources is also presented. The simulation result shows that the driving function obtained using the WFS method results in the correct synthesis of evanescent wave below aliasing frequency. Above the aliasing frequency, when the consecutive secondary sources are in antiphase, it will produce evanescent waves. Otherwise, propagating plane waves get produced. Different errors in the reproduced wave field which comes due to the use of discrete and fixed array length are also investigated, and some solutions to mitigate those errors are presented.

Link to paper
A study of different tapering windowing functions and referencing curve for the improvement of sound field using wave-field synthesis

Amrita Puri¹, Akash Kumar¹
¹Department of Mechanical Engineering, Indian Institute of Technology Jodhpur, Jodhpur, India

Wavefield synthesis is a well-known sound field reproduction technique. The correct synthesis of the desired sound field ideally requires a continuous source distribution over an enclosed surface. Due to practical limitations, a finite length of secondary source array is used. This results in distortion in the reproduced sound field due to the diffraction effect from the edge loudspeakers. To alleviate this problem, tapering window functions are utilized. In this paper, the influence of various windowing functions on the reproduced fields for different secondary source geometry and virtual source type is studied, and different parameters are used to make a quantitative comparison between the performance of different windowing functions. Further, the effect of the different referencing curves for the synthesis of correct amplitude is also presented. From the simulation results, it was found that the Tukey window function provides a wider sweet spot area with a minimal amplitude ringing effect. The selection of a proper referencing curve depends on the array geometry and the type of virtual source.

[Link to paper]
Experimental and numerical investigations of rain fall induced noise from roofing sheets

Akarsh S1, Akshay C C1, Abhinav K V1, Abhilash P1, Sudheesh Kumar C P1

1Government College of Engineering Kannur, Kannur, India

Rainfall creates noise as it strikes roofing sheets and most of the time it causes a lot of disturbances and distractions to the occupants. Wide variety of roofing sheets with different materials, thicknesses, profiles and other specifications are available in the market now. Metallic roofing sheets provide high durability, long life, and greater protection with good reliability and value for money. Their effective life expected is about 40-70 yrs. They are free from cracks and pest attacks and can withstand in rain, snow, winds etc. However, they have a major drawback of generating large noise during rainfall. But, one can be control the noise to a great extent by wise and effective selection and installation of roofing sheets. The main aim of the present work is to study the effects of various parameters on rainfall induced noise from roofing sheets. The parameters considered are material, profile, thickness and angle in which the sheets are placed. Both experiment and numerical simulations (using COMSOL software) are carried out. Results obtained from the present work can greatly help the manufactures to adopt methods to make modifications in the existing sheets so as to cause minimum rainfall induced noise.

Link to paper
Spatial audio for interactive hearing research

Matthieu Kuntz¹, Bernhard U. Seeber¹
¹Audio Information Processing, Technical University Of Munich, Arcisstrasse 21, 80333 München, Germany

The use of sound field synthesis for hearing research has gained popularity due to the ability to auralize a wide range of sound scenes in a controlled and reproducible way. We are interested in reproducing acoustic environments for interactive hearing research, allowing participants to move freely over an extended area in the reproduced sound field. While the physically accurate sound field reproduction using sound field synthesis is limited to the sweet spot, it is unclear how different perceptual measures vary across the reproduction area and how suitable sound field synthesis is to evaluate them. To investigate the viability of listening experiments and provide a database for modelling approaches, measurements of binaural cues were carried out in the Simulated Open Field Environment loudspeaker array. Results show that the binaural cues are reproduced well close to the center, but exhibit more variance than in the corresponding free field case. Off center, lower interaural coherence is observed, which can affect binaural unmasking and speech intelligibility. In this work, we study binaural cues and speech reception thresholds over a wide area in the loudspeaker array to investigate the feasibility of psychoacoustic experiments involving speech understanding.

Link to paper
Interaction between annoyance, indoor noise levels and acoustic classification of buildings

Selma Kurra, Ayca Sentop

Istanbul Technical University (rtd), consultant To Dbkes Engineering., Krizantem Sk No 70 Levent Istanbul 34330, Turkey

Assessment of annoyance “at home” from environmental noises has been widely investigated so far and the ISO/TS 15666:2021 was developed to lead the socio-acoustic surveys. On the other hand, the rating of buildings’ acoustical performance considering also the indoor noises, has been also well concerned in building acoustics and the studies have ended up with the ISO/TS 19488:2021 covering the acoustic classification system for buildings. Basically the rating system needs to be supported by the subjective tests in the field or in laboratories, to acquire data about the annoyance/disturbance or satisfaction of residents. If the target is to design the healthy, comfortable and sustainable acoustical environment, both technical standards might be harmonized in the future. In this paper, based on the dose/response relationships with respect to the indoor noise levels, an approach is proposed to translate the acoustic classes proposed in ISO/TS 19488, into the annoyance boundaries in terms of different scales (verbal/numerical and the HA%) referred in ISO/TS 15666. The results from the previous laboratory and field studies conducted by the authors, have been used for verification of this approach.
Aeroacoustic shape optimization using adjoint sensitivity analysis based on lattice Boltzmann method for bluff bodies

Kazuya Kusano

Kyushu University, Fukuoka, Japan

The present study developed a shape optimization method using adjoint sensitivity analysis based on lattice Boltzmann method to suppress aerodynamically sound generation around bluff bodies. In this method, flow and acoustic fields are directly simulated using the lattice Boltzmann equation (LBE) with an athermal model under low-Mach-number conditions. The sensitivities of far-field sounds to numerous design variables that define an object shape can be evaluated by solving the adjoint equation, which is derived from the LBE. The adjoint equation can be computed easily and efficiently, similar to the LBM. The proposed method was applied to the cylinder Aeolian tone, and the cylinder shape was optimized.

Link to paper
Modal Decomposition Analysis of Bluff-Body Stabilized Lean Premixed CH4/H2/air Flames Based on LES Data

Halit Kutkan¹, Alberto Amato², Giovanni Campa², Luis Tay-Wo-Chong³

¹University Of Genoa, Genoa, Italy, ²Ansaldo Energia S.p.A, Genoa, Italy, ³Ansaldo Energia Switzerland AG, Baden, Switzerland

Unsteady flow and flame dynamics of bluff body stabilized CH4/H2/air premixed flames are investigated numerically with LES and modal decomposition techniques. Energy ranked and frequency dependent modes are identified with proper orthogonal (POD), spectral proper orthogonal (SPOD) and dynamic mode decompositions (DMD). Flow and flame coherent structures are extracted based on the axial velocity and heat release rate contours. Two cases, namely 100% CH4/air (V-flame) and 43.4% CH4 + 56.6% H2/air (M-flame), are selected for the analysis. Each case is acoustically excited in large eddy simulation (LES) with harmonic excitation signals at distinct frequencies and with a broadband excitation signal, to produce snapshots for modal decomposition analysis. In POD, the frequencies of the relevant modes are extracted with the discrete Fourier transform (DFT) of time coefficients, while in SPOD and DMD the extracted modes are frequency dependent by nature. Results are compared and commented.

Link to paper
Modeling, analysis, and control of shaft transverse vibration from rotating systems through active bearing concept

Junhee Kwon¹, Dongwoo Hong¹, Byeongil Kim¹

¹Yeungnam University, 280 Daehak-Ro, Gyeongsan, Gyeongbuk 38541, South Korea

Rotating parts are widely applied to mechanical systems such as pumped-storage hydroelectricity, nuclear power plant, machining tools and so on. While operating, they can be easily damaged or destroyed by unbalanced mass, bending, torsion and misalignment. In order to solve this problem, rotor vibration control can be conducted through active bearing concept. In this work, active bearing system which consists of piezo actuators and rubber grommets is proposed and applied to a rotating system motivated from a pumped-storage hydroelectricity, for performing active vibration control. The main point of this paper is to prevent damage or failure caused by harsh transverse vibration through active bearings. First, the rotating system is modeled by transfer matrix method (TMM) based on Euler-Bernoulli beam theory and in order to check accuracy of this model, the responses of TMM are compared with the responses from the finite element method (FEM). For implementing active control in real time, normalized least mean square (NLMS) algorithm is utilized. The results show that the proposed active bearing concept shows great performance on the attenuation of shaft transverse vibration.
Association between hearing threshold and low-frequency walking sounds on concrete floors

Mikko Kylliäinen¹, Jesse Lietzén¹
²Tampere University, Tampere, Finland

The sufficient frequency range to be measured for the rating of impact sound insulation of floors has been a relevant research question since the 1960's when the lower limit of the measured frequency range was set at 100 Hz. It has been long recognized that walking sounds at frequencies lower than 100 Hz might have a significant effect on the experienced impact sound insulation of floors. Recently, it has been suggested that the frequency range to be measured for the rating of impact sound insulation should be enlarged down to 20 Hz. This suggestion is based on studies concerning wooden buildings. It is not known whether such low-frequency walking sounds are generated by walking on concrete floors. The purpose of this preliminary study was to produce sound spectra of several living impact sound sources. The spectra of different sound sources were measured in a laboratory. The results show that, in the case of concrete floors, such low-frequency living sound spectra that would exceed the hearing threshold do not exist, or they are at least uncommon.
Robust estimation of open aperture active control systems using virtual sensing

Chung Kwan Lai¹, Chung Kwan Lai¹, Jing Sheng Tey¹, Dongyuan Shi¹, Woon-Seng Gan¹
¹School of Electrical and Electronic Engineering, Nanyang Technological University, Singapore, Singapore

For active noise control systems in an open aperture application, virtual sensing system is often needed to overcome design constraint in terms of microphone placement. The virtual sensing system, however, make assumptions to the acoustical field and thus is highly sensitive to any changes in the primary field. Taking the window aperture ANC application for example, incoming disturbance signals could impinge from multiple locations, altering the spatial correlation between the physical and virtual microphones. For instance, in the context of a high-rise apartment window, aircraft noise would propagate downwards from the sky, whereas traffic noise propagate upward from the ground. This paper considers the estimation performance of the remote microphone technique, an example of a virtual sensing method, in an open aperture application when faced with changes in the primary noise source. Additionally, this paper introduces a new method for estimating the spectral density due to multiple sources through the incoherent decomposition method. It has been shown experimentally that this algorithm is able to improve the nearfield estimation of the system.
Numerical design of Helmholtz resonators with multiple necks for multi-tonal noise control

Zacharie Laly¹,², Christopher Mechefske², Sebastian Ghinet³, Charly T. Kone³, Noureddine Atalla¹

¹CRASH, Centre de Recherche Acoustique-Signal-Humain, Université de Sherbrooke, 2500 Boulevard de l'Université, Sherbrooke, J1K 2R1, Canada, ²Department of Mechanical and Materials Engineering, Queen's University, Kingston, K7L 3N6, Canada, ³National Research Council Canada, Aerospace, 1200 Montreal Road, Ottawa, K1A 0R6, Canada

The reduction of multi-tonal noise at multiple frequencies simultaneously is a challenge in many industrial fields. Different solutions such as metamaterials consisting of periodic Helmholtz resonators embedded into a porous layer have been studied in the literature. Generally, a classical resonator made of a cavity connected to a neck provides only one resonant transmission loss peak. In this study, a design of acoustic metamaterials is proposed numerically using the finite element method for multi-tonal noise reduction. The resonator is made of multiple necks extended into the cavity and is periodically distributed within a porous material. The cylindrical global cavity of the resonator is partitioned into several sub-cavities, which are separated from one another by a rigid wall, and each sub-cavity is connected to one neck. Helmholtz resonators with 2, 3, 4, and 5 necks are presented, they exhibit multiple resonance transmission loss peaks which correspond respectively to the number of the resonator necks. The proposed acoustic metamaterial designs can be used to reduce multi-tonal noise at several frequencies simultaneously.
Modelling of acoustic metamaterial sound insulator using a transfer matrix method for aircraft cabin applications

Zacharie Laly¹,², Christopher Mechefske², Sebastian Ghinet³, Charly T. Kone³, Noureddine Atalla¹

¹CRASH, Centre de Recherche Acoustique-Signal-Humain, Université de Sherbrooke, 2500 Boulevard de l'Université, Sherbrooke, J1K 2R1, Canada, ²Department of Mechanical and Materials Engineering, Queen's University, Kingston, K7L 3N6, Canada, ³National Research Council Canada, Aerospace, 1200 Montreal Road, Ottawa, K1A 0R6, Canada

The incorporation of acoustic metamaterials in the design of aircraft fuselage panels in order to reduce the low frequency noise inside the cabin is nowadays a major research subject in order to offer passengers a comfortable cabin environment. In this study, acoustic metamaterial made of Helmholtz resonators periodically embedded into a porous material is investigated using a transfer matrix approach combined with finite element calculations. This transfer matrix method is based on the two-load methods where the two loads in the numerical simulations are two different termination conditions (plane wave radiation and rigid wall) in order to retrieve the equivalent transfer matrix of the porous layer with embedded periodic Helmholtz resonators. The equivalent matrix is then coupled analytically in series with others analytical matrices to model complex multilayer metamaterials. The results of the transmission loss obtained exclusively using finite element method for single and double wall configurations are compared with the results of the proposed transfer matrix method and good agreements are obtained. It is observed that the frequency band of the transmission loss of the double wall configuration is larger than the one of the single wall configuration with higher transmission loss peak value. The investigated metamaterial can potentially be used in the design of aircraft cabin panels for low frequency noise reduction.

Link to paper
Numerical modelling of acoustic metamaterial made of periodic Helmholtz resonator containing a damping material in the cavity

Zacharie Laly\textsuperscript{1,2}, Christopher Mechefske\textsuperscript{2}, Sebastian Ghinet\textsuperscript{3}, Charly T. Kone\textsuperscript{3}, Noureddine Atalla\textsuperscript{1}

\textsuperscript{1}CRASH, Centre de Recherche Acoustique-Signal-Humain, Université de Sherbrooke, 2500 Boulevard de l'Université, Sherbrooke, J1K 2R1, Canada, \textsuperscript{2}Department of Mechanical and Materials Engineering, Queen's University, Kingston, Canada, \textsuperscript{3}National Research Council Canada, Aerospace, 1200 Montreal Road, Ottawa, Canada

Acoustic metamaterials are frequently used in many fields such as aerospace, buildings and ground transportation industries for low frequency noise control applications. Different solutions based on membrane or Helmholtz resonators have been investigated in the past few years. In the present study, a numerical design of acoustic metamaterial made of Helmholtz resonator with a membrane in its cavity is presented. The resonator with a neck extended into the cavity is periodically embedded within a porous material. The membrane inside the resonator cavity is modelled as a linear isotropic elastic material with free and fixed boundary conditions. The transmission loss (TL) of the proposed metamaterial design, predicted by finite element method presents multiple resonant peaks while only one peak is obtained with a conventional resonator. Two TL resonance peaks are observed when the membrane circumferential boundary is free inside the resonator cavity. For fixed boundary conditions, more than two resonance peaks are obtained. The proposed metamaterial design can therefore be used in many industrial applications for low frequency noise attenuation.
Ideas for improving diversity and inclusion in acoustics

Angela Lamacraft¹, Susan Witterick¹
¹dBx Acoustics Ltd, Bramley, United Kingdom

Diversity within the acoustic profession in the UK is gradually widening in general, but there is still a significant need for improvement in terms of inclusion, diversity and equality. In order to address this need the UK Institute of Acoustics (IOA) has recently established a working group to examine the current situation within the Institute and within the wider profession in the UK. This paper will provide a summary of the current membership demographics of the IOA to provide a benchmark for improvement. Examples of successful initiatives from other national acoustical societies will be provided and ideas for improving the numbers and experience of underrepresented people in the IOA will be discussed.
A Preliminary Investigation of an Active Membrane-type Acoustic Metamaterial

Felix Langfeldt¹, Jordan Cheer¹
¹University of Southampton, Southampton, United Kingdom

One of the most promising features of membrane-type acoustic metamaterials (MAM) is their anti-resonance at low frequencies, which typically exhibits sound transmission loss values that can significantly exceed the corresponding mass-law values. The bandwidth of this anti-resonance, however, is usually very small, which limits the applicability of MAM in practical noise control problems. In previous research it has been shown that different types of actuators (e.g. magnets, electrodes, or pressurized air) can be used to adjust the anti-resonance frequency of MAM, for example to adapt to changing tonal frequencies. However, these actuation principles require additional components to be added to the otherwise lightweight MAM. To overcome these limitations, this paper will present preliminary results from an experimental study of a smart MAM which has the sensors and actuators compactly embedded within the added mass located at the center of the membrane of the unit cell. A small accelerometer is used to measure the vibration of the added mass and this signal is fed back to a controller, which is used to actuate the MAM using a small electrodynamic exciter. An impedance tube is used to measure the sound transmission through the smart MAM and different control algorithms are compared.

Link to paper
SEA based statistical approaches for the mid and high frequency vibro-acoustic analysis of complex systems

Robin Langley

University Of Cambridge, Cambridge, United Kingdom

This paper will present methods for predicting the statistics of the frequency response functions of complex random vibro-acoustic systems. The statistical properties include the ensemble mean, the ensemble variance, level crossing rates, extreme values, and quefrencies. The approach is based on a combination of statistical energy analysis (SEA), the finite element method, random point process theory, and random matrix theory. In the mid frequency range the finite element method is used to model components that have a low modal density, while other components are modelled as SEA subsystems. The coupling between the finite element components and the SEA subsystems is effected using the diffuse field reciprocity principle, which was developed some years ago. The blocked modes of the SEA subsystems are assumed to have natural frequency statistics that are governed by the Gaussian Orthogonal Ensemble, and this enables the statistical properties of the response to be found without any need for Monte Carlo simulations. The use of SEA leads to a relatively low number of degrees of freedom used in the model, and thus the approach is numerically efficient well suited to the design stage, where many design options may be explored.
Evaluation of the restorative potential of church buildings

Josée Laplace¹,²,³, Catherine Guastavino¹,²,³
¹McGill University, Montreal, Canada, ²Centre for Interdisciplinary Research in Music Media and Technology (CIRMMT), Montreal, Canada, ³Sounds in the City partnership, Montreal, Canada

We report the preliminary results of a study on the experience of soundscape and architectural ambiances of church buildings, with an emphasis on their restorative qualities.

Through questionnaires, soundwalks and interviews with 16 diverse participants, we aim to characterize the sensory qualities of 2 contrasting church buildings in Montreal. Our data collection instruments operationalize concepts at the intersection of different research fields: soundscapes, attention restoration, quiet areas, architectural ambiances and heritage (including religious) places. As such, it encompasses a broad range of descriptors and outcomes.

At a methodological level, we discuss the relative contributions of the different methods used and how they complement one another to provide a better understanding of experiences of church interiors.

At a theoretical level, we report the main findings in term of experiences of space, sound, ambiance and associated benefits. In particular, we discuss the restorative potential of church building(s) and questions raised in relation to the particular context of this field work.

[Link to paper]
Shore power connection for offshore vessels - Measured noise reduction in port and dock

Bernt Mikal Larsen

Multiconsult Norway, Fjellgata 6, 4612 Kristiansand, Norway

The presentation will summarize measured noise reduction for drilling, pipelay and offshore support vessels due to shore power connection. The noise level at office or storage building in distance of 100-250 m from the vessels has been registered continuously through days and nights. Noise levels at nights without and with shore power connection has been compared. A drilling vessel had Lw 110 dB and a noise reduction due to shore power connection of 18 dB. A pipelay vessel had Lw 105 dB without shore power, and a noise reduction of 15 dB due to the effect of shore power. Both drilling and pipelay vessel seem to have Lw of 90-92 dB with shore power connection. Two different offshore support vessels have also been measured with sound power level Lw of 107 dB and 100 dB. The noise reduction with shore power connection is 13 dB for the first and 6-7 dB for the latter. With shore power connection, both offshore support vessels have Lw of 94 dB. The sound power level with shore power connection seems to be limited by the fact that ship noise level from ventilation and fans seems to be the same.
Whole glass facade in office building - Measured noise level and requirement for facade

Bernt Mikal Larsen¹
²Multiconsult Norway, Fjellgata 6, 4612 Kristiansand, Norway

The presentation will summarize calculated and measured noise level from road traffic in office building with whole glass facade. The experience is based on a new office building called Baneheia Park in Kristiansand in Norway. With a whole glass facade with Rw+Ctr 46 dB, both calculated an measured noise level from road traffic was Ld 39-40 dB. In Norway the required noise level in offices is Ld 35 dB from road traffic. If effect of reduced sound isolation due to profile system (4 dB) and effect of correction due to area/dimension (4 dB) were included, the requirement for the facade in the given situation should have been Rw+Ctr 51 dB. With such facade, the indoor noise level of Ld 35 dB would have been achieved. When taking both effect of sound transmission through profile system and correction due to area/dimension into account, the required sound isolation from laboratory should normally be at least 8-10 dB higher than the value achieved for the facade in field.

Link to paper
Description of sound absorption by a flat resonator stacking metamaterial with double porosity model

Daniel Craig Brooke¹, Olga Umnova¹, Philippe Leclaire², Thomas Dupont³

¹University of Salford, Manchester, England, UK, Manchester, England, ²DRIVE EA1859, Univ. Bourgogne Franche Comté, F58000, Nevers France, Nevers, France, ³Ecole de Technologie Supérieure (ETS) – Université du Québec, Montréal, Canada

Acoustic metamaterials can be designed by inserting along the path of a sound wave periodically spaced side resonators. An example of efficient design was recently proposed consisting of a perforated stacking of flat annular cavities (the pancake resonator), the perforation allowing the propagation of sound waves. The pancake resonator is used in absorber mode and the theoretical description of sound absorption can be achieved with the help of the theory of sound propagation in fluid saturated porous media in which two porosities are considered: the main porosity associated with the perforation and a porosity associated with the flat cavity volumes. Considering a perforation diameter and flat cavity thickness ranging from submillimetric values to a few millimeters allows a wide range of material permeabilities and permeability contrasts between main pore and stacking of cavities. The relatively small values of diameter and cavity thickness also results in the existence of viscous and thermal boundary layers in the main pore (the perforation) and in the flat cavities. This metamaterial makes simultaneous use of viscothermal losses and periodicity in order to achieve low frequency sound absorption for an overall small absorber thickness. Experimental results are also presented for the validation of the model.

[Link to paper]
Sound masking depending on spectral and temporal characteristics of residential noise and natural sound

Songmi Lee¹, Chunwon Eom¹, Jeonghun Kim¹, Suhong Kim¹, Eunsung Song¹, Dokyeong Kim¹, Jongkwan Ryu¹

¹Chonnam National University, Gwangju, South Korea

This study aimed to investigate the sound masking according to spectral and temporal characteristics of residential noise and natural sound through auditory experiment. Since there are various types of residential noise sources (maskee) and natural sounds (masker), stimuli to be used for experiment were selected by dividing the sound source groups through the k-means cluster method. The stimuli consisted of a total of 7 maskee including a brown noise, and 7 masker (birdsongs and water sounds). In the auditory experiment, the preference of masker and the annoyance and unpleasantness of single maskee and masker and mixed sources (maskee+masker) were investigated. Result showed that Phoenicurus auroreus and stream-Fast were the highest preference among masker, and masker preference were significantly correlated with masker annoyance. In addition, it was found that impact sound (children jumping and running and piledriver) show relatively higher annoyance than other sound sources. Relative annoyance of mixed sources (maskee+masker) to single maskee was analyzed and masking effect was discussed based on spectral and temporal and the Zwicker’s parameters of each sound source.

Link to paper
Aerodynamic noise due to complex internal flow through cordless vacuum cleaner and suction tower station

Kwongi Lee¹, Cheolung Cheong¹, Kyeonghun Park², Jinman Jang²

¹Pusan National University, Pusan, South Korea, ²LG Electronics, Changwon-si, South Korea

Although the demands and sales of cordless vacuum cleaner are on the rise in the global home appliance markets, consumers face the inconvenience of short battery life and frequent emptying of the dust box. To solve this inconvenience, a station tower that can automatically charge the battery and empty the dust box has been developed. However, aerodynamic noise generated when the station tower sucks dust causes another inconvenience. The purpose of this study is to identify the major aerodynamic noise sources that occur when such a station tower is connected to a wireless vacuum cleaner and operate, and to develop a low-noise design based on this. First, the entire flow path of a cordless vacuum cleaner and a station tower was simulated using the unsteady compressible RANS equations. Then, the main aerodynamic noise sources were identified using the vortex sound sources. From these results, the flow region through the head throat of the cordless vacuum cleaner was identified one of the most significant aerodynamic noise sources. Based on the identified noise source mechanism, new throat design was proposed, and its validity was investigated using a high-resolution Large Eddy Simulation technique. It was found that the strength of vortex sound source of pipe flow through the new head throat was much less than the original one. Finally, the new design geometry was applied to create a prototype, and the sound pressure spectrum measured for the prototype was compared to the original, which showed that the radiated noise level of the new one was less than the original one.

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Application of active noise control based on neural network to vehicle's engine sound

Donghyeon Lee¹, Narae Kim¹, Junhong Park¹
¹Hanyang University, Seoul, South Korea

Active noise control (ANC) is a particularly effective system for reducing low-frequency noise to compensate passive noise control. With the recent development of digital signal processor (DSP) performance, ANC has the potential to be developed with various algorithms. Accordingly, several ANC algorithms using various controller such as artificial neural network (ANN) are being proposed. In nonlinear system; at many practical applications, the ANC algorithm using a neural network gets more reduction performance compared to the linear ANC. In this study, the methodology proposed neural network based FxLMS algorithm to reduce noise for non-linear system by predicting time series data for near future. This proposed algorithm is applied to reduce the engine noise of vehicle to construct silent inner environment and verify the performance by below.

Link to paper
Investigation of vibrational and acoustic characteristics of compressor discharge duct using CFD and FE-BE method

Sangheon Lee¹, Chulung Cheong¹, Jinhyung Park²

¹Department of Mechanical Engineering, Pusan National University, Pusan, South Korea, ²LG electronics, Changwon, South Korea

The compressor and fan in air conditioner outdoor unit are the core component which determines noise performance as well as cooling or heating performance. Among these, the compressor has larger contribution to the noise of outdoor units. For high efficiency air conditioner, the size and operating speed of compressor are smaller and faster. The high-speed compressor causes loud noise which is complaints for the customer. Traditionally, it is well-known that the vibration of compressor and connected duct is main noise source. However, as the compressor speed increases, the refrigerant flow in the compressor discharge duct also emerged as a major noise source. To reduce the compressor noise operating at high speed, it is necessary to analyze vibrational and acoustic characteristics of compressor discharge duct. This duct noise has the two-types source: structure born noise and flow induced noise. The structure born noise is generated by the duct vibration caused by compressor movement. For the flow induced noise, the static pressure field of refrigerant flow in the duct is vibrational source. In this paper, the compressor discharge duct noise considering two mechanisms was investigated. The refrigerant flow is solved using CFD and duct vibration and noise radiation are computed by FE-BE method.
Inter-channel Conv-TasNet for source-agnostic multichannel audio enhancement

Dongheon Lee¹, Jung-Woo Choi¹
¹Korea Advanced Institute of Science and Technology (KAIST), Yuseong-gu, South Korea

Deep neural network (DNN) models for the audio enhancement task have been developed in various ways. Most of them rely on the source-dependent characteristics, such as temporal or spectral characteristics of speeches, to suppress noises embedded in measured signals. Only a few studies have attempted to exploit the spatial information embedded in multichannel data. In this work, we propose a DNN architecture that fully exploits inter-channel relations to realize source-agnostic audio enhancement. The proposed model is based on the fully convolutional time-domain audio separation network (Conv-TasNet) but extended to extract and learn spatial features from multichannel input signals. The use of spatial information is facilitated by separating each convolutional layer into dedicated inter-channel 1x1 Conv blocks and 2D spectro-temporal Conv blocks. The performance of the proposed model is verified through the training and test with heterogeneous datasets including speech and other audio datasets, which demonstrates that the enriched spatial information from the proposed architecture enables the versatile audio enhancement in a source-agnostic way.

[Link to paper]
Flyover noise evaluation of low-noise technologies applied to a blended wing body aircraft

Ingrid Legriffon¹, Lothar Bertsch², Francesco Centracchio³, Daniel Weintraub⁴

1Office National d’Études et de Recherches Aérospatiales (ONERA) – Paris Saclay University, Châtillon, France, ²German Aerospace Center (DLR), Göttingen, Germany, ³Università degli Studi Roma Tre, Dipartimento di Ingegneria, Rome, Italy, ⁴RWTH Aachen University, Institute of Jet Propulsion and Turbomachinery, Aachen, Germany

In the frame of the European research project ARTEM (Aircraft noise Reduction Technologies and related Environmental iMpact), new aircraft architectures and alternative propulsion systems, e.g. Blended Wing Body (BWB) and geared turbofan engine concept, are investigated, as well as innovative noise reduction technologies such as metamaterials and low noise high-lift device systems. A noise impact assessment has been performed on a long-haul BWB concept developed by Roma Tre University, using the System Noise Prediction Tools of ONERA (CARMEN) and DLR (PANAM). First, shielding effects on the main noise sources are discussed, through installation effects hemi-spheres at chosen frequencies around the aircraft. Based on the shielding assessment, detailed take-off and landing procedures are simulated for several aircraft configurations. Two motorisations of the BWB are evaluated (BPR 8 and BPR 12), provided by RWTH Aachen. Finally, the most promising low noise technologies developed in the frame of ARTEM are applied, and their impact on noise levels on the ground is discussed. It can be demonstrated how the specific aircraft configuration, the engine type and the additional low-noise technology result in a significant overall noise reduction. A joint conference paper presents flyover auralisations based on these noise emission calculations.

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A Prediction Method for Indoor Vibration in the Metro Depot Throat Area Based on the Coupled Vibration Response of the Turnout

He Lei¹, Ruixiang Song¹, Yubin Wu¹, Yanan Wu¹
²Institute Of Urban Safety And Environmental Science, Beijing Academy Of Science And Technology, Beijing, China

Environmental vibration pollution is the primary environmental problem faced by the superstructure of metro depots. The throat area is especially prone to high wheel-rail impact vibration due to multiple joints and turnouts, which may cause high annoyance to the residents in the superstructures both on the upper cover and surrounding areas.

In this paper, based on the coupled dynamic analysis of wheel-turnout, a prediction method to evaluate the indoor vibration of over-track building is established. Firstly, subway turnout with variable sections on switch, connection part and frog and vehicle models are established, and wheel-rail force is obtained through multibody dynamics calculation. Secondly, the track-foundation-structure finite element numerical model was built, loading the wheel-rail force excitation, then the indoor vibration could be obtained. The accuracy of this method is verified taking a 32 story residential superstructure in North China as an example. The vertical vibration accelerations were measured on every other floor when a A-type train travelled on a 7-turnout. The error between the measured data and the calculated results was within 5%, indicating that this prediction method has certain accuracy.

The research results have certain guiding significance for the prediction and control of vibration in metro depot.

[Link to paper]
Noise and Deprivation in Scotland’s Four Largest Cities: Glasgow, Edinburgh, Aberdeen and Dundee

Ashley Leiper¹, Andrew Hood
²SSE Renewables, Glasgow, United Kingdom

Scotland’s draft National Planning Framework 4 (NPF4) Integrated Impact Assessment states that deprived communities tend to be exposed to higher levels of noise than those in less deprived areas. However, this has not yet been specifically investigated in Scotland. The majority of studies find a higher likelihood of noise exposure in deprived communities, although some find the opposite to be true, suggesting that the relationship is highly dependent on the context of the study area. To address a need in the literature for more research in this area and to comment on the statement in NPF4, a spatial analysis has been conducted using Scottish Government published datasets, the Scottish Index of Multiple Deprivation and the Round 3 Noise Mapping. A statistically significant positive relationship between noise exposure and multiple deprivation is found in Glasgow. No statistically significant relationship between noise exposure and multiple deprivation is found for Aberdeen, Dundee or Edinburgh. The relationships between deprivation and both Noise Management Areas and proximity to Quiet Areas are explored.

Link to paper
Effects of binaural classroom noise scenarios on primary school children's speech perception and listening comprehension

Larissa Leist¹, Carolin Reimers², Stephan Fremerey³, Janina Fels², Alexander Raake³, Maria Klatte¹
¹TU Kaiserslautern, Kaiserslautern, Germany, ²RWTH Aachen University, Aachen, Germany, ³Technische Universität Ilmenau, Ilmenau, Germany

When it comes to learning in school, perception of speech and listening comprehension are crucial. The ability to listen effectively under the conditions of background noise and reverberation in a classroom involves the ability to continuously filter out background noise and fill in missing pieces in the speech communicated by teachers or classmates. A large number of experimental tasks have demonstrated that children's speech perception is significantly more sensitive to unfavorable listening settings than adults' (Buss et al., 2017; Klatte et al. 2013). Despite this, there are just a few studies that have looked at the impact of real-world classroom noise on children's performance in listening tasks that take into account the demands of school-based education. Rather, the increased listening effort appeared to lower the amount of resources available for storing and processing information in working memory, as demonstrated by Klatte and colleagues (2010). The goal of this study is to compare children's performance on word identification and listening comprehension tasks in realistic classroom scenarios, which include monaural and binaural reproductions of complex background noises such as typical classroom sounds and non-native children's speech. Conclusions on the acoustic design of learning environments and the development of speech-in-noise perception in primary school students can be drawn.

Link to paper
Public address and sound emission by an active noise control system in ventilation duct networks

Stephane Lesoinne

2Bbri, Limelette, Belgium

In a ventilation duct network, two types of silencers can be used: passive (medium and high frequencies) and active (low frequencies). Active silencers have a loudspeaker (control loudspeaker) that generates an anti-noise. Usually, this system is placed close to the fan and far from the duct air opening. However, when the system is placed close to an air opening, the control speaker can not only be used to reduce the fan noise, but also as a background speaker to play music, information, alerts (the target signal) ... This concept has been implemented in an active noise control (ANC) system based on the adaptive feedforward normalized FxLMS algorithm which uses a reference and an error microphone to pick up respectively the noise to attenuate and the residual noise after control to be minimized. The algorithm is modified so that the target signal does not contaminate the reference nor the error signals. The new algorithm is tested in real time in a short duct with different type of noises and target signals.

Link to paper
Nonlinear response of laminar premixed flames to dual-input harmonic disturbances

Xiaozhen Jiang¹, Jingxuan Li¹,², Lijun Yang¹,²
¹School of Astronautics, Beihang University, Beijing, China, ²Aircraft and Propulsion Laboratory, Ningbo Institute of Technology, Beihang University, Ningbo, China

In gas turbines, aero-engines and rocket engines, flames are always disturbed by perturbations of dual or multiple harmonic frequencies, resulting in corresponding combustion instability. This paper analyses the nonlinear response of laminar premixed flames to dual-input harmonic disturbances to further understand those associated combustion instability. Nonlinear results of flame dynamics were derived from analytical and numerical solutions of the G-equation. The spatial front-tracking of premixed flames was obtained, where types of nonlinear behaviors were classified and related mechanisms of that were elucidated. A dual-input flame description function (DIFDF) was proposed to separately determine global nonlinearities of flame responses of fundamental and higher harmonics frequencies under dual-input disturbances. The fundamental frequency response consists of linear and nonlinear components, and the higher harmonic frequency one is purely nonlinear. The DIFDF properties of conical and "V" flames were compared, with particular emphasis on their differences in nonlinear behavior. The spatial and global effects of the second input frequency on the flame kinematics perturbed by the first frequency were also clarified. Furthermore, the roles of perturbation amplitude and flame height in spatial flame dynamics and DIFDF were quantified.
Modeling and analysis for the deployment dynamic behavior of the large flexible solar array

Ning Li¹, Ma Xiaolong¹, Zhang Chongfeng¹, Zou Huaiwu¹, Liu Jinglong¹, Yang Wenmiao¹
¹Shanghai Institute Of Aerospace System Engineering, Shanghai, China

The large flexible solar array for the satellite will deploy when it reaches the scheduled orbit by the space rocket, which is key for the normal running of the satellite. However, undesirable and unpredicted frequency vibration may be resulted from the flexibility of elements of the solar array. In this paper, the dynamic model of the solar panel was firstly developed based on the modal synthesis method. Moreover, the stretchable mechanism in the solar array was introduced by applying Euler-Bounerlli beam theory. Also, guide ropes, hinges and electric cables were considered in the proposed model. It was found the proposed model could achieve a higher accuracy of simulation compared to the traditional method with the coordinate method. Especially, the dependence of the guide rope tension on the deployment dynamic behavior of the solar array was explored by this model. Results showed that vibrations of the solar array could be reduced by improving the guide rope tension, which could be used in design and operation of the solar array.

Link to paper
A benchmark study on room acoustic simulations with various material input complexities

Yue Li¹,², Julie Meyer², Tapio Lokki², Jacques Cuenca¹, Onur Atak¹, Wim Desmet³

1Siemens Digital Industries Software, Leuven, Belgium, ²Aalto University, Espoo, Finland, ³KU Leuven, Leuven, Belgium

This work investigates and evaluates the capabilities of an explicit finite-difference time-domain (FDTD), a fast multipole indirect boundary element method (FMBEM), and a ray-tracing (RT) solver in the context of room acoustic modeling and simulations. In room acoustic simulations, the wave-based FDTD and FMBEM methods are known for generating accurate results at low frequencies, while the RT technique is in principle more valid at higher frequencies. The numerical aspects of setting up the solutions for each solver are discussed. Special attention is given to the influence of material input data of various degrees of detail. Single/multiple frequency-independent/dependent materials are considered in the model setup. The modeling capabilities of the three solvers in handling material input with various complexities are analyzed. Numerical results are evaluated in both frequency and time domains. Room acoustic parameters, including the reverberation time (T₂₀), early decay time (EDT), clarity (C₈₀), and definition (D₅₀), are compared. These results are also compared with available measurement data. Last but not least, the computational efficiencies of the three solvers are briefly discussed.

[Link to paper]
A 2D low-order thermoacoustic network model of annular combustor with baffles in the plenum

Liang Ji¹, Yuanqi Fang³, Jingxuan Li¹,², Gaofeng Wang³, Lijun Yang¹,²

¹School of Astronautics, Beihang University, Beijing, China, ²Aircraft and Propulsion Laboratory, Ningbo Institute of Technology, Beihang University, Ningbo, China, ³School of Aeronautics and Astronautics, Zhejiang University, Hangzhou, China

Experimental results showed that configuring different baffles (a regular flat, a single- or double-layer perforated plate and a Helmholtz resonator) in the plenum can well suppress the self-excited oscillation in annular combustor. In this paper, a 2D low-order network model is proposed to describe this phenomenon and predict the modal frequencies and growth rates of longitudinal and circumferential thermoacoustic modes for annular combustor with different baffles. In the plenum, only the circumferential acoustic propagation and the influence of baffles on it are accounted for as the longitudinal geometry size is much smaller than the acoustic wavelength of the longitudinal mode. Pure longitudinal acoustic propagation is considered in burners and both longitudinal and circumferential ones are accounted for in the combustion chamber. These three modules are connected by jump conditions. The numerical prediction matches the experimental results. Baffles using Helmholtz resonators feature the best damping performance. The circumferential mode is converted to two unfolded non-degenerate modes when configuring perforated plates baffles. Best damping effect for the configuration of the baffles in the plenum can be achieved based on the proposed model.

[Link to paper]
Four-element planar arrays focus a point-like source based on the artificial iterative phase conjugated processing

Ting Li¹, Yi Zhang¹, Liufang Fu¹
¹Department Of Underwater Weaponry And Chemical Defense, Dalian Naval Academy, Dalian, China

The artificial iterative phase conjugated processing is an improved algorithm of phase conjugation and has been proven to focus a sharp focal spot using linear array. Because cross-shaped four-element planar array and triangular four-element planar array are widely used in the situation of little acoustic measuring points, their focal patterns by the artificial iterative phase conjugated processing are discussed in this paper. Theory analysis and numerical simulations gives conclusions. Based on the artificial iterative phase conjugated processing, two arrays focus a smaller focal spot than that by phase conjugation. As their iterate number increases, focal spot size decreases but the sidelobe amplitude becomes big. Considering the focal spot size and sidelobe interference, the triangular four-element array has a clearer pattern than the cross-shaped one.

[Link to paper]
Focal spot enhanced by artificial iterative phase conjugated twin-line planar array

Ting Li¹, Zhu Kou¹, Jiajing Wang¹

¹Department Of Underwater Weaponry And Chemical Defense, Dalian Naval Academy, Dalian, China

It has been proven that the artificial iterative phase conjugated linear array can enhance the focus. In this paper, twin-line planar array based on artificial iterative phase conjugated processing focuses a point-like source in a homogenous medium. Theory analysis and numerical simulations give conclusions. Contrasting with phase conjugation, artificial iterative phase conjugated twin-line planar array focuses a small focal spot and low sidelobes. Meanwhile, focal size and sidelobe amplitude decrease as iterate number increases. Furthermore, the focal spot size becomes sharp if the distance between the two linear array is larger than half a wavelength.

Link to paper
Piezoelectric vibration suppression of a flexible mounting link for precise space robot operating

Feng Li¹, Lanqing Hu², Huaiwu Zou¹
¹Shanghai Institute of Aerospace System Engineering, Shanghai, China, ²Shanghai Aerospace Equipment Manufacturer Limited Company, Shanghai, China

In large-range manipulator operating mission, it is essential to connect an additional link with end-effectors to enlarge the operation space, which unavoidably introduces the vibration disturbance. An active piezoelectric vibration suppression method is proposed in this paper. The multiple piezoelectric patches shunted with time-variant resonant circuit are mounted on the link and an adaptive controller acting on circuit is utilized for suppressing the vibration due to excitation on various mass on the tip of the link during the robot operating. The electro-mechanical system of a kinematic manipulator model and an analytical flexible link model is established. The vibration controller is designed using the neural network which maps the relationship between the output voltage of piezoelectric sensors and the proper impedance of the circuit. The simulation study shows that the proposed method in this paper could be well applied in space robot operating.
Design method of asphalt mixture with balanced noise reduction and mechanical properties

Mingliang Li1, Yingtao Li2, Jun Li3, Wei Zhou2, Yaqun Zu2
1Research Institute Of Highway Ministry Of Transport, Beijing, China, 2Jiangsu Expressway Maintenance Engineering Technology Co., Ltd., Nanjing, China

A design method of asphalt mixture is proposed for reducing the tyre/road noise while having good mechanical properties. Firstly, by comparing the simulated sound absorption coefficient curve with noise-frequency curve from practical road surface, the target air voids contents are obtained. Then, models which can predict the texture level and sound absorption coefficient from the given mixture properties, such as porosity, gradation, particle size, asphalt content, etc. as inputs parameters, are used for preliminarily selecting the design parameters of mixture. Test samples are made according to these selected design parameters in the lab. Test vales of the texture level, sound absorption coefficient and the skid resistance of the mixtures are obtained from laboratory measurements. These measurement values are used for predicting the attenuation of the tyre/road levels by means of statistical models. Mixtures with superior predicted noise reduction properties are selected for mechanical performance validation. Mixture design which shows the promising noise reduction properties as well as satisfying the mechanical performance requirement are considered as the optimal one, and it is suggested to be used as the road surface. Road surface designed from this method can both meet the needs of traffic load and noise reduction function.
Study on the scoping prediction of railway-induced environmental vibration based on transfer learning

Ruihua Liang\textsuperscript{1}, Weifeng Liu\textsuperscript{1}
\textsuperscript{1}Key Laboratory of Urban Underground Engineering of Ministry of Education, Beijing Jiaotong University, Beijing, China

While the urban rail transit infrastructure provides convenience to the people, environmental vibrations and radiated noise generated by its operation can also affect the residents in the surrounding buildings. Therefore, during the preliminary design stage of railway lines, extensive vibration scoping prediction needs to be carried out, which can promote reasonable vibration mitigation design, thus minimizing the impact of the railway induced environmental vibration. Considering the limitations in the accuracy of existing methods, a deep learning-based vibration scoping prediction model is proposed in this paper. Moreover, the transfer learning strategies are used to enable the model to be trained with the railway induced vibration data obtained from both numerical simulations and field measurements, which allows the model to be trained more sufficiently and thus achieve higher prediction accuracy while keeping high efficiency. To validate the performance of the proposed method, a case study is presented. Specifically, vibration data under different conditions obtained from numerical simulations and measurements are used to train and test the deep learning-based models using transfer learning strategies. Then, by comparing the performance of the trained model with the existing scoping methods, the feasibility and advancement of the proposed method are demonstrated.
The application of sound field control to outdoor live events at low frequencies is a recent one due to increased concerns regarding noise pollution and stronger regulations. Here is presented an overview of the techniques being recently investigated based on model, data or hybrid approaches. The approaches presented here provide encouraging results but they all deal with the problem at relatively short distances (approximately 100m). Translating these results to larger distances is going to be a challenge as a new set of problems needs to be addressed. An overview of the most relevant issues encountered in long range applications such as uneven terrain, properties of the medium, ground and obstacles interactions is also presented.
Efficacy evaluation of low-emission asphalts in port areas using the CPX and SPB method

Gaetano Licitra¹, Luca Fredianelli², Lara Ginevra Del Pizzo³, Antonino Moro³, Francesco Bianco³, Francesco Fidecaro⁴

¹Arpat, Via Vittorio Veneto 27, Pisa, Italy, ²Italian National Research Council, Pisa, Italy, ³IPOOL S.r.l., Pisa, Italy,
⁴University of Pisa, Physics Dpt., Pisa, Italy

The INTERREG IT-FR Maritime financed various projects for filling the gap in knowledge regarding port noise, recognized as environmental issue in the Tyrrhenian area. Passenger road traffic and heavy vehicle traffic related to port activities are among the main sources of disturbance, together with ship noise and dockside operations. Among several projects, REPORT developed simulation models and guidelines for noise evaluation and control strategies, then applied for mapping noise in various ports of the projects. MONACUMEN installed continuous noise monitoring units. The main objective of RUMBLE was to reduce port noise and, among the noise mitigation interventions that were prescribed by the project and carried out during the three years, low-emission asphalts were laid in the Italian ports of Portoferaio (LI) and Cagliari, and in the French ports of Bastia and Ile Rousse. The present work evaluates the effectiveness of these acoustic interventions by comparing the results of specific measurement campaigns carried out before and after the new laying. The measurements were carried out using both the CPX methodology, which evaluates the noise emission due to the interaction of the tyre with the pavement, and the CPB methodology, which is based on the acquisition of the noise levels produced on the roadside by the passage of the test vehicle on the investigated pavement. Since the two tests were performed simultaneously with the same vehicle, these measurements provide a good estimate of the efficacy of the low-noise pavements in a port environment.

Link to paper
Quantifying the annoyance caused by flat tops on the wheels of railway vehicles

Manfred Liepert¹, Christine Huth, Melissa Forstreuter  
²Möhler + Partner Ingenieure AG, Prinzstraße 49, Germany

As part of a research project by the Federal Environment Agency measurements of the pass-by noise of railway vehicles with and without flat spots on the wheels were conducted. The aim of the project was to define an acoustic maintenance criterion for the wheels. To do so listening tests were carried out to quantify the annoyance the noise caused by a flat spot. In order to determine the level adjustment equivalent to the increased annoyance caused by the flat spot, the following method of adjustment was used. The test subjects were each presented a pair of sounds consisting of a vehicle passing with and a vehicle passing without a flat spot. By raising or lowering the level of the signal without a flat spot, the test subjects were able to adjust the two signals individually to “equal annoyance”. Furthermore different noise levels and psychoacoustic indices were tested in order to describe the impact of the flat spot on the caused annoyance.

Link to paper
Masking effect of HVAC noise on walking sounds on concrete floors

Jesse Lietzén¹, Mikko Kylliäinen¹, Ville Kovalainen²
¹Tampere University, Tampere, Finland, ²AINS Group, Turku, Finland

Background noise masks living sounds in apartment buildings. Depending on the sound insulation properties of the structures of the apartments, background noise affects the audibility of the perceived airborne and impact sounds from neighboring dwellings. This preliminary study focused on the masking effect of the background noise generated by HVAC systems on the impact sounds generated by walking on concrete floors. The study was carried out by determining the signal-to-noise ratios of walk induced sound levels on the concrete floors and measured background noise levels. The walking sounds were generated by walking with socks and shoes on nine concrete floors, and the sound pressure levels were measured in a receiving room below the floors. The background noise levels, where these walking sounds were compared, consisted of the results collected in 210 measurements carried out in Finnish apartment buildings. The results of the study show how it is likely that the background noise masks sound from walking with socks and shoes differently. To investigate the phenomenon more in detail, follow-up research has been proposed.
Validation of a potential-based active sound control methodology

Hyun Lim¹, Luis Gomez-Agustina¹
¹London South Bank University, London, United Kingdom

This paper describes a global active sound control methodology based on difference potentials in a three-dimensional space. The proposed alternative method allows the reduction of a boundary value problem set in a complex domain to a boundary equation. The only input data needed by the methodology are the acoustic quantities at the perimeter of the protected region. By minimizing the number of input data, the characteristics of the method provide a practical and cost-effective control system. Moreover, these quantities may pertain to the overall acoustic field composed of both the unwanted and wanted components. The most distinctive feature of this methodology is its ability to automatically differentiates between the wanted sounds and unwanted noise within targeted domains. The proposed approach requires information of neither the wanted nor unwanted component separately, but the measurements of the total field on the boundaries of the shielded domain only. This capability can be very useful for the applications related to personal audio and building acoustics as it enables protection of the predefined personal space against the noise coming from the outside. In doing so, the controls will not interfere with the detectors' recognition of the wanted sound or communication among speakers in the room.

Link to paper
Glass cover with high acoustic performance and specification challenges

Milena Lima

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Atenua Som, São Paulo, Brazil

We are faced with a situation in which a commercial establishment in a residential area receives constant complaints due to the loud sound of music, the request was made with a high degree of urgency, the challenge of this study is to find an acoustic solution that maintains the requested aesthetics, bringing a comfortable atmosphere to those who are inside the environment and remedy the apprehension of the neighborhood. After a thorough field study and technical measurements, it was defined that the insulation required for making the roof will be Rw50.

The biggest challenge was to find reliable tests, already carried out on high-performance glass that would guarantee the acoustic efficiency required. This proved to be a difficulty because not enough data were found and the deadline for execution was extremely short. The acoustic tests were started using Brüel & Kjær equipment, a model 2270-S sound level meter, Capacitive Microphone 4189 and Preamplifier ZC-0032 in a laboratory meeting the recommendations of ISO 717-1:2013 Rating of sound insulation in buildings and of building elements - Part 1: Airborne sound insulation, ISO 16283-1:2014 Acoustics – Field measurement of sound insulation in buildings and of building elements - Part 1: Airborne sound insulation and ISO 3382-2:2008 Acoustics — Measurement of room acoustic parameters — Part 2: Reverberation time in current ordinary rooms. During the laboratory tests, several tests were necessary to achieve the expected result, with the data available in Brazilian regarding the loss of sound transmission from the glasses, we calculated a specification that theoretically would meet the need, but the results obtained were very different, requiring some modifications beyond the glass, until make the final product.
Modeling the impact of traffic noise: analysis of lightning geometry and its contribution to direct, specular and diffuse path propagation.

Dayane Cristina Lima Estercio¹, Paulo Fernando Soares²

¹State University Of Campinas (UNICAMP), Campinas, Brazil, ²State University of Maringa (UEM), Maringá, Brazil

The evaluation of urban noise is an important tool in noise control. From existing sources of noise, vehicular traffic is considered the main cause of discomfort in the population. The intensity of the noise that reaches the receiver depends on the level of sound power emitted by the source and the attenuation that occurred in the propagation medium. The analysis of the dispersion of rays in different urban geometries allows the evaluation of parameters that influence the trajectory of noise. The objective of this study is to analyze the contribution of the energy fraction of each path in different urban settings in the global noise, to contribute to the analysis and adoption of mitigating measures. For this, the mathematical model of prediction of noise levels was adopted, which calculates the direct and specular (source-image method) and diffuse (radiosity method) paths. The study was applied in two sectors of the city of Maringá, Brazil. In total, 73200 paths were evaluated in 14640 readings of source positions in 54 measured points. The results showed the part of contribution that each path represents in the acoustic field, and the sound decay caused by obstacles, urban geometry, distance and material properties.

Link to paper
Active Vibration Control of a Rotating Mechanical System with a Rigid Coupling using Active Disturbance Rejection Control

Tingyu Lin¹, Dunant Halim¹, Liaoyuan Ran¹, Zhuang Xu², Chung Ket Thein³
¹Department of Mechanical, Materials and Manufacturing Engineering, University of Nottingham Ningbo China, Ningbo, China, ²Department of Electrical and Electronic Engineering, Ningbo, China, ³School of Aerospace, Ningbo, China

The work aims to develop an active control method for mitigating torsional vibration of a rotating mechanical system with a rigid coupling, driven by an electric motor, particularly for suppressing vibration associated with its mechanical resonances. It is commonly known that torsional oscillations in a rotating system, which is normally used for various power transmission systems, can generate significant levels of vibration and noise. In this work, therefore, an active control system that was based on the Active Disturbance Rejection Control approach was utilized to develop an active control system that was robust against uncertainties associated with the internal dynamics and external disturbances affecting the system. The dynamic interactions between the inertias of the electric motor and the load, which were connected through elastic shafts and a rigid coupling, were investigated. The Extended State Observer was used to estimate the generalized disturbance consisting of not only the external disturbances but also the disturbances associated with internal dynamics of the rotating system. The effectiveness of the developed controller was demonstrated, which showed that in the case of the varying load inertia, the control system could still perform well in mitigating the torsional vibration.
Active Control of an Unbalanced Rotor System using Active Bearings and the Generalized Disturbance Estimation

Liaoyuan Ran¹, Dunant Halim¹, Tingyu Lin¹, Chung Ket Thein², Michael Galea³

¹Department of Mechanical, Materials and Manufacturing Engineering, University of Nottingham Ningbo China, Ningbo, China, ²School of Aerospace, Ningbo, China, ³Department of Industrial Electrical Power Conversion, Msida, Malta

The work is aimed to develop an active control method for suppressing unbalanced vibration of an elastic rotor system via the utilization of active bearings. The active bearing was implemented by the developed control system to actively control the displacements of the bearing for regulating the bearing forces. To address the issue of uncertainties associated with the unbalanced forces and internal dynamics of the rotor system, the Extended State Observer (ESO) was utilized to provide an accurate estimation of the generalized disturbance that consisted of the external disturbance in the form of radial forces caused by the unbalanced rotating mass of the rotor, and the disturbance associated with uncertainties in the internal dynamics of the rotor system. Active Disturbance Rejection Control (ADRC) method was utilized to cancel the effect of the generalized disturbance, allowing a simpler control input implementation to the active bearing. It was shown in this work that the ESO was able to accurately estimate the disturbances affecting the rotating system in real time. As the result, the active bearing control system could reject the disturbances effectively to minimize the unbalanced vibration of the rotor system.
Fluctuations by atmospheric turbulence in aircraft flyover auralisation

Dorothea Lincke\textsuperscript{1}, Reto Pieren\textsuperscript{1}

\textsuperscript{1}Empa Materials Science And Technology, Überlandstrasse 129, 8600 Dübendorf, Switzerland

Long-term exposure to aircraft noise causes significant health issues among residents near airports. Therefore, noise impact assessments and noise control at the source are important aspects of the design of new aircraft. The design process of low-noise aircraft can be supported with auralisation of virtual flyovers. In order to render plausible aircraft auralisations, multiple propagation phenomena have to be considered, such as geometrical spreading, air absorption, Doppler effect, and reflections from the ground. Additionally, measurements of aircraft flyover show clear patterns of amplitude and phase fluctuations by atmospheric turbulence. Aircraft flyover auralisations should incorporate these clearly audible features of sound propagation in real-world conditions to be perceived as plausible. We present new approaches of time-variant filtering techniques to account for phase and amplitude fluctuations as a function of atmospheric conditions characterised by the von Kármán turbulence spectrum of wind and temperature fluctuations. Compared to earlier approaches, the proposed model is closer to the physical mechanisms. The application of the filters leads to a reduction of unnatural flanging and to a higher naturalness of level fluctuations. As the proposed method has shown to increase plausibility of aircraft flyover auralisation, its application in perception-based evaluation of future aircraft concepts is foreseen.

[Link to paper]
Occupational exposure to noise and myocardial infarction risk one year later in Sweden

Claudia Lissåker¹, Maria Albin¹², Theo Bodin¹², Mattias Sjöström¹², Jenny Selander¹
¹Karolinska Institutet, Stockholm, Sweden, ²Centre for Occupational and Environmental Medicine, Stockholm, Sweden

Objective: To explore the association between occupational noise exposure and myocardial infarction (MI) one year later.

Methods: Data came from the SNOW cohort, comprised of all individuals born between 1930 and 1990 in Sweden, with demographic, occupational, and outcome data available from 1960 until 2017. In this study, we included working individuals with at least one occupational code between 1985 and 2013. These were matched to a job exposure matrix (JEM) in five categories (LAeq8h): <70, 70-74, 75-80, 80-85, >85 dB(A). MI status in the year following exposure was ascertained using the patient register. To account for time-varying occupational data, we utilized a discrete-time proportional hazards model adjusted for individual confounders and other occupational exposures.

Results: Preliminary results show that exposure to over 75 dB(A) of occupational is associated with a 13-21% increased risk for MI one year later. After adjusting for psychosocial work exposures, physical workload, exposure to vibrations, and chemical and particle exposure, noise exposure was no longer associated with an increased risk for MI.

Conclusion: Exposure to noise was not associated with an increased risk for MI one year later after adjusting for other work exposures among this younger, working population. Additional in-depth analyses are ongoing.

Link to paper
Sound isolation via temporal modulation material based on piezoelectric elements

Xiang Liu¹, Chunqi Wang¹, Yumin Zhang¹, Keming Wu¹, Lixi Huang¹
²The University of Hong Kong, Hong Kong, Hong Kong

The temporal modulation material is investigated to be used as lightweight sound isolation material. This smart composite material consists of a lightweight structure attached with shunted piezoelectric ceramic (PZT) patches. The shunt circuits are connected to the two poles of PZT patches to act as some local electrical resonators to improve the sound isolation. The circuit is composed of operational amplifiers and passive analog circuit elements, so the system is always stable, and the power consumption is low. The metal-oxide-semiconductor field-effect-transistor (MOSFET) is added in the shunt circuit connected to the PZT patches, so the time sequence of the working circuit is controlled with the MOSFET devices in each resonant shunt. The motivation of this study is to improve the sound isolation in the low-to-middle frequency range. The temporal modulation material proposed in this study has many potential applications in environmental acoustics, precise instrument, automotive sector, and aerospace technologies.

Link to paper
Experimental study on vibration response of wooden house façade to low-frequency outdoor sound

Jinyu Liu¹, Naohisa Inoue², Tetsuya Sakuma¹

¹The University of Tokyo, Bunkyo-ku, Japan, ²Maebashi Institute of Technology, Maebashi-shi, Japan

Generally wooden house has low sound insulation performance for low-frequency outdoor noise due to the lightweight façade wall system. Moreover, the sound insulation performance is caused by the vibration responses of window and wall systems, that are strongly coupled with normal modes in a room. In order to clarify the complicated phenomena, field measurements of vibration characteristics are conducted for a test house with Japanese traditional wooden structure, under the cases with single/double window systems. As outdoor sound source, low-frequency band noise from 25 Hz to 160 Hz is emitted from a subwoofer, and vibration acceleration is measured on each element, such as window glazing, interior walls, floor and ceiling. From the analysis of measured vibration transfer functions and indoor sound pressure distribution, the vibration characteristics of the whole coupled system are discussed, especially on the effect of different window systems.

Link to paper
The time-frequency characteristics analysis and prediction of ground vibration near a subway station

Bideng Liu¹, Yubin Wu¹, Ruixiang Song¹, Lei He¹, Qiong Wu¹
²Institute Of Urban Safety And Environmental Science, Beijing Academy Of Science And Technology, Beijing, China

This paper presents the time-frequency characteristics of ground vibrations near subway stations through field tests and analyses. More than 15 ground vibration measurement points are set up in the longitudinal and transverse directions of the track near a subway station. Overall, the ground vibration level (VLzmax) above the tunnel is approximately 73 dB on the border between the station and mainline, while it attenuates to 63 dB away from the tunnel by approximately 30 meters; the dominant frequency in the mainline area is approximately 63-80 Hz. The results in the longitudinal direction show that the ground vibration increases rapidly as the train drives away from the station because of the train speed growing, and VLzmax is less than 10 dB between the station and near the mainline area, while the dominant frequency in the mainline area is higher than that in the station area. The attenuation rate of the ground vibration in the transverse direction for the mainline area is faster than that for the station area. The power distribution law y=Ax^(-α) can describe the vibration attenuation characteristics, and its "peak and long tail effect" and "scale-free characteristics" can predict the vibration at any position by measuring two specified locations.
An exponentially convergent adaptive robust based space manipulator noise control method

Jinglong Liu\textsuperscript{1,2}, Ning Li\textsuperscript{1,2}, Xiaolong Ma\textsuperscript{1,2}, Feng Li\textsuperscript{1,2}
\textsuperscript{1}Shanghai Institute Of Aerospace System Engineering, Shanghai, China, \textsuperscript{2}Shanghai Key Laboratory of Spacecraft Mechanism, Shanghai, China

Because most of the traditional nonlinear control methods are model-based control methods, it will dramatically increase the parameter identification burden of multi-rigid-body system dynamic model. Meanwhile, Unmodeled dynamics, parameter drift, model uncertainty, complex motor hysteresis characteristics, etc are unfortunately in the practical systems, which makes it very hard to accurately build the noise model and identify the model parameters. Among them, the accurate values of the viscous friction coefficient, elastic friction coefficient, the distance between the centroid and the rotation center of the connecting rod, the inertial moment and products of each joint, these exact values can hardly be obtained. In this paper, direct adaptive control and the robust model reference adaptive control based on Lyapunov direct method are adopted, which can make the noise error close to zero under the condition of parameter uncertainty and unknown nonlinear friction characteristics.

[Link to paper]
Speech privacy through dynamic fundamental frequency matching

Charlene Lo¹, C. T. Justine Hui, Yusuke Hioka
¹Acoustic Research Centre University Of Auckland, Auckland, New Zealand

The lack of speech privacy is known to be detrimental to one’s physical and psychological health. When physical barriers are not feasible to provide this, a masking noise may be implemented to provide speech privacy. Such maskers are most effective when the difference in mean fundamental frequency (F0) between speech and the masker is minimised. Furthermore, noise annoyance is primarily attributed to the loudness and presence of high-pitched components. The present study investigates the effectiveness and annoyance caused by a masker that minimises instantaneous F0 differences.

Two seed maskers (pink and babble noise) were used to generate a unique masker for each test sentence read by a variety of speakers. A subjective listening test and annoyance survey were carried out to determine the effects of the dynamically matched masker, a stationary masker at the mean fundamental frequency of each speaker, and the seed masker without F0 processing. The maskers were played at a variety of target to masker ratios. Preliminary results show that the dynamically matched masker is as effective and less annoying than the stationary masker.

Link to paper
Assessing the environmental burden of disease due to road traffic noise in Hesse, Germany

Matthias Lochmann¹, Janice Hegewald, Melanie Schubert, Andreas Seidler
²HLNUG (Hessian Agency for Nature Conservation, Environment and Geology), Wiesbaden, Germany

As guidance for informed decision-making, we estimated the environmental burden of disease attributable to road-traffic noise in Hesse.

Using detailed road-traffic-noise exposure data provided by HLNUG, we calculated the DALYs due to road-traffic noise > 40 dB(A) L24h (unweighted average 24 h noise level) and other noise metrics for endpoints with known dose-response functions and evidence in the literature (NORAH-study on disease risks and WHO reviews).

For Hesse, we found a total of 26,501 DALYs attributable to road-traffic noise or 435 DALY per 100,000 persons for the reference year, 2015. The endpoints "Annoyance" and "Sleep disturbance" contribute more than 70% of the burden.

Further, we estimated that a hypothetic uniform road-traffic-noise reduction of 3 dB would prevent 23% of this burden of disease. We suggest an alternative approach to extract an annoyance function from raw data used in the WHO-review.

Our findings imply that the burden attributable to street-traffic-noise is of the same order of magnitude as, for example, the more fully researched environmental risk factor particulate matter. HLNUG is evaluating expanding the BoD-approach including uncertainty assessment to other environmental risk factors and its use for informing decision makers.

[Link to paper]
Field Validation of Octave Band Sound Modeling for Wind Turbines

Dana Lodico¹
¹RSG, Denver, United States, ²RSG, White River Junction, United States

The Sugar Creek Wind Project is a 57-turbine wind farm in Logan County, Illinois, with a capacity of up to 202 megawatts. Preconstruction sound modeling of the final Project layout was conducted in July 2019. Following construction of the Project, postconstruction attended sound measurements were made at 38 sites in the vicinity of Project turbines in September, October, and November 2021. Measured postconstruction sound levels were compared to the octave band sound level limits applicable under the Project’s Conditional Use Permit. A comparison of the modeled and background-adjusted measured octave band sound levels for the Project indicate that with the proper modeling parameters, octave band sound levels can be conservatively predicted.
Local authorities in The Netherlands supported by new software tooling in delivering European strategic noise maps

Dorien Lolkema¹, Danny Greefhorst¹, Jan Skornsek¹
¹National Institute for Public Health and the Environment, Bilthoven, Netherlands

The new reporting mechanism of the European Environmental Agency makes for uniform and standardized data exchange. It is an inevitable move in a world where environmental data needs not only to be available, but also accessible to all people. This change however, asks a lot of competent authorities. All competent authorities must now alter their standard operating procedures when producing strategic noise maps and other reports. The Dutch government wants to support competent authorities in complying with this new reporting mechanism by developing software tooling. The tooling is an extension of an already developed platform that supports the Dutch noise legislation rules. With this specialized tooling, competent authorities can upload a file with their strategic noise map. The tooling takes care of reprojecting to the required coordinate system and the validation of the file to the information model of the new reporting mechanism. It also merges individual strategic noise maps to compose national strategic noise maps. In addition, the tooling takes care of publishing the according INSPIRE compliant services. In this presentation, we will show you how this works, and how it fits in with national and European noise legislation. Finally, future perspectives of this development will be presented.
The city of Ravello and its hundreds clerical buildings. Acoustic discoveries of the St Mary Gradillo’s church

Ilaria Lombardi¹, Rosaria Parente², Silvana Sukaj³

¹University of Campania Luigi Vanvitelli, Aversa, Italy, ²Benecon University Consortium, Napoli, Italy, ³European University of Tirana, Tirana, Albania

Hundreds of churches and monasteries have been erected in a small town nearby Naples during the Medieval Age. A recent proposal by the local authority regards the utilization of some clerical buildings to be part of the places selected to host musical venues during the festival that is annually recurring in Ravello. The St Mary Gradillo’s church has been built during the 11th century, to be composed by three naves marked by columns, following the architectural features of a basilica. The different height and typology of roof, to be a double slope in the central nave and vaulted in the lateral ones, is characterised by a dome located at the junction of the wings crossed at the level of the altar. This paper deals with the assessment of the existing acoustic conditions of the church. The evaluation is based on the analysis of the main acoustic parameters in accordance with ISO 3382-1. Measures adopted to adjust the acoustics to host musical venues have been treated in terms of additional absorbing panels other than mountable solutions for a temporary wooden stage.

[Link to paper]
Witches Valley acoustics

Ilaria Lombardi\textsuperscript{1}, Antonella Bevilacqua\textsuperscript{2}, Cobi van Tonder\textsuperscript{3}
\textsuperscript{1}University of Campania Luigi Vanvitelli, Aversa, Italy, \textsuperscript{2}University of Parma, Parma, Italy, \textsuperscript{3}University of York, York, UK

The city of Benevento is famous for the legend of witches as they gathered in a place outside the city and danced under a magical Walnut tree. This legend was resumed in 1639 in Piperno's book "De Nuce Maga Beneventana" which describes this place located in the valley of the river "Sabato". Another hypothesis states that this legend is due to the invasion of the Longobards (Germans people) during the Middle Ages, as the city was their capital Centre. The Longobards were used to perform rituals dancing under a tree accompanied by the rhythm of drums. The Longobards selected a place where the sound could be amplified by the natural conformation of the landscape in order to impress the participants. This paper deals with the sound analysis typical of various places located in the valley of the river Sabato. The presence of rocks naturally amplifies the sound. The acoustic measurements have been performed by using firecrackers and the impulse response was acquired with a Brahma microphone. The acoustic analysis confirms that these places are characterized by a development of sound reflections, a phenomenon that can explain why a drum roll is perceived as a very reverberant sound.

Link to paper
Effects of noise and vibration on operatives with machine interaction in manufacturing environments

Mario Buono\textsuperscript{1}, Antonella Bevilacqua\textsuperscript{2}, Sonia Capece\textsuperscript{1}, Ilaria Lombardi\textsuperscript{1}

\textsuperscript{1}University of Campania Luigi Vanvitelli, Aversa, Italy, \textsuperscript{2}University of Parma, Parma, Italy

Human-machine interaction is an ordinary paradigm in the manufacturing industry. This area of business has to ensure high standard of safety levels in order to protect the operatives while performing their tasks. If the safety criteria are not met nor controlled, psychological disease and physical injuries can be developed in the working environments. The effects could lead to short or long-term diseases such as tinnitus or hearth attacks, based on the levels of stress. During the last decades, different methodologies have been developed to analyse and evaluate the parameters linked to the human-machine interaction. These methodologies include the biomechanics overload, noise and vibration. This paper deals with a case study as representative of the manufacturing sector. The noise and vibration levels of different machines have been extracted by a database of been measured on site by using a class 1 sound level meter. The purpose of the paper is to make a data analysis, assuming a long-term projection of the physical and psychological effects that could affect the operatives in case any criteria has not been met.
The re-use of an abandoned building is probably among the most sustainable choices we can do in the built environment. A dismissed public building has been donated to the University of Foggia, Italy, due to the demand of facilities that the different departments requested for their academic meetings and events. The original building was provided with a swimming pool on the ground floor, to be 50 m long and 3 m deep. The architects in charge to apply the change of use have designed the realization of an auditorium within the original pool. The project consists of the installation of the audience seats on a 10% sloped stalls area, having a rectangular plan layout. The short dimension headwall, that is 3 m high, has been designed to allocate a screen for image and video projection. Before any change, a campaign of acoustic measurements has been undertaken in order to assess the existing conditions of the room, having a volume size of 4000 m3. The results from the first survey highlight that the main acoustic parameters were significantly outside the optimal range for an auditorium. This paper presents a parametric investigation of some mitigation solutions applied to lower the reverberation time and to increase the speech intelligibility (and the STI). The addition of absorbing surface areas allowed the users to effectively make use of this facility. A second campaign of measurements carried out after the realization of the acoustic design have been compared with the predictions, to finally tune the retrofitted room.
A mass-spring analogy for modeling the acoustic behaviour of a metamaterial

Maël Lopez¹, Thomas Dupont¹, Raymond Panneton²
¹École de Technologie Supérieure de Montréal, Montréal, Canada, ²Université de Sherbrooke, Sherbrooke, Canada

Absorbing sound almost completely at specific frequencies with conventional acoustic materials whose thickness is at least 60 times smaller than the wavelength is a challenge, particularly at low frequencies. For this purpose, acoustic metamaterials are of a great interest. Here, the metamaterial is called multi-pancake cavities. It is composed of a main pore with a repetition of thin annular cavities (pancake cavities). Previous research has shown that this repetition increases the effective compressibility of the main pore. This increase makes it possible to decrease the effective sound speed in the material and, consequently, the main pore resonance frequencies. At these resonances, the metamaterial presents absorption peaks, the first one can have a wavelength to material thickness ratio of more than 60 (subwavelength material). To complete the analysis and prediction of absorption peaks (especially secondary peaks) of these metamaterials, it is proposed to adapt a conventional mass-spring model to this metamaterial. Due to the small cavity length-to-diameter ratios, radial propagation is considered inside the annular cavities. This model shows a good agreement with the results obtained by finite element method and by impedance tube measurements. Finally, comparisons with previous theoretical approaches are presented and discussed.
New ASTM ratings for impact noise insulation

Wayland Dong¹, John LoVerde¹
¹Veneklasen Associates, Santa Monica, United States

New ratings to evaluate impact noise insulation have recently been published as ASTM standards, which are commonly used to evaluate building acoustics measurements in North America. ASTM E3207 defines new ratings for low-frequency impact insulation, defined by the 50-80 Hz third-octave bands. ASTM E3222 defines new ratings for high-frequency impact insulation, defined by the 400-3150 Hz bands. These ratings are based on the two-rating method of evaluating impact noise isolation proposed by the authors [LoVerde and Dong, J. Acoust. Soc. Am. 141 (2017)]. By evaluating the low and high-frequency components of impact noise independently, the proposed ratings perform better than existing ratings in terms of correlating with subjective reaction, designing assemblies, and evaluating products and mitigation measures. Motivations, development, and examples illustrating the use of the new ratings are presented, and suggested classification schemes are discussed.

[Link to paper]
In situ measurements for sound levels near facades in low-rise courtyards with different geometries exposed to aircraft noise

Martijn Lugten¹
²TU Delft, Julianalaan 134, 2628BL, Delft, Netherlands

Aircraft noise prediction models traditionally omit buildings to optimize speed. Buildings and vertical surfaces scatter and reflect incident sound, affecting sound levels around buildings and within streets. Previous studies showed the impact of buildings on aircraft noise, based on a small number of measurements. Based on additional numerical models, it was found that the shape of buildings, i.e. a slanted or overhanging roof, lead to lower sound levels compared to streets comprised of vertical and flat surfaces. To examine these findings, a full-scale field lab was built near Amsterdam Schiphol Airport, comprised of shipping containers. The experiment consists of three courtyards, in which ten microphones measure sound levels from aircraft flyovers, near facades facing towards and away from the sound source (airplanes). Measurements are matched with meteorological and radar data, which gives information about the position of aircraft and the local weather conditions. The measurements show substantial differences depending on the position, ranging between 11dB(A) for a courtyard with straight facades, up to 14dB(A) for facades in a courtyard with a slanted roof and a roof overhang. Results can be used to rethink the way areas near airports are designed.

Link to paper
Deep Neural Networks for Selective Fixed-filter Active Noise Control

Zhengding Luo\(^1\), Dongyuan Shi\(^1\), Woon-Seng Gan\(^1\), Qirui Huang\(^2\), Libin Zhang\(^2\)

\(^1\)Nanyang Technological University, Singapore, Singapore, \(^2\)Huawei International Pte Ltd, Singapore, Singapore

Due to its rapid response time and a high degree of robustness, the selective fixed-filter active noise control (SFANC) method appears to be a viable candidate for widespread use in a variety of practical active noise control (ANC) systems. In comparison to conventional fixed-filter ANC methods, SFANC can select from a variety of pre-trained control filters for different types of noise. Deep learning technologies, thus, can be used in SFANC methods to enable a more flexible selection of the most appropriate control filters in the presence of varying incoming noise. Furthermore, deep neural network parameters can be learned automatically from noise data rather than through trial and error, significantly simplifying and improving the practicability of ANC design. Therefore, this paper compared the performance of SFANC using several different neural networks. Two-dimensional and one-dimensional neural networks are used to classify noise types in the frequency and time domains, respectively. Additionally, we compare training from scratch versus fine-tuning training to determine which network training strategy is superior in SFANC methods.

[Link to paper](#)
Subjective evaluation of the acoustic annoyance in a large passenger aircraft cabin

Bingcong Lv\(^1\), Yu Huang\(^1\), Weikang Jiang\(^1\)
\(^1\)Shanghai Jiao Tong University, Shanghai, China

People demand better acoustic comfort for higher travelling quality and security in aircraft. It is necessary to evaluate and predict the subjective annoyance caused by the noise in aircraft cabins. This study investigates the noise-induced annoyance in a large passenger aircraft. We recorded the noise at 21 positions in the aircraft cabin without passengers and selected 21 stimuli during the cruising. Each stimulus has a duration of 5 seconds and a sound pressure level in the range of 72–81dB(A). The psychoacoustic parameters such as loudness, sharpness, roughness and articulation index were also calculated. Twenty-four subjects evaluated the subjective annoyance of the stimuli by the absolute magnitude estimation method. Results showed the noise annoyance at the middle section of the cabin is significantly higher than that at the front or rear section. The principal component analysis and correlation analysis found that annoyance is mainly affected by loudness, sharpness and roughness and dominated by loudness. We proposed a multiple linear regression model between the subjective magnitudes of annoyance and the psychoacoustic parameters to evaluate and predict the noise annoyance in the aircraft cabin well.
Numerical investigation of thermo-acoustic instability in a model afterburner with a simplified model for observed lock-in Phenomena

Muthaiah M¹, Ragul Senthilkumar¹, Varunkumar S¹
²Department of Mechanical Engineering, Indian Institute Of Technology - Madras, Chennai, India

Thermoacoustic oscillations in a gas turbine afterburner are numerically investigated using CFD. A simplified 2-dimensional axisymmetric afterburner with bluff-body stabilized flame is considered in the investigation. Occurrences of both low and high-frequency thermo-acoustic oscillations in the afterburner chamber are observed at specific fuel flow rates. The flow field from the CFD shows the bluff-body vortex shedding frequency to lock-in with the acoustics of the chamber during the thermo-acoustic oscillations. The synchronization and lock-in of bluff-body wake with chamber acoustics happen with increase in fuel injection rates resulting in thermoacoustic coupling. The Proper Orthogonal Decomposition of the flow field revealed the presence of chamber acoustics in the pressure field confirming the coupling. Then a simplified mathematical model based on the van-der Pol oscillator is attempted to reproduce the observed lock-in behavior of the bluff-body wake. The chamber acoustic field is considered as the forcing term for the simplified oscillator. The oscillator model qualitatively captures the synchronization of the flame-holder wake oscillations with the chamber acoustics. This model could be extended to combustors with bluff-body wake in predicting the thermo-acoustic oscillations.

Link to paper
Study on the correlation between noise perception and annoyance level of residents in residential areas along the tracks

Jinglun Ma¹, Yue Wu¹, Qi Meng¹
¹School of Architecture, Key Laboratory of Cold Region Urban and Rural Human Settlement Environment Science and Technology, Ministry of Industry and Information Technology, Harbin Institute of Technology, No. 66 West Dazhi Street, Harbin, China

Noise has gradually become a key problem that cannot be ignored in urban environment. In recent years, with the rapid development of railway transportation in China, the sound environment of residential areas along the track is very complex, among which the noise and vibration brought by train running will affect human health. Therefore, this study adopts the subjective evaluation method to conduct a questionnaire survey on the sound environment of residential areas along the track, and studies the correlation between residents' noise perception and annoyance level. The results show that there is a strong correlation between noise perception and annoyance (p<0.01). In addition, noise perception and annoyance level are significantly different between daytime and nighttime. It is found that the sensitivity and annoyance level of railway noise in daytime are lower than those in night. The above results may be due to the masking effect of residents' activities and road noise on railway noise during daytime, which reduces the perceptual sensitivity of railway noise during daytime. The results can provide guidance for setting noise limits of railway running in different periods.

Link to paper
Accelerating knowledge transfer from research to sound aware practice

Arnthrudur Gisladottir¹, Trond Maag²
¹Aarhus University, Department of Civil and Architectural Engineering, Aarhus, Denmark, ²FOEN, Federal Office for the Environment, Switzerland

Sound is a crucial factor for the health of inhabitants in city environments and plays an essential role in people's general well-being and how they perceive spaces within the urban realm. However, sound is seldom an influential parameter within urban development projects unless there are regulations to fulfill. During the last decades, increased knowledge of the subject has been gained through research activities. Still, findings only slowly reach into the work fields of architects and urban designers. This paper presents a series of workshops designed to gain input on how the transfer of knowledge of urban sound from research findings to the urban planning and design practice could be accelerated. Furthermore, the paper explores how sound experience walks additionally can improve understanding of the relationship between sound and urban space. In particular, developed as city sound models, the walks can support practitioners' knowledge and public involvement in the acoustic environment.

Link to paper
Sensing of aircraft position through IoT camera system installed with a fisheye lens.

Takashi Maeyama¹, Takumi Asakura¹, Junichi Mori², Makoto Morinaga², Kentaro Nishino³, Shigenori Yokoshima³, Ippei Yamamoto⁴

¹Tokyo University of Science, Noda, Japan, ²Kanagawa University, Yokohama, Japan, ³Kanagawa Environment Research Center, Hiratsuka, Japan, ⁴Defense Structure Improvement Foundation, Shinjuku, Japan

Airport radars using GPS or radio waves are often used to sense aircraft flight positions. These techniques can be applied for sensing in a wide range of areas, but they tend to be interrupted due to the radar blind spots resulting from the low flight altitude in the vicinity of an airfield. For managing or investigating aircraft operations, three-dimensional measurement in the local area from the ground is effective. So, we have developed an IoT camera system installed with a fisheye lens and measured the flight path of aircraft passing overhead at multiple points near the end of the runway. As a result, it was found that our camera system can detect continuous flight paths even if the flight altitude is low.

Link to paper
Sound Insulation Property of Waste Jute Fiber/Recycled High-Density Polyethylene Composites

Jonty Mago¹, Sunali¹, Ashutosh Negi¹,²,³, S. Fatima¹

¹Automotive Health Monitoring Laboratory, Centre for Automotive Research & Tribology, Indian Institute of Technology Delhi, Hauz Khas, New Delhi-110016, India, New Delhi, India, ²Renewable Energy and Chemicals Laboratory, Department of Chemical Engineering, Indian Institute of Technology Delhi, New Delhi-110016, India, New Delhi, India, ³School of Interdisciplinary Research, Indian Institute of Technology Delhi, Hauz Khas, New Delhi-110016, India, New Delhi, India

Noise pollution is a potential threat to human health and the environment. Using acoustic materials (barriers/insulators and absorbers) in the noise path is a customarily approach for noise control. Nowadays, compared to traditional sound insulating materials (metals, gypsum and concrete), polymers (plastics) have gained more interest among researchers because of their unique features like lightweight, ease of design, low cost, and available state-of-the-art technologies for mass production. Concurrently, the massive amounts of solid waste such as plastic, e-waste, garment waste (textile) and agro residue end up in landfills or are incinerated. Disposal of these solid wastes through landfilling or burning in the air deteriorates the environment. Therefore, in the context of these problems, the present research aims to prepare sound-insulating material by utilizing waste jute fibre (WJF) and recycled plastic (high-density polyethylene-rHDPE) through compression moulding. The effect of WJF weight percentage on sound insulation property was studied. The prepared composites were thoroughly characterized for their properties related to sound insulation, i.e., density and tensile strength. The sound transmission loss of the composites was measured as per ASTM-E2611 using a four-microphone impedance tube setup. It was found that with the increase in WJF amount, the sound transmission loss was significantly improved. Moreover, the measured experimental results were compared with the theoretical results computed from mass and stiffness law equations, which showed a good agreement.

[Link to paper]
Modeling the Influence of Under-Sleeper Pads on the Vibration Emissions from Railway Traffic

Nils Mahlert¹, Sascha Hermann¹
¹DB Systemtechnik GmbH, Vöckerstraße 5, 80939 Munich, Germany

One of the aims of the European research project FINE-2 is to contribute to reducing noise and vibrations caused by railway traffic. In this context, the development of models describing the influence of relevant parameters on the excitation of train-induced vibration emissions were investigated in WP 8 “Ground Vibration” which is led by DB Systemtechnik. Here, resilient track components and especially under-sleeper pads were considered by a new modelling approach. Dependent on the dynamic stiffness of the relevant superstructure components, the model is based on the German standard DIN 45673-4, which describes an approach to compute the insertion loss of under-ballast mats by using an impedance model. The paper will show a general description of the model, the steps taken to adapt the existing model to consider under-sleeper pads instead of under-ballast mats, as well as results validated by using existing measurements.

Link to paper
The Vibration Reduction Index of Typical Canadian CLT Junctions

Jeffrey Mahn¹, Markus Müller-Trapet¹, Iara Cunha¹
¹National Research Council Canada, Ottawa, Canada

In support of the National Building Code of Canada, The National Research Council Canada has published research report RR-335 which describes the results of measurements of the transmission of structure-borne noise through junctions between mass timber elements. The Code only allows for the use of measured data for the vibration reduction index from the NRC's reports or reports from other research institutes. The Code does not currently allow for the use of empirical data for the calculation of the apparent sound transmission class of mass timber buildings. A lack of published data for typical mass timber junctions used in Canada can result in the overdesign of buildings or buildings which don't meet the acoustic requirements of the Code. The NRC has embarked on a program to measure the vibration reduction index of a number of mock junctions of typical junctions used in Canada including junctions between cross-laminated timber floors and lightweight timber framed walls. The new data will aid in the development of empirical models of typical Canadian mass timber constructions.

[Link to paper]
Sound source directivity considering source movement

Yusuke Makino¹, Yasushi Takano¹
¹Kyoto University, Graduate School of Engineering, Kyoto-City, Japan

When the source moves, frequency modulation (Doppler effect) occurs in the radiated sound, and the directivity of source changes. In addition, the source can be not located in a direction from the direction of arrival of radiated sound. Therefore, the sound pressure directivity may differ depending on whether the source is static or moving. There are two types of wave equations, one that describes sound pressure as a variable and one that describes velocity potential as a variable. When the sound source moves at a constant velocity and the equation is solved assuming that the source strength is constant with respect to the velocity, the sound pressure directivity of the radiated sound changes depending on the description method of the wave equation. The sound pressure was obtained by solving the wave equations where a single monopole source and a dipole source are moving at a constant velocity. From the results, we showed the difference of sound pressure directivity when source is moving from the directivity of static source.
Analysing changes in physiological response to different soundscape scenarios.

Manish Manohare¹, Elangovan Rajasekar¹, Tin Oberman², Francesco Aletta², Jian Kang², Manoranjan Parida¹

¹Indian Institute of Technology, Roorkee, Roorkee, India. ²UCL Institute for Environmental Design and Engineering, The Bartlett University College London, London, United Kingdom

Noise pollution is one of the key environmental stressors leading to multiple health impacts for people and communities. Exposure to high noise levels may also be responsible for sudden emotional and physiological changes in humans.

The experiment examines the change in Galvanic Skin Response (GSR) signals during exposure to pre-recorded soundscape scenarios. These scenarios were recorded in New Delhi, India and London, UK, using a binaural microphone set. The listening experiment was conducted in a laboratory, where 24 healthy individuals without any hearing impairment or any psychological issues participated. A total of 30 soundscape scenarios were presented to each participant in a randomised order.

The continuous decomposition analysis is conducted to decompose that data into tonic and phasic components. The phasic component of the signal is used for the analysis. It is observed that skin conductance response (SCR) increases with changes in the overall loudness of the signal. Psychoacoustic indicators are used to identify the relationship between different acoustical characters of noise and changes in SCR. The perception-based survey suggests that GSR response is highly dependent on the pleasantness level of the soundscape scenario.

Link to paper
An Heuristic Prediction Method for Managing Environmental Blast Noise Impacts

Gethin Manuel¹, David Waddington¹
¹Acoustics Research Centre, University Of Salford, Salford M5 4WT, United Kingdom

The aim of this work is to manage adverse environmental impacts from long-range blast noise. The work was carried out as part of ongoing research at the DNV Spadeadam Testing and Research site (STaR). STaR carries out crucial major hazards work including improving safety concerns within industry decarbonization sectors and government agencies. The site performs a variety of explosives testing, resulting in environmental blast noise at off-site residential locations. The site is surrounded by complex topography, with terrain featuring range-dependent ground impedance and thermal properties which in turn effects the local meteorology. While accurately modelling blast wave propagation through such environments using traditional computational methods is a computationally expensive task, the required complex and rapidly varying meteorological data are not adequately available. To address this deficiency, a data-driven heuristic method is proposed for the prediction of blast noise levels at several sensitive receivers ranging from 4-14km. The model is formed from a preliminary dataset of off-site blast noise measurements, correlated with a multivariate array of available meteorological data. A principal component analysis is used to determine the atmospheric features which are most influential to sound propagation, and predict the likely range of peak sound pressure levels expected. It is concluded that useful predictions over time scales from an hour to a number of days can be obtained for managing environmental blast noise impacts, and that further measurements of blast noise, along with further correlations with measured atmospheric conditions, could improve the performance of the model.
The Status of International Guidance and Standards for Environmental Noise Assessment

Douglas Manvell¹
²DMdB, Charlottenlund, Denmark

Since its first publication in 1971 of ISO/R 1996:1971 on Acoustics Assessment of Noise with Respect to Community Response, the International Organization for Standardization (ISO) has developed and published a range of standards for environmental noise assessment. The main ISO 1996 series of standards on Description, Measurement and Assessment of Environmental Noise has been developed in phases. And almost 30 years ago, ISO 9613 Attenuation of Sound During Propagation Outdoors was added. More recently, supporting standards such as the ISO PAS 20065 Objective Method for Assessing the Audibility of Tones in Noise and the ISO 17534 series concerning Software for the Calculation of Sound Outdoors have been added, and cooperation initiated with the International Electrotechnical Commission on the IEC 61400-11-2 Assessment of Wind Turbines Noise at receptor positions.

This paper provides an overview of ISO standards related to environmental noise assessment. It also describes the historical development of the ISO 1996 series and related standards. Current developments, including their status, are described. Finally, it provides some suggestions and considerations for further research.
Combining mobile measurements on noise and soundscape evaluation in a University Campus after a renovation plan.

Efstathios Margaritis\textsuperscript{1}, Ferry van Kann\textsuperscript{2}

\textsuperscript{1}University of Groningen, Groningen, Netherlands, \textsuperscript{2}University of Groningen, Groningen, Netherlands

This paper contributes on the popular topic of smartphone-based noise mapping and in general participatory sensing. It has a dual aim as on one hand it provides a methodological framework on the spatio-temporal variability of noise and soundscape and in parallel, it investigates the role of green space and water features on soundscape preference with respect to certain activities. The study was organised in Zernike University Campus in Groningen, the Netherlands around 13 predefined locations, equipped with seating facilities. A big part of the study area was recently redesigned as part of the Zernike promenade. Students, enrolled in the course of Environment and Engineering, used the ArcGIS 123 Survey and the NoiseCapture mobile applications for soundscape and noise data collection respectively. Statistical analysis and GIS tools were used to investigate the noise and soundscape variability in different time periods from morning to evening. Additionally, the effect of green space and water features on soundscape quality and users’ preference is identified by exploring the links with activities related to socializing and relaxing. The contribution of the above-mentioned technologies in participatory planning and urban design interventions is discussed parallel to the educational benefit of these tools in the achievement of the course learning objectives.

[Link to paper]
Noise-related challenges in combined commercial and military operations at an airport

Jan Anders Marheim\textsuperscript{1}, Michael Newman\textsuperscript{1}
\textsuperscript{2}Avinor AS, Gardermoen, Norway

At Harstad/Narvik Airport Evenes, a NATO QRA detachment using F-35 fighter planes has changed the noise characteristics at the airport dramatically. The challenges of determining the correct health hazard values to avoid hearing damage on passengers and employees at an operating airport is difficult. Initial noise mapping shows large areas around the terminal building and the car park with very high noise levels during F-35 take off using afterburner. The noise level increases rapidly during a take off but it is not comparable to an impact noise event. The focus of the work is twofold; Finding the right noise limits to reduce hearing damage risk to an acceptable level at the same time as establishing noise abatement measures that is necessary to avoid hearing impairment to employees and passengers on their way to and from aircraft. A noise limit of $\text{LASmax} = 115 \text{ dB}$ is established.

[Link to paper]
Perceptual acoustic space of tire noise

Thibaut Marin-cudraz¹, Juan J. García², Etienne Parizet¹
¹Laboratoire Vibration Acoustique - INSA Lyon, Villeurbanne, France, ²Applus+ IDIDA, Santa Oliva, Spain

Road traffic noise accounts for the majority of perceived urban environmental noise and has important health consequences. The rolling noise of vehicle tires is a major contributor to perceived road noise. The tread pattern of light vehicle tires is already designed to minimize the amplitude of the noise emitted, but this is not the case for heavy vehicles. The European LEON-T project aims to minimize the nuisance of heavy vehicle tires, especially noise. Prior to a study of the effects of tire noise on sleep, an experiment was conducted to determine the timbre parameters of such noise. The data set used was obtained by a series of recordings on a standardized track using tires of various sizes. These stimuli were presented to headphones in a free sorting task.

The presentation will show the results of this experiment, including the correlations between acoustic parameters and perceptual space structure determined from the groups formed by the participants.
Experimental investigation of a phase-cancelling slow-sound metamaterial with mean flow

Richard Martin, Bruno Schuermans, Nicolas Noiray

CAPS Laboratory, Department of Mechanical and Process Engineering, ETH Zürich, Zürich 8092, Switzerland

Acoustic metamaterials have a wide variety of potential applications in various engineering disciplines. In many cases, the acoustic medium can be assumed to be at rest. However, for a lot of engineering applications a moving fluid is used to transport energy or substances, or to perform mechanical work. For those cases, acoustic waves are advected and acoustic energy can be dissipated or generated. These effects play a significant role for the design of acoustic metamaterials.

In this work, an acoustic metamaterial with a low Mach number mean flow is presented. It is an array consisting of an even number of channels. Half of them are equipped with a slow-sound metamaterial, whereas the other half has unaltered sound propagation characteristics. Thus, the resonance frequencies of the channels are shifted. This results in a phase shift in the acoustic velocity response between both types of channels for a given pressure excitation, resulting in phase cancellation. However, this effect is weakened for higher mean flow velocities.
Relationship between vortex shedding noise and remotely-sensed surface pressure fluctuations of a structured porous-coated cylinder

Reza Maryami1, Elias J. G. Arcondoulis1, Chenghao Yang1, Yu Liu1
1Southern University Of Science And Technology, Shenzhen, China

Tonal noise suppression of a cylinder placed in uniform flow has been achieved, to some extent, by coating it with a structured porous material as a form of passive flow and noise control. A previously studied structured porous-coated cylinder is investigated in an anechoic wind tunnel to determine the relationship between the far-field vortex shedding noise and the pressure recorded on the outer porous surface. To date, no experimental studies have been conducted on the surface pressure of any type of porous-coated cylinder. Acoustic measurements are obtained using an equispaced microphone arc array and simultaneously unsteady surface pressure fluctuations are obtained around the cylinder mid-span circumference using remote-sensing techniques. By obtaining simultaneous time-dependent signals, more light is shed on the underlying noise-reduction mechanism of the structured porous-coated cylinder. In this paper, strong relationships between surface pressures and acoustic signals are revealed at the vortex shedding frequency. A spatio-temporal relationship between surface pressure and vortex shedding phenomena is also presented that helps explain the role of the structured porous media in passive flow and noise control.

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Wind turbine noise modeling including aeroacoustic sources and propagation effects: comparison against field measurements

David Mascarenhas¹, Benjamin Cotté¹, Olivier Doaré¹, David Ecotière², Gwenaël Guillaume², Benoit Gauvreau², Isabelle Schmich-Yamane³, Fabrice Junker⁴

¹IMSIA, ENSTA Paris, CNRS, CEA, EDF, IP Paris, Paris, France, ²Univ. Gustave Eiffel, Cerema, UMRAE, Lyon, France, ³EDF HYDRO-DTG, France, ⁴EDF Renewables, France

The study of wind turbine noise and its impact is of growing importance with the increase in the demand for green and clean energy. As it is known that wind turbine noise can be a cause of annoyance in the vicinity of wind farms it is beneficial to predict with certain accuracy the generated noise in the design phase itself. A crucial step is the validation of prediction models against field measurements (in-situ). This article presents a wind turbine noise prediction model that combines Amiet’s theory to calculate trailing edge noise and turbulence interaction noise in free field with a wide-angle parabolic equation valid in moving media to account for the long-range acoustic propagation effects. The model considers the wind turbine as an extended noise source and the rotation effects (such as the convective amplification and Doppler effect) are taken into account. The predicted noise levels are compared to those obtained from a measurement campaign where acoustic, meteorological and ground impedance data have been recorded simultaneously. First, the sound source model is validated close to the wind turbines for different wind speeds and directions. Then, noise predictions are compared to SPL measurements at various distances from the sound source, between 350 and 1300 meters.

[Link to paper]
The effects of different sound environments on physiological stress recovery and perceived restorativeness.

Massimiliano Masullo¹, Roxana Adina Toma¹, Juan Miguel Navarro Ruiz², Jorge Hernandez Bellot², Luigi Maffei¹

¹Università degli Studi della Campania “Luigi Vanvitelli”, Aversa (CE), Italy, ²UCAM Universidad Católica de Murcia, Murcia, Spain

In a threatening situation, various physiological and psychological processes are activated. The activation of the sympathetic nervous system, in particular, is responsible for the increase in heart rate, electrodermal activity, and negative emotions. According to Ulrich's theory, stress recovery involves physiological and psychological components, while the recharging of anabolic energy involved in the psychophysiological response to a stress factor falls under the broader concept of Restorativeness. Indoor, outdoor, natural and built environments can affect differently stress recovery and perceived Restorativeness. Through a test conducted within the Catholic University of San Antonio campus in Murcia (UCAM), this still ongoing study investigates the changes of some physiological variables and subjective assessment in different multisensory environmental conditions (i.e., acoustic, temperature, relative humidity) and presents some preliminary results.

Link to paper
Spatial Interpolation of Early Room Impulse Responses Using Equivalent Source method based on Grouped Image Sources

Haruka Matsuhashi¹, Izumi Tsunokuni¹, Yusuke Ikeda¹
¹Tokyo Denki University, 5 Senju-Asahi-Cho, Adachi-ku, Japan

The Room Impulse Response (RIR), which indicates the propagation characteristics of sound, is used in various acoustical applications. In particular, multi-point measurement of RIRs is important for applications that require spatial information, and measurement of these is difficult. Previously, spatial interpolation methods of RIRs based on physical models have been proposed. Especially, the sparse Equivalent Source Method (ESM) with Image Source Method (ISM) achieve the spatial interpolation of the early reflected sounds with higher accuracy at high frequency. However, this method has a problem that when the order of reflected sounds to be estimated increases, it becomes difficult to find the optimal solutions because the number of bases increases. In this study, to reduce the number of bases in each optimization problem, we proposed a sparse ESM with the image sources grouped by the arrival times of reflected sounds. The optimization problem for each group of image sources is individually solved. In the simulation experiment, it is revealed that the proposed method can estimate higher-order reflections with higher accuracy compared to the conventional method. In addition, we found that the estimated region with high accuracy became broader.
Causal-based acoustic optimization of micro-perforated structures with rigid backing

Teresa Bravo¹, Cédric Maury²

¹CSIC, Madrid, Spain, ²Ecole Centrale Marseille, Marseille, France

The acoustical design of compact micro-perforated absorbers (MPA) that exhibit high performance over a broad bandwidth is a difficult challenge, often faced in building, ventilation and transportation industries. A causal-based optimization criterion of the MPA constitutive parameters is considered as an alternative to the maximization of the frequency-weighted overall absorption. It maximizes the directional gradient norm of the total intensity reflection coefficient (in logarithmic scale) integrated over all positive wavelengths. The causal and standard optimization strategies are assessed for single- and double-layer MPAs as well as for MPA arrays, the former (resp. the latter) designs being supported by Kundt tube measurements (resp. finite element simulations). The causal criterion ensures perfect absorption and the broadest possible bandwidth at one or several Helmholtz resonances of the MPA, with efficient grouping and merging of these resonances for the optimized MPA array. The resulting performance are comparable to direct maximization of the total inverse-frequency weighted absorption.
Vibroacoustic simulations with non-homogeneous TBL excitations: Synthesis of wall pressure fields with the Continuously-varying Uncorrelated Wall Plane Waves approach

Corentin Guillon\textsuperscript{1}, Emmanuel Redon\textsuperscript{1}, Laurent Maxit\textsuperscript{1}\\\textsuperscript{1}Insa Lyon, Villeurbanne, France

A numerical method is presented to predict the vibro-acoustic response of a vibrating structure excited by a spatially inhomogeneous turbulent boundary layer (TBL). It is based on the synthesis of different realizations of the random pressure fluctuations that can be introduced as loadings of a vibro-acoustic model (such as a finite element model). To generate the pressures of the non-homogeneous turbulent boundary layer, the Uncorrelated Wall Plane Wave (UWPW) approach used so far for homogeneous TBL is extended. On a first step, this extension is based on a decomposition of the excited surface into sub-areas and on the averaged TBL parameters for each sub-area. In a second step, it consists in taking into account the interaction between the sub-areas and a refinement of the sub-area decomposition. This leads to the Continuously-varying Uncorrelated Wall Plane Waves (C-UWPW) approach. The accuracy of the proposed approach is investigated on a panel with a varying thickness and excited by a growing TBL triggered at one edge of the plate. The interests of the proposed approach in terms of accuracy and computation time are discussed. Finally, an illustration of the proposed approach to predict the radiated noise from a blade immersed in a water flow is proposed.

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Accurate reconstruction of point and transfer mobilities using the round-trip method

Ramin McGee¹, Joshua Meggitt¹, John Smith¹, Andrew Elliott¹
¹University Of Salford, Manchester, United Kingdom

The round trip method enables the indirect determination of point and transfer mobilities along interfaces that cannot be easily excited. One embodiment of the method requires excitation at a subset of points either side of the interface, while responses are measured along it. This is typically done by instrumented hammer or shaker. Alternatively, the excitation required can be generated by equipment operational in use, using the concept of the generalised transmissibility. In the present paper, we investigate the sensitivity of the round-trip method with respect to the number of remote measurement positions used, their locations, and signal-to-noise-ratio. Numerical and experimental examples are provided which demonstrate that there exists an optimum number of excitation and response positions for the accurate reproduction of point and transfer FRFs.

Link to paper
Prediction of impact noise from gym sources on resilient matting

Nikhilesh Patil¹, Martin Mcnulty¹
¹Hoare Lea Vibration, Manchester, United Kingdom

Controlling impact noise continues to be a challenging design issue in new and existing gyms. Within design and prediction phases, in-situ measurements on bare slab and flooring test samples are often required to reduce uncertainty. These can be intrusive, and to date, there is no consistent test methodology within the industry. This is further complicated by the nature of the problem comprising numerous source mass and height combinations, and the potential number of flooring samples to be tested. Emerging guidance within the UK will fill the gap on predictions for typical gym floors via reliance on engineering grade assumptions and empirical limits, however, this does not reduce the need for robust in-situ test data to complement predictive approaches. There is a need for a methodology bridging the gap between prediction and in-situ elements which is reliable, time efficient and can be used on wider source cases and in varied locations or structures. The paper presented discusses potential ways of simplifying prediction and testing strategies, with a view to estimating noise and vibration levels from bare slabs only. Furthermore, a potential method is showcased whereby the noise and vibration levels in the presence of a flooring solution can be predicted.

Link to paper
Appraising the performance of floating floors using dynamic sub-structuring methods

Martin McNulty1, Nikhilesh Patil1
1Hoare Lea Vibration, Manchester, United Kingdom

Floating floors are a common means of reducing airborne and structure-borne noise, however, prediction of in-situ performance remains a challenge for many consultants. The specification of such floors, usually based on single degree of freedom assumptions, does not account for the influence of floating floor dynamics, dynamics of host structures or interplay/power flow between the two via the isolating mounts. Reliance on single degree of freedom systems tend to over-predict the performance of the floating floor element, often leading to noise/vibration issues in the finished construction. A more robust approach is needed, though is challenging due to complexities in characterising large-scale constructions, where source-to-receiver Frequency Response Functions (FRFs) must account for multiple points of contact between floating and structural elements. This paper first presents a hybrid method for evaluating the source-receiver FRF of a simple floating floor via a sub-structured approach, and confirms the validity of the method to that of the source-receiver FRF measured directly. Efforts to simplify the analysis to a set of engineering-grade operations is also presented, the aim being movement towards a methodology that can be more readily utilised by practitioners, without the need for expensive modelling software or high end hardware setups.

Link to paper
Noise and soundscape in Welsh planning policy

Martin McVay1
1Welsh Government, Cardiff, United Kingdom

In Wales, noise policy now sits within the sustainable development framework of our Well-being of Future Generations Act. Under this Act, public bodies must look to the long term; take an integrated approach; involve a diversity of the population in decisions affecting them; work with others in a collaborative way to find shared sustainable solutions; and act to prevent problems from occurring or getting worse.

The Welsh Government has adopted a Noise and Soundscape Action Plan calling for the creation of appropriate soundscapes, meaning “the right acoustic environment in the right time and place”. We have rewritten Planning Policy Wales and included appropriate soundscapes amongst our National Sustainable Placemaking Outcomes.

We committed to providing further guidance to support planning policy on air quality, noise and soundscape, and drafted a new Technical Advice Note, with a supporting document on soundscape design.

Soundscape design in Wales means more than just design of the sound environment. It is a process giving as much weight to people and context as to the sounds themselves, from the outset. This approach is expected to be followed, referring to soundscape standards where appropriate, when and to the extent it may be expected to result in better placemaking.

Link to paper
The eventful environment that characterises Indonesia's urban soundscape


1Petra Christian University, Jalan Siwalankerto 121-131 Surabaya 60236, Indonesia, 2Ciputra University

Noise control is still one method to improve the urban acoustic environment in many countries, including Indonesia. The noise control tries to reduce the sound level in a particular space to increase comfort. In other words, the acoustic environment is designed to be comfortable and uneventful. Previous studies have shown that public spaces in Indonesian cities have a unique sound than cities in developed countries. Here, further studies to investigate whether the soundscapes of these cities are also unique are reported. Soundscape surveys added with sound pressure level (SPL) measurement and audio recording in 28 public places in ten major Indonesian cities indicate that a noise control approach to provide acoustic comfort and uneventful public spaces may not suit Indonesia. The analysis shows that, in general, the soundscape is perceived as an eventful environment, which is compatible with the SPL and audio recording. Furthermore, the results were significant among the ten cities. This study shows that soundscape improvement should focus on developing an environment that is perceived as eventful and comfortable at the same time. Therefore, a different strategy is needed to improve the acoustic environment in Indonesia.

Link to paper
Validation of three inherently different aircraft noise calculation programs

Jonas Meister¹, Stefan Schalcher¹, Jean-Marc Wunderli², Beat Schäffer¹
²Empa, Dübendorf, Switzerland

Aircraft noise affects large areas around airports. Noise calculation programs therefore need to account for air operations with high accuracy. In this contribution, we simulated several thousand single flights with the three aircraft noise calculation programs FLULA2, sonAIR and AEDT, and compared the results among each other and with corresponding noise measurements to evaluate their accuracy. While FLULA2 and sonAIR calculations are adjusted to local conditions, AEDT was run with default settings (NPD data and standard procedural profiles) to assess its performance when using unadjusted input data. We found that results of all three programs on average agree well with measurements and with each other. sonAIR is more accurate when using flight configuration data, but also in greater distances to the airports. Exemplarily adaptations of AEDT input data to local conditions showed that such adaptations clearly improve its calculation results. It was shown that, despite their inherently different modelling approaches, (a) all three programs are on average equally capable of reproducing the sound exposure in the vicinity of airports, (b) adaptions of input data to local conditions substantially improve results and (c) sonAIR is able to reproduce single flights with higher accuracy when provided with flight configuration data.

Link to paper
On homogenized ribbed-panel model for SEA analysis

Abderrazak Mejdi¹, Luca Alimonti¹, Bryce Gardner¹
¹Esi-north America, San Diego, United States

This paper presents an investigation into a recent model of homogenized rib-stiffened panels. An equivalent panel model is developed from the skin and the stiffeners of the panel. In this case a space-harmonic-based approach is used, and first-order shear deformation theory is employed to account for the wavefield’s in-plane/out-of-plane coupling effect in the skin. The panel’s stiffeners interact with the skin through internal forces and moments at the connections. A periodic FE mesh is then used to compute the wave dynamics and the results are used to develop the required terms to solve for vibro-acoustic results in Statistical Energy Analysis (SEA). This process is used to predict the vibro-acoustic response of an aircraft structure. The SEA results are compared with detailed FE models of the rib-stiffened aircraft structure.

Link to paper
Audio-frequency surface waves over multiple width and depth grooves

Steve Mellish¹, Shahram Taherzadeh, Keith Attenborough
¹The Open University, Milton Keynes, United Kingdom

Previous studies of airborne surface waves have been carried out at audio-frequencies over periodically rough surfaces formed by lighting lattices and bricks and at ultrasonic frequencies over mm scale compound gratings involving grooves of the same depth but different widths. In this paper, a modal model, which has been found to give comparable predictions to BEM while being much faster to run is used, together with BEM, to investigate audio-frequency sound propagation over grooves of varying widths and depths in the order of cm. Predictions of excess attenuation spectra, pressure contours and zeroes in the effective reflection coefficient over grooves with multiple widths and depths are used to indicate the nature of the surface waves which involve overlapping quarter wavelength resonances. Predictions are extended to multiple depth grooved surfaces without and with porous infills.
Deployment of an autonomous system for noise monitoring based on digital MEMS microphones

Felipe Ramos de Mello¹, William D’Andrea Fonseca¹
²Federal University Of Santa Maria, Santa Maria, Brazil

Noise monitoring is a useful diagnostic tool for making better decisions in noise control projects and understanding the sonic behavior of a place. Traditionally, sound pressure levels are measured using a sound level meter (SLM), usually for a limited time frame. However, recently much interest has arisen in developing wireless sensor networks that work continuously, especially using cost-effective embedded systems. In this sense, digital micro-electrical-mechanical (MEMS) microphones are a great promise in creating such devices due to their low-cost, high-quality, and integrated analog to digital converter. This paper presents a noise monitoring system based upon digital MEMS microphones and an Arduino compatible microcontroller (Teensy). The system connects to a server through an ethernet cable (providing also a power supply), and sound pressure level data is saved both on the server and an SD card (for redundancy). Furthermore, a backup power supply guarantee that the system continues working even in power shortage situations. The device was deployed in an office and successfully measured throughout a week. Ultimately, the system could be applied to indoor noise monitoring (such as in condominiums and buildings) and used to assess the effectiveness of noise control projects, for example.

[Link to paper]
Acoustic comfort at Kyiv metro stations

Illia Melnyk¹, Yevhen Fridlib, Artem Maksymenko, Hanna Klisuhnichenko

¹Acoustic Group, Kyiv, Ukraine

Kyiv Metro was opened in 1960 and became the first metro system in Ukraine. From then until the beginning of the 21st century it was developing without considering the acoustic comfort of its passengers and employees. Increased levels of noise and vibration in public transport are mostly ignored, although they are certainly recognized as the reasons for increasing the harmfulness of work for metro employees. The present report analyzes noise levels at metro stations depending on their design features. There are several main types of stations in the Kyiv metro: deep-lying, shallow-lying, as well as above-ground stations. For all types of underground stations, there are options both with and without sound-absorbing finishes. Also, during the construction of the newest stations of the Kyiv metro, vibration isolation systems were used for the construction of the permanent way were used. Within this study, sound pressure levels were measured on the platform at stations of various types. These measurements made it possible to establish a significant influence of the shape of the station vestibule, the presence of sound-absorbing finishes in it, as well as the vibration isolation of the permanent way, on the objective and subjective parameters of acoustic comfort for passengers and employees of the subway.

Link to paper
Acoustic performance of a heat exchange silencer for marine diesel engine

Lianghu Meng\textsuperscript{1,2}
\textsuperscript{1}Harbin Engineering University, Harbin, China, \textsuperscript{2}Henan Diesel Engine Industry Co., Ltd, Luoyang, China

For the noise contribution of a marine diesel engine, exhaust noise plays an important role, especially considering its low frequency characteristics. The marine exhaust silencer is an effective device to attenuate the engine exhaust noise. Expansion chamber or resonators have been the backbone of almost all marine exhaust silencers, but issue of bulkiness remains. It is well known that the passband for an expansion chamber is related to its geometric length. For a fixed firing frequency, if the exhaust gas is cooled, then the wavelength of the firing frequency can be reduced. Inspired by this principle, the heat exchanger and silencer are combined to improve the low frequency effect of the device. Various reactive configurations are tried to get a well-balanced silencing effect. The effectiveness-number of transfer unit method and acoustic finite element method are adopted to calculate the noise reduction effect with or without exhaust gas cooling. It is concluded that that the heat exchange silencer has satisfactory cooling effect on the exhaust gas, but its contribution to noise attenuation is very limited. Since the reduction of the exhaust gas temperature, low-frequency performance of the silencer is enhanced.
A simulation study on the influence of aircraft panel thickness on the cabin sound quality

Zhenjing Miao¹, Yu Huang¹
²Shanghai Jiao Tong University, Shanghai, China

Currently, noise control aims to optimise the psychoacoustic characteristics of aircraft interior noise to improve comfort and security during a flight. This study investigates the influence of transmission loss of aircraft panels on the sound quality of the cabin. We established an aircraft cabin acoustic model based on the statistical energy analysis method. The psychoacoustic parameters (i.e., loudness, sharpness, roughness, psychoacoustic annoyance, and articulation index) were simulated with the varying thickness of the aluminium alloy layer. Results showed that loudness and roughness significantly reduced, whereas sharpness increased with increasing thickness. The noise annoyance also declined as the thickness increased. However, the articulation index appeared a sudden drop when the thickness increased.

[Link to paper]
Application of the transfer path analysis to vehicle doors

Thomas Michaelis¹, Steffen Marburg², Stefanie Retka¹

¹University of Applied Sciences Würzburg-Schweinfurt, Ignaz-Schön-Strasse 11, 97421 Schweinfurt, Germany, ²Technical University of Munich, Chair of Vibroacoustics of Vehicles and Machines, Boltzmannstrasse 15, 85748 Garching b. München, Germany

Transfer path analysis (TPA) is a proven method for identifying critical structure-borne and airborne sound paths. The basic idea is to divide the overall system into an exciting active component (source) and a passive component, e.g. the mechanical structure to be investigated, with their respective measurement points. By separating them, two independent systems are created, whereby on one hand, the excitation behaviour can be characterised and on the other hand, the transmission behaviour can be assessed. Finally, both systems are validated by comparing them to each other and deciding whether changes to source or structure are required or not. The advantage is the simple description of the source as a black box without complex modelling. In this contribution, this systematic is applied to window regulator systems as they are found in vehicles. The focus is on a hybrid approach between experimental and numerical transfer path analysis. For this purpose, the basic workflow of suitable TPA methods is discussed. This includes the operational measurement of different exciting electric motors variants, the determination of the transfer functions of the structure, the calculation of the contact forces and the analysis of the individual transfer paths.
Active Sound Power Attenuation with a Ring of Harmonic Acoustic Pneumatic Sources for Destructive Interference (RHAPSODI) and near field in-duct microphones

Philippe Micheau\(^1\), Julien Drant\(^1\), Alain Berry\(^1\)
\(^1\)CRASH-UdeS, Université De Sherbrooke, 2500 Blvd de l’universite, Canada

Much research has been conducted to investigate active noise control of turbofans with loudspeakers as noise cancellation sources. However, the required power consumption, fragility, and weight and volume penalty make them unsuitable for engine nacelle applications. An alternative source technology, developed at Sherbrooke, is a harmonic acoustic pneumatic source (HAPS). They are mounted on a ring to perform multimodal active noise control in duct by destructive interference of primary noise (RHAPSODI). A dedicated MIMO harmonic control strategy based on complex envelopes is required to control the RHAPSODI with in-duct microphones located at a very close distance from it or with external in-duct microphones located 1 meter away from the duct mouth. During a training phase, active radiated power minimization is performed with the external microphones for different modal components of the primary harmonic noise. The optimal HAPS control and the optimal signals from the in-duct microphones are then used to tune the specific MIMO controller with a field compensation matrix close to the in-duct microphone signals. A typical result shows that RHAPSODI using 5 in-duct microphones and 5 HAPS can provide high attenuation of radiated sound power (22 dB-SPL, 1 kHz, primary sound power 130 dB).
Effects of differences in speaker performance on sports performance - Behavior analysis using OpenPose

Satoshi Miharu

Kanagawa Institute of Technology, 1030 Shimo-ogino, Atsugi City, Kanagawa, 243-0292 Japan, Japan

Most of the sound quality evaluation methods for loudspeaker are based on physical evaluation and subjective evaluation. In the physical evaluation, we focus on the peak sound pressure and the rise speed. In the subjective evaluation, the sound quality is evaluated by the subjective evaluation experiment using the sound quality evaluation word. However, it’s difficult for people who don’t have professional knowledge in the field of acoustics to judge the performance of a loudspeaker from these evaluation methods. In addition, according to the engineers of a speaker manufacturer, the difference of the sound quality of the loudspeaker may affect the movement and motivation of the game. In this study, aims to evaluate the sound quality of loudspeaker objectively from a new point of view. In order to clarify whether the difference of the sound quality of the loudspeaker affects the movement, the movement analysis using OpenPose was carried out. As a result, it was found that the complicated motion was not likely to be affected by the difference of the sound quality of the loudspeaker. However, the results suggested that simple and familiar actions may be affected by the difference in loudspeaker sound quality.
Study on Sound and Vibration Propagation Caused by External Flow Affecting Interior Noise of Railway Vehicles

Gaku Minorikawa¹, Kousuke Hotta², Noboru Yamano¹
¹Hosei University, Koganei, Japan, ²Nippon Sharyo Co., Ltd., Nagoya, Japan

Among the aerodynamic noises generated by Railway Vehicles running at high speed, the noise generated by the structure on the roof not only affects the environment along the railroad tracks outside the vehicle, but also propagates inside the vehicle, damaging the comfort of the cabin. Exterior noise is a phenomenon in which aerodynamic noise generated by the structure propagates, and the source of the noise has been clarified and predicted. On the other hand, interior noise is a combination of flow-induced aerodynamic noise propagating acoustically and structural excitation caused by pressure fluctuation due to wake vortices around the structure, and these two phenomena have not been investigated quantitatively. In this study, the effects of aerodynamic noise generated by structures in the airflow on the acoustic environment inside and outside the vehicle were experimentally investigated using a small low-noise wind tunnel from the viewpoint of source and propagation characteristics, and practical modeling of these effects was attempted. In addition, the characteristics of the sound source were investigated in detail by computational aeroacoustic analysis.

Link to paper
Tyre/road noise measurements on ISO tracks using the modified CPX method

Piotr Mioduszewski¹, Truls Berge²

¹Gdansk University Of Technology, Gdansk, Poland, ²SINTEF AS, Trondheim, Norway

Tyre rolling noise test method specified in the UNECE Regulation 117 is directly used in the Tyre Labelling Directive. Noise level specified on EU Tyre Label of each new tyre available on the European market was determined based on vehicle coast-by noise measurements performed on the standard reference road surface proscribed in the ISO 10844:2014. Available data from investigations by the vehicle and tyre industry and results from the STEER project show that the effect of ISO test track is significant.

To estimate the noise variation on existing ISO test tracks, a small Round Robin Test was conducted on 3 of them, as a part of the joint Polish-Norwegian project ELANORE. The modified CPX method was used for this purpose. Measurements were performed for 9 selected tyres of summer, winter and all-season type, with label noise values ranging from 66 to 74 dB. Additionally, 2 standard reference tyres, P1 (SRTT) and H1 (Avon AV4), specified in the ISO 11819-3:2017 were tested.

The obtained differences in noise levels for the tested tyres were up to 3.7 dB depending on test track. The ranking of tyres regarding measured noise levels didn’t correspond at all to the noise values given on tyre labels.
Assessment of a Statistical Energy Analysis model to perform automotive acoustic comfort subjective evaluation

Valentin Miqueau, Etienne Parizet\textsuperscript{1}, Sylvain Germes\textsuperscript{2}

\textsuperscript{1}Laboratory of Vibration and Acoustic, Lyon, France, \textsuperscript{2}Saint-Gobain Research Compiègne, Thourotte, France

Saint-Gobain is currently developing Statistical Energy Analysis models in order to predict the mid-high frequency airborne interior noise generated by the wind excitations on vehicles. Our objective is to assess the possibility of using the predictions of this model to perform subjective evaluation of the acoustic comfort inside the cabin. This way, as a tier-one supplier of automotive glazing, Saint-Gobain could investigate psycho-acoustic evaluations earlier in its design process.

A car equipped with several sets of glazing was exposed to an in-lab representative excitation to record an experimental set of sounds. Concurrently, those car configurations were simulated using the model and a numerical set of sounds was auralized. Both sets were compared through two jury testing campaigns. The campaigns highlighted that the participants gave similar evaluations of sounds regardless of their origin set. However, the ratings were not exactly the same between measurement and simulation. The definition of the glazing inside the model and/or its interaction with elements linked to it, like the window seals, might be the cause of those rating differences. More investigations were thus conducted to assess the influence of the window seals on the acoustic insulation performances of the glazing.
Modelling of piano string vibration using coupled mobilities and a state-space approach

Pablo Miranda¹, Giacomo Squicciarini², David. J Thompson¹
¹University of Southampton, Southampton, United Kingdom
²University of Southampton, Southampton, United Kingdom

In musical acoustics a double decay can occur if there are two decay slopes in the sound envelope with the second part of the time history having a less pronounced slope than the first. In piano strings the double decay can be caused by the differences between the decays of vibration in the two transverse directions of a single string: normal and parallel to the soundboard. Herein we aim to reproduce this phenomenon by coupling a stiff string model and the soundboard, in both frequency and time domain, using mobility coupling and state-space model approaches.

The dynamics of a stiff string tensioned between the two end pins but disconnected from the soundboard bridge is first studied. The two transverse directions of vibration are assumed to be uncoupled due to symmetry. On the contrary, the soundboard mobilities at the point of connection with the string can be represented by a multidimensional (2x2 in this work) and fully populated matrix implying coupling between different directions. The string and the soundboard will be connected by means of frequency and time domain models to show the importance of the cross-mobility terms on the vibration response and double decay of the string.

Link to paper
Influential Factors on Recognition of Sound Emitting Direction Using in Evacuation Guidance System

Tetsuya Miyoshi

1 Hannon University, Matsubara, Japan

It is difficult to find an appropriate evacuation route in complicated buildings and underground malls. Therefore, evacuation guidance systems using sound and light has been proposed. The method of the emitting sound was proposed as one of them. In this evacuation guiding method, several influential factors such as speaker setting configurations and sound emitting methods affect the recognition of the emitting direction of sound. In this paper, we discuss the sound emitting configuration to improve the performance of the sound direction recognition through the experiments changing the emitting configurations of audio speaker distance and emitting time interval.
Numerical prediction method for vibration characteristics of steel-framed ALC floor structure

Haruki Mizunuma¹, Takumi Asakura¹, Yasuhiko Ishiwatari³, Takayuki Shiraishi³, Fumiaki Satoh²

¹Tokyo University of Science, 2641 Yamazaki, Noda-shi, Chiba Prefecture 278-8510, Japan, ²Chiba Institute of Technology, 2-1-1 Shibazono, Narashino, Chiba 275-0023, Japan, ³CEL Corporation, 3-7-1 Kyobashi, Chuo, Tokyo 104-0031, Japan

The prediction of floor vibration is of great importance from the viewpoint of accurate prediction of sound environment. In this paper, applicability of the finite-element analysis to the vibration simulation of autoclaved lightweight aerated concrete (ALC) floor structure on a steel-framed structure was verified. The results of a numerical case study has confirmed that the numerical coupling scheme of the ALC floor panels and the steel-framed structure had a significant influence on the simulated vibration characteristics of the ALC floor panels. Then, the validity of the proposed method was finally confirmed by comparison with the measurement results.

[Link to paper]
Nonlinear characterization of azimuthal combustion instability exhibiting flame transient phenomena

Balasundaram Mohan¹, Sathesh Mariappan¹

¹Indian Institute of Technology Kanpur, Kanpur, India

This article characterizes the nonlinear features observed in an annular combustor exhibiting self-excited azimuthal thermoacoustic instability. The annular combustor consists of 12 burners with flames stabilized by bluff bodies protruding into the combustion chamber. This burner configuration closely resembles the flame stabilization geometry and flame shape in ramjet and afterburners configurations. As a first step, two different bluff bodies stabilize the flame: 1) circular and 2) conical and associated instability dynamics are characterized. The combustor exhibits intermittent oscillation in pressure with dominant 1A-1L (first azimuthal – first longitudinal) acoustic mode at about 630 Hz. The duration of periodic oscillation in the intermittent pressure fluctuation varies non-monotonically with the airflow rate. Further, relatively large amplitude pressure fluctuations are observed for intermediate values of airflow rate in both flame stabilization. During these large-amplitude pressure fluctuations, localized flame extinction in certain burners is observed, leading to partial blow-off operation of the combustor. This localized flame extinction is subsequently followed by either successful or unsuccessful re-ignition, leading to introduction of slow time scale heat release rate modulation in the problem. Further, this slow time scale heat release rate modulation is stochastic, contributing to the appearance of intermittent oscillation in pressure.

Link to paper
RENAULT Smart Cocoon Technology CAE

Philippe Mordillat
Renault Group, 1 Avenue Du Golf 78288 Guyancourt Cedex, France

RENAULT was the first OEM to introduce mass production Battery Electric Vehicles in Europe with the ZOE in 2012. With the new Megane ETECH, RENAULT set the NVH comfort to higher level to match the customer expectations on BEV vehicles. One of the components that contributes to the silence of Megane is the “Smart Cocoon Technology”. This innovative solution has been developed to transform the battery into an acoustically active element. An insulation foam has been embedded between the body floor and the battery casing in order to use the battery mass to improve the floor transparency and damping, and subsequently the Transmission Loss.

To support further developments of this technology RENAULT and its CAE partners are developing a simulation methodology to achieve simultaneously three goals: predict the behavior of the smart cocoon technology on the whole vehicle NVH performance, optimize the performance and weight of the insulation package, and secure the assembly process. This paper presents in detail each step of this process. Non-linear simulations of the battery assembly process are used to capture the preloading effects in foam and body panels. The vehicle high frequencies NVH performance is then simulated for vehicle rolling conditions. In a last part of the paper, CAE results are compared with the test measurements on the Megane prototype.

Link to paper
Experimental tests of a multichannel active noise control system with single and multiple reference signals applied to the cabin of a tractor

Francesco Mori\textsuperscript{1}, Paolo Bonfiglio\textsuperscript{2}, Patrizio Fausti\textsuperscript{1}, Francesco Pompoli\textsuperscript{1}, Andrea Santoni\textsuperscript{1}
\textsuperscript{1}University of Ferrara, Engineering Department, Ferrara, Italy, \textsuperscript{2}Materiacustica s.r.l., Ferrara, Italy

A feedforward active noise control system represents a valid solution whenever it is necessary to attenuate a disturbing noise at low frequency. One example of application is the case of tractors, in which the agricultural operators are exposed for several hours per day to loud noise at low frequency, mainly generated by the engine. Generally, the feedforward systems make use of one reference sensor to measure the noise produced by the main source. However, this way of proceeding could be inadequate to describe the disturbing noise, especially when the noise is divided both in structure-borne and air-borne components. In this article, a comparison between the use of a single and multiple reference signals, processed in a multichannel active noise control system applied to the cabin of a motionless tractor, is proposed. In particular, an accelerometer positioned on the turbocharger is used to sense the vibration generated by the engine, while a microphone placed near the engine is used to measure the air-borne noise. The active system implements the filtered-X least mean squares (FXLMS) algorithm to produce the anti-noise signals. The results show that the use of two simultaneously acquired reference signals improves the performance of the active system.

Link to paper
Study on Power-level Measuring Method of Structure-Borne Noise of Viaduct Road

Tatsuaki Mori, Kimikazu Ikeya, Tomoyuki Itiki, Akinori Fukushima

NEXCO Research Institute Japan, Tadao 1-4-1, Machida City, Japan

Noise is generated when vehicles running on the viaduct road cause the structure to vibrate. The authors studied a measuring method for the power levels of structure-borne noise of viaducts, generated when tyres of running vehicles excite the road surface. This paper reports on the findings of the study on the effects of diffracted noise and measuring positions on the measured power levels.

On the effect of diffracted noise, as a result comparing the structure-born noise measured at a point on the boundary of the road bridge site with a value gained by subtracting the diffracted vehicle noise from the measured noise, it was confirmed that the effect of diffracted noise is sufficiently low. As for the influence of measuring positions, when comparing values measured at a position located 1.2 m above ground with those at 0 m, a difference of about 3 dB was found. Considering the fact direct waves and ground reflected waves synthesize, it was confirmed that the difference is valid. As this study shows, influences of diffracted waves and measuring positions are small, and based on these results, the practical measuring method is proposed.

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Study on the objective assessment of sleep disturbance due to environmental noise by wearable devices

Makoto Morinaga¹, Chikashi Takara², Yosiaki Sasazawa³, Hiroshi Nakamura²

¹Kanagawa University, Yokohama, Japan, ²Nakamura Clinic, Urasoe, Japan, ³University of Ryukyu, Nishihara, Japan

Introducing noise standards or limits at night is necessary to prevent sleep disturbance due to environmental noise, such as transportation noise. In general, noise standards should be based on robust exposure-response relationships derived from many human response data, and subjective evaluation obtained from large-scale socio-acoustic surveys can provide reliable scientific evidence. However, it is also necessary to investigate an easy method to collect objective data on sleep effects with little cost and effort. In the present study, we conducted a laboratory study and investigated how accurately wearable devices can estimate the sleep stage. Participants wore a smartwatch installed with photoplethysmography (PPG), a portable ECG, and equipment of PSG simultaneously. As a result, the agreement of the sleep stage between the estimations by PPG and by PSG was moderate (kappa coefficient = 0.47). Furthermore, we estimated the sleep stage by random forest using the data measured by the ECG, and it was highly agreed with the sleep stage by the PSG (kappa coefficient = 0.75). It is suggested that we could easily estimate the sleep stages such as waking, REM, and non-REM with a certain level of accuracy by these wearable devices.

Link to paper
A laboratory investigation into the threshold of the oppressive or vibratory feeling to low-frequency pure-tone

Makoto Morinaga¹, Shigenori Yokoshima², Tomohiro Kobayashi³, Sakae Yokoyama³, Koichi Makino³, Tetsuya Doi³

¹Kanagawa University, Yokohama, Japan, ²Kanagawa Environment Research Center, Hiratsuka, Japan, ³Kobayasi Institute of Physical Research, Kokubunji, Japan

The feeling of oppressive or vibratory due to low-frequency sound is widely known as a sensation inherent to low-frequency sound. Some previous studies showed the frequency characteristics of sound pressure levels that induced an oppressive or vibratory feeling, finding that these feelings tended to occur prior to others. However, the threshold of the feeling has not been investigated yet. In the present study, we conducted a laboratory experiment and investigated it by the method of adjustment. The participants adjusted the sound pressure level by themselves, at which they started to feel an oppressive or vibratory sensation. The frequencies of the stimuli were 20 Hz, 40 Hz, 50 Hz, 63 Hz, and 80 Hz. The results showed that the higher the frequency was, the lower the threshold it was, in the range of the frequency of the present experiment. Also, the threshold is largely different among the participants, and the higher the frequency, the more pronounced it was. In the future, we will examine the validity of the results using a different method from that in the present study.
Flow and surface loading induced by a supersonic jet over an aft deck

Philip Morris¹, Darryl Douglas¹
¹Penn State University, State College, United States

Aircraft designs may include an engine that exhausts over the upper fuselage of the aircraft. This design has many benefits including reduced noise below the aircraft. However, the scrubbing of the high-speed turbulent jet flow over the fuselage has the potential to cause structural fatigue. This paper describes a joint experimental/computational study of the surface pressure fluctuations induced by the supersonic jet flow. The model configuration consists of a rectangular convergent-divergent nozzle that exhausts over a flat plate. The plate is a continuation of the lower lip of the nozzle. Pressure measurements are made at several locations on the plate surface. In addition, schlieren visualization is used to identify the jet’s shock cell structure. Numerical simulations are performed using Large Eddy Simulation (LES). Results are compared between the simulations and the experiments. The importance of shock turbulent boundary layer interaction to the surface loading is identified.

Link to paper
Use of Sound “PHONONS’ in the modelling and Optimisation of automotive acoustic systems in 3D

Rodney Morris-kirby

Adler Pelzer Group, 33 Barrys Lane, Padstow, Cornwall, United Kingdom

Automotive manufacturers demand components with an ever higher acoustic performance combined with lower environmental impact, tuned to the emerging EV market, and are pressured into reducing lead times and prototype investment. Consequently, there is a desire for enhanced simulation techniques, utilizing advanced methods. The three-dimensional aspect of many palliative treatments can be shown to afford significant benefits to their acoustic performance, both in their transmission loss and random incidence absorption characteristics.

Virtual system engineering enables construction fundamentals to be created in CAD, but often acoustic treatments are chosen based on flat sample performance or simple power balance models. These do not tell the complete story. Current acoustic simulation techniques such as SEA, may present the model in a 3D environment to aid in visualization but, solving is done on a 2D matrix basis, and does not account easily for diffusion and refractive interaction caused by the complex shape of the component under investigation. BEM and FEM techniques are 3D based simulations but have a host of limitations due to mesh density and available processing power. Constructing models of individual palliatives such as wheel arch liners, dash insulations or carpets using such techniques may be of academic interest but of restricted use in the pressured world of component design and manufacture. It is not helped by the need to furnish the model with accurate, validated, material performance data. A modelling procedure was required that could import component CAD from the product design team and rapidly create an acoustic model that could accurately predict its performance in both a transmission loss suite and associated random incidence “Alpha cabin” absorption test. Thus, short circuit the need for at least one if not more prototype test phases or enable quotations for new business to be formulated with a higher degree of clarity. Subsequently to export results from this model into a range of “full vehicle” modelling environments or compare to prototype test results. After considerable research the authors created and validated a toolbox approach using a combination of open-source code together with bespoke modifications and defined processing procedures.
Costing the benefit of low noise surfacing

Matthew Muirhead

AECOM, Basingstoke, United Kingdom

Low noise pavements are an important mitigation measure in the drive to minimise the impact of traffic noise on all our lives. The benefit provided by such surfaces is an important element of any associated life cycle cost analysis. There are existing methodologies for monetising the relative noise reductions from quieter pavements in terms of the societal cost of the associated health benefits. However, this approach requires input data on the potential reduction in exposure to traffic noise. For a particular road scheme such data are often derived from a detailed noise model, but this is not possible when considering potential benefits at a regional or national level. This paper examines potential approaches in estimating the comparative reduction in traffic noise exposure between different surface types at this strategic level. This includes methods for considering population density, noise exposure and the extent to which a low noise surface will impact the surrounding sound environment.
Virtual work experience in acoustics

Matthew Muirhead¹, Vicky Wills²
¹AECOM, Basingstoke, United Kingdom, ²Atkins, Epsom, United Kingdom

The Institute of Acoustics is in the process of organising a virtual work experience for up to 1000 GCSE and A-Level students. Unlike traditional workplace work experience, the virtual environment will provide an overview of the acoustics industry, an opportunity to engage with a large number of students from anywhere in the UK and a window to show young people the huge range of careers in acoustics. Through this initiative it is hoped that we will be able to inspire a pipeline of future acousticians.

The work experience has been designed to run over two weeks, for 1 hour a day, and will include engaging content like videos, games, activities and live webinars. The modules will cover careers in consultancy, research, local authority, medical science, music and technology, and will cover the range of career pathways into our industry.

This paper outlines the collaborative approach taken in creating and curating the virtual work experience programme. It gives an insight into structuring an inclusive and exciting experience for students and discusses the lessons learned from attempting to successfully showcase such an inherently diverse subject.

[Link to paper]
A fully-coupled vibro-acoustic model of an electronic stethoscope

Snehashis Mukherjee¹, Anoop Akkoorath Mana¹

¹Department of Mechanical Engineering, Indian Institute of Technology Palakkad, India

A piezoelectric based stethoscope picks pressure fluctuations originating from the patient and the physician sides. This may include unwanted acoustic signals from the patient and the doctor sides of the stethoscope, which needs to be filtered either electronically or mechanically by appropriately designing the vibro-acoustic elements of the electronic stethoscope. This work intends to establish a mathematical model of the piezoelectric stethoscope. Initially, a multi-degrees of freedom vibration model of the electronic stethoscope is developed. The model is used to compute the response of the piezoelectric plate due to the pressure excitations on the input side and that due to the displacements of the connected mechanical elements in the stethoscope. Further, a two-port lumped parameter model of the piezoelectric composite plate is developed to compute the output voltage created by the displacement of the piezoceramic disc. Here, an axisymmetric plate vibration model (Kirchhoff’s plate theory) is used to find the displacement of the piezoelectric composite plate. Subsequently, the vibration and the lumped parameter piezoelectric models are combined to represent the vibro-acoustic characteristics of the piezoelectric stethoscope. Further, using the developed fully-coupled vibroacoustic model, the output voltage of the device is studied for different patient and physician side excitations.

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Acoustic wave propagation through panels that are made of used tea bags

Stefano Mundula1, Haydar Aygun

1London South Bank University School of the Built Environment and Architecture, London, United Kingdom

These days more than ever, society habits raise the necessity to consider the future of the environment. This presentation will tackle the aspect of more eco-friendly acoustic materials, more specifically analysing the properties of consumed tea bags, starting from the collection up to the application and measurement of the final product. Many good options are often avoided, or not implemented for the lack of reliable properties analysis, encouraging existing materials to be chosen instead, the more information could be found about new materials, the more these could have a chance to be used, compared, or eventually improved. Sound absorbing panels that are made of tea bags were designed and developed to investigate acoustic sound transmission through tea-bag panels. Measurements were carried out on tea-bag panels in an impedance tube using a transfer function method to determine their sound absorption and transmission loss. Furthermore, the impedance gun system was used to determine acoustical properties of larger panels. Results show that 70 mm thick panels give an absorption coefficient higher than 0.8 between 500 Hz and 1600 Hz while 17 mm thick panels give an absorption coefficient that is mostly effective at higher frequencies. Up to 9 dB sound transmission loss is obtained at some frequencies.
Fan Noise Reduction by Acoustic Liners Combined with Fine-Perforated-Film: Noise Tests by a Small Turbofan Engine DGEN 380

Yo Murata¹, Tatsuya Ishii², Shunji Enomoto², Hideshi Oinuma², Kenichiro Nagai², Junichi Nagai², Hirofumi Daiguji¹

¹Department of Mechanical Engineering, The University of Tokyo, Tokyo, Japan, ²Aviation Environmental Sustainability Innovation Hub, Aviation Technology Directorate, Japan Aerospace Exploration Agency, Tokyo, Japan

Resonant-type liner panels are one the primary countermeasures for the fan noise of aircraft engines, though the sound absorption performances of the liners are known to be tolerated by the grazing flow streaming on their surface. Therefore, suppressing the effect of the flow on the liners is greatly important for higher sound absorption efficiency. In this study, liner panels with special surface structures were manufactured and applied to an outdoor test using a small turbofan engine, DGEN 380. A special thin film, Fine-Perforated-Film (FPF), was applied to two liner samples. In the first sample, FPF was applied directly to the surface of a typical liner. In the second sample, a gap was fixed between the FPF and liner surface. In addition, a rigid wall and a typical liner were used for comparison, to investigate the effect of the structures. During the test, the samples were installed to the exhaust bypass duct of the DGEN engine. The acoustic pressure inside the duct and in far field was measured. Analysis and comparison of the results showed that the new structures suppressed the effect of the grazing flow and caused a larger amount of noise reduction, compared to the typical liner sample.
Using burden of disease or harmful effect assessments for quantifying health impacts from environmental noise?

Enda Murphy¹, Jon-Paul Faulkner¹

¹University College Dublin, Dublin, Ireland

Commission Directive (EU) 2020/367 describes how harmful effects may be calculated for ischemic heart disease (IHD), high annoyance (HA), and high sleep disturbance (HSD) for road, rail, and aircraft noise. However, traditionally the negative health impacts of environmental noise have been assessed using the WHO's Burden of Disease methodology. In terms of evaluating how harmful effects and burden of disease methodologies compare in terms of the requirements for calculation, interpretation of results, practical application, and suitability for measuring the negative health impacts of environmental noise, our analysis suggests that the EU's harmful effects assessment may be a superior methodology because: 1) the harmful effect methodology is more efficient, less health data is necessary, and it requires less calculation; 2) for assessment that requires the application of national incidence statistics, results can be obtained for spatially localised areas as opposed to overall national figures; and 3) results from harmful effect assessment may be easier to interpret. However, it must also be emphasised that the pervasive application of burden of disease assessment means that comparative analysis with non-noise-induced disease states is possible, whilst this is not possible with harmful effect assessment.

Link to paper
A quantitative approach to density-based clustering of flight trajectories for efficient air traffic noise simulations

Shreyas Mysore Guruprasad¹, Gil Felix Greco¹, Tobias P. Ring¹, Sabine C. Langer¹
¹Technische Universität Braunschweig, Institut für Akustik, Braunschweig, Germany

The continuous growth of air traffic and increased availability of open source data has enabled the application of data-driven approaches for the prediction of noise contours around airports. Aiming at efficient noise simulations, this contribution proposes a framework for the probabilistic description of the air traffic around an airport. The methodology is based on using the density-based clustering algorithm OPTICS to cluster flight trajectories. The clustered trajectories serve as a basis for the creation of backbone and dispersion tracks, which, together with a prescribed number of flight operations per aircraft type, provide a probabilistic description of the air traffic to the noise simulations. A major focus is given to quantitatively assess the sensitivity of the OPTICS algorithm to different hyper-parameters to reduce the dimensionality of the problem. This framework is demonstrated utilizing a dataset of ADS-B trajectory data associated with flights approaching Hannover airport. Noise simulations based on the ECAC Doc. 29 best-practice method are conducted using SoundPLAN. A good agreement between noise contours is obtained when comparing simulations performed using the proposed framework and the full dataset while the computational time required decreased. Furthermore, this approach identifies most of the trajectory patterns with the least amount of outliers.

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A slug length calculation for a contraction with mean flow between two half cylinders

Wei Na¹, Dong Yang², Aswathy Surendran³, Susann Boij⁴, Aimee Morgans⁵, Huadong Yao¹

¹Department of Mechanics and Maritime Sciences, Chalmers University Of Technology, SE-412 96 Gothenberg, Sweden,
²Department of Mechanics and Aerospace Engineering, Southern University of Science and Technology, 518055 Shenzhen, PR China, ³Department of Engineering Physics and Computation, Technical University of Munich, 85747 Garching, Germany, ⁴KTH Royal Institute of Technology, Marcus Wallenberg laboratory for Sound and Vibration Research, Dept. of Engineering Mechanics, Stockholm, Sweden, ⁵Department of Mechanical Engineering, Imperial College London, SW72AZ London, United Kingdom

A slug length is widely used to describe additional mass inertia at low frequencies in duct acoustics. It is often used in acoustic energy analysis, e.g. as one of the inputs for semi-analytical or empirical models to obtain the acoustic reflection and transmission coefficients. However, the calculation of slug length is usually empirical and limited to many conditions, such as simple geometric configurations, low frequencies, no mean flow, etc. In this paper, the slug length at a contraction with mean flow between two half cylinders is calculated by different methods: solving the Laplace’s equation both analytically and numerically, solving the Helmholtz equation, and using the Cummings – Fant equation based on the numerical results of frequency-domain linearized Navier-Stokes equations. Both the frequency-dependence and the mean flow effect are discussed. The calculated slug lengths are then used in the semi-analytical model to predict the acoustic scattering at tube rows in the presence of a cross mean flow.
Re-examining the perceived affective quality attributed to soundscapes

Koji Nagahata¹
¹Fukushima University, Kanayagawa 1, Fukushima, 960-1296, Japan

According to ISO/TS 12913-3, the eight perceived affective quality scales proposed in ISO/TS 12813-2 originated from the achievement of the environmental psychologists, especially Russell and his colleagues. However, as the author partly pointed out in the last inter-noise, the way of application of the Russell’s results, on the scales is inaccurate, and this can cause adverse effects on the interpretation of the results. This study re-examines the eight perceived affective quality scales using the results of soundwalks directed by the author, and points out the problematical points of the scales in detail.

Link to paper
Experimental Results of Double Near-field Holography method for a commercial Product

Masao Nagamatsu¹
²Hokkaido University Of Science, Sapporo, Japan

In my laboratory, the new localization method, Double Near-field Acoustic Holography (DNAH) method is being Developed. This method is developed to overcome the limit of acoustic holography methods, that the acoustic holography methods cannot measure low frequency noise precisely. In former presentations, the numerical simulation results, and basic experimental results are reported. In these presentations, it is verified that the DNAH method has good resolution for low frequency sound sources. But they are carried out for simple sound source(s), simulated point source(s). In this presentation, the experimental results for a commercial product will be presented. From these results, it is verified that the DNAH method has good resolution for low frequency noise of a commercial product between 10Hz and 200Hz, and the DNAH method has enough resolution for low frequency sound localization.

[Link to paper]
Method for estimating aircraft noise corresponding to changes in thrust and speed during start of takeoff roll

Toshiyasu Nakazawa¹, Naoaki Shinohara¹, Kazuyuki Hanaka²

¹Organization Of Airport Facilitation, 1-3-1-5F, Shiba-koen, Minato-ku, Japan, ²Narita International Airport Promotion Foundation, Japan

In aircraft noise calculation by international guidelines such as ICAO Doc.9911, NPD (Noise Power Distance) data that relates aircraft thrust and noise are used. In these guidelines net-thrust use as power in NPD data. However, net-thrust of an aircraft engine cannot be measured directly. Therefore, net-thrust has to be estimated using the conversion equation with engine parameters such as N1% RPM and EPR, as well as speed. Meanwhile, for recent aircraft types, the coefficients for the N1% and speed terms of the conversion equation are not available. For this reason, Japanese aircraft noise models use N1% and EPR directly in place of net-thrust to create NPD. These parameters change the most at the start of the takeoff roll, and it is necessary to confirm the validity of the noise calculation in this area. In this study, noise measurements at the side of the runway and aircraft onboard data were analyzed to investigate an alternative method of estimating noise changes to net-thrust. The result shows that it is reasonable to correct the noise according to the speed change in addition to the noise calculation in the section of lower speed state of takeoff roll.
Instrumentation Techniques for the Measurement of Gunfire

Anthony Nash

Charles M. Salter Associates, San Francisco, United States

The peak sound pressure from near-field small arms gunfire is commonly used when assessing a shooter’s hearing damage risk. Close to a shooter’s ear, the peak sound pressure level from a rifle or pistol can be 155-to-160 decibels with a pulse rise time on the order of ten microseconds. Standard dosimeters equipped with conventional measurement microphones significantly under-report the true peak levels from proximate gunfire; hence, the shooter’s exposure is either unknown or underestimated. The U.S. Military has established exposure limits for small arms gunfire; however, the specified properties of the measurement instrumentation are more prescriptive than performance-based. The implication is that the practitioner is responsible for pre-qualifying his or her own instrumentation. For near-field gunfire, the leading cause of measurement error occurs when the wide-band signal from the acoustical transient is transduced by a relatively large-diameter measurement microphone having limited bandwidth. Secondary measurement errors include the finite bandwidth of the microphone signal amplifier and its slewing limit, the characteristics of the anti-aliasing filter used, and the sampling rate of the digital recording device. The paper discusses these instrumentation constraints and recommends minimum performance requirements to help attain reproducible measurements of small arms gunfire.
A sketch is an important tool that architects use to visualize and formulate design decisions. The sketch process is a crucial stage where design iterations and decisions can be made fast, easy and abundant. Sketching facilitates idea spawning, design assessment, modification and communication. This exploratory study focuses on qualities with Virtual Reality that can be used for sketching sound in the architectural design process. The study was influenced by Contextual Inquiry Interviews and used trained architects as respondents. The main result of this study is a summary of the pros and cons on how Virtual Reality work today and discusses how to develop a test bed for future research. One of the main cons, as of now, is the bulkiness of the equipment and the fact that it is not intended for sketching sound, yet. Computing speeds and acoustic rendering is another issue on the technical side. A possible benefit of using Virtual Reality is that it gives architects the possibility of incorporating sound in the architectural design process, thus making it an integral part of the practice.
Localization of higher order exceptional points from finite element model and their applications to duct acoustics.

Benoit Nennig\textsuperscript{1}, Emmanuel Perrey-Debain\textsuperscript{2}, Martin Ghienne\textsuperscript{1}
\textsuperscript{1}Institut supérieur de mécanique de Paris (ISAE-Supmeca) - Laboratoire Quartz EA 7393, Saint-Ouen, France, \textsuperscript{2}Université de Technologie de Compiègne - Laboratoire Roberval, UMR CNRS 7337, Compiègne, France

This work reviews the state of the art for high order perturbation method for parametric eigenvalue problems and propose some extensions for the multiparameters case.
This approach allows to locate high order exceptional points (EP) arising in eigenvalue problems. EP correspond to a particular tuning of some complex-valued parameters which render the problem degenerate. These non-Hermitian degeneracies have raised considerable attention in the scientific community as these can have a great impact in a variety of physical problems (PT-symmetry, thermo-acoustic or fluid-structure instability, etc.) and their numerical solution.
For applications dealing with dissipative acoustic waveguides, strong modal attenuation can be achieved close to EP and a maximum of attenuation occurs at EP of high order corresponding to the coalescence of more than two modes.
The method is based on the automatic computation of the successive derivatives of some selected eigenpairs with respect to the parameters so that, after recombination, regular functions can be constructed.
This algebraic manipulations permit to build a reduced order model allowing i) to quickly solve the eigenvalue problem for other parameters values, ii) to follow modal branches, iii) to locate higher order EPs.
The method is applied to the particular case of a circular duct with a locally reacting liner at its wall which admittance varies with azimuthal position.

Link to paper
Acoustic classification with the descriptor of the weighted standardized level difference \( \text{DnT}_w \) with use of the weighted apparent sound reduction index \( \text{R'}_w \)

Reinhard Neubauer\(^1\)
\(^1\)IBN Bauphysik GmbH & Co. KG, Ingolstadt, Germany

Buildings must ensure sound insulation appropriate to their use. This sound insulation is regulated by building regulations. In many Europe countries this is by use of the weighted apparent sound reduction index \( \text{R'}_w \) or the weighted standardized level difference \( \text{DnT}_w \). This paper shows that a direct assignment of the quantities \( \text{R'}_w \) and \( \text{DnT}_w \) is only possible for certain geometric ratios of room volume and separating area (V/S). If a permissible deviation between \( \text{R'}_w \) and \( \text{DnT}_w \) is accepted, a classification of the sound insulation values (\( \text{R'}_w \)) with fixed class limits can be made. This makes it possible to classify the sound insulation with reference to the descriptive parameter \( \text{DnT}_w \) using the weighted apparent sound reduction index \( \text{R'}_w \).
Construction details affecting flanking transmission in cross laminated timber structures for multi-story housing

Maximilian Neusser¹, Thomas Bednar¹
¹TU Wien - Institute of Material Technology, Building Physics, and Building Ecology, Karlsplatz 13, 1030 Vienna, Austria

The desire of the building developers to leave the surfaces of cross laminated timber constructions in multi-story housings visible for the building user, leads to acoustic problems with the flanking sound transmission that cannot be controlled by means of wall linings. As a result, controlling flanking sound transmission by measures directly in the joint is getting increasingly important. The main parameter for describing the vibrational power transmission over a junction between structural elements is the vibration reduction index Kij. For this quantity, some planning values are spread over numerous publications. None of the currently available data sources represents a holistic view on the building acoustic performance of the on the market available products for elastic interlayers and fasteners which are used in a wall-ceiling junction. The following paper shows results of measurements of vibration reduction indexes of different configurations of a wall-ceiling joint in a test facility. Different elastic interlayers and fasteners were investigated. The vibration reduction indexes spread from 16db to 26dB as a function of the joint configuration and the load applied on the joint. The measurement results obtained are discussed and the essential parameters for influencing the flanking sound transmission are worked out and quantified.

[Link to paper]
A Practical Method to Increase the Low Frequency Sound Insulation of Timber Frame Constructions

Michael Newman\textsuperscript{1}, Arild Brekke\textsuperscript{2}, Ståle Ellingsen\textsuperscript{2}, Frode Eikeland\textsuperscript{2}
\textsuperscript{1}Avinor, Oslo, Norway, \textsuperscript{2}Brekke & Strand Akustikk, Oslo, Norway

Timber framed houses have little or no sound insulation at low frequencies. A significant set of noise sources emit loud low frequency noise and for some of these, the noise is single frequency or tonal. Improvement of the low frequency insulation has been shown using two methods: increasing the stiffness and applying vibration neutralizers to the structure of the house. A study was carried out on a wall element to assess the viability of the method in a simplified test facility. Impedance measurements were carried out on a test section consisting of 3 studs and panel construction. An initial field implementation has been carried out on a re-purposed dwelling at the end of the runway at Bergen’s airport. Reductions of the order of 5-10dB in the C-weighted indoor noise level have been achieved. The additional attenuation achieved using vibration neutralisers only has effect when the outside noise level exceeds 87dBC.
The development of sustainable policies to manage noise around airports in Vietnam

Thithanh Vu\textsuperscript{1}, Thulan Nguyen\textsuperscript{2}, Masaharu Ohya\textsuperscript{3}, Keishi Sakoda\textsuperscript{3}, Ichiro Yamada\textsuperscript{3}

\textsuperscript{1}Department of Science, Technology and Environment, The Civil Aviation Authority of Vietnam, Hanoi, Vietnam, \textsuperscript{2}Department of Architectural Design, Shimane University, Matsue, Japan, \textsuperscript{3}RION Co., Ltd., Tokyo, Japan

Before the outbreak of the Corona pandemic, Vietnam was one of the world's fastest-growing aviation markets. With the ambition that more than ninety percent of the population will have access to the airport within 100 km, the Vietnamese government approved developing the airport systems of 22 existing airports and six new airports. The rapid increase in air traffic in Vietnam has given rise to serious noise problems around airports. Preservation of the living environment for the areas around the airport was an urgent task to the Vietnamese government. Although the situation has entirely changed by the pandemic, environmental problems will be severe again as the aviation industry recovers. Therefore, a sustainable approach is to create a policy framework to prevent and decrease noise from air traffic parallelly with strengthening the air transport network. However, although Vietnam issued standards for general environmental noise, there had not been a legal and regulatory system that formed the basis of policies for aircraft noise. In this paper, the authors introduce Vietnam's viewpoints and efforts in developing the framework related to noise management around airports and discuss future issues and prospects. The authors summarize the activities that the Civil Aviation Authority of Vietnam has been working on with the support of Japanese experts for several years before the outbreak of Corona on noise policy development in Vietnam, including evaluation methods and monitoring technologies. These efforts have formed the basis for Vietnam's aviation noise policy.
New guidance manual for the monitoring and evaluation of aircraft noise in Vietnam with an experimental application to the aircraft noise monitoring at Noi Bai International Airport

Thulan Nguyen¹, Thi Thanh Vu², Naoaki Shinohara³, Koichi Makino⁴, Keishi Sakoda⁵, Ichiro Yamada⁵

¹Department of Architectural Design, Shimane University, Matsue, Japan, ²Department of Science, Technology and Environment, The Civil Aviation Authority of Vietnam, Hanoi, Vietnam, ³Organization of Airport Facilitation, Tokyo, Japan, ⁴Kobayasi Institute of Physical Research, Japan, ⁵RION Co., Ltd., Tokyo, Japan

Along with air traffic expansion, an increasing number of complaints from residents regarding aircraft noise from the airport operation has raised an environmental awareness of aircraft noise pollution in Vietnam. It is an urgent task for local authorities to assess aircraft noise exposure reliably. Aircraft noise monitoring systems and suitable policies need to be developed for land use and flight operation control to reduce and prevent aircraft noise pollution. However, Vietnam has had no legal documents or instructions on measurement and evaluation methods or the equipment and monitoring systems for measuring and analyzing aircraft noise. Against that background, the Civil Aviation Authority of Vietnam (CAAV) has developed a new guidance manual to measure and evaluate aircraft noise within the cooperation project on Airport Environment Preservation and Aircraft Noise Monitoring in Vietnam. This project was implemented by the CAAV, the Japan International Cooperation Agency (JICA), and RION Co., Ltd.. As a model case, a system of the minimum required equipment with four noise monitors for the continuous monitoring of aircraft noise was installed around Noi Bai International Airport. This study explains the formulation of the new guidance manual and discusses the analysis results of the monitoring data obtained from January 2019 to August 2021.
Assessment of Drone Noise Within Urban Soundscapes

Rory Nicholls¹, Antonio J Torija
¹University of Salford, Salford, United Kingdom

Drones have the potential to be implemented in the infrastructure of metropolitan areas to provide services to the public such as delivery, maintenance, and even blue light services. The scope for drone capability is large, but this comes with the risk of introducing a dominant, unpleasant noise source above urban areas, with potentially adverse health effects. This paper describes research which investigates whether, and to what extent, different urban soundscapes mask noise from drone operations, and using statistical analysis methods such as principal component analysis interrogates which frequency ranges of drone noise should be appropriately masked to reduce perceived annoyance. A subjective experiment was carried out, where participants gave response values to a comprehensive set of drone sounds embedded into differing urban soundscapes. Response values included perceived annoyance, perceived loudness, drone noise dominance and soundscape pleasantness. Critical-band rate specific sound quality metrics were then calculated for the soundscapes with and without each drone sound present, and the metric value differences were used in principle component analysis, with the results suggesting which specific sound quality metrics contribute significantly to the response values.
Effect of Bearing Direction and Mounting Techniques on Cross-Laminated Timber Elements in the Field

Erik Nilsson¹,³, Sylvain Ménard¹, Delphine Bard Hagberg², Klas Hagberg³

¹University of Québec at Chicoutimi, Department of Applied Sciences, Chicoutimi (Québec), Canada, ²Lund University, Engineering Acoustics, Lund, Sweden, ³Acouwood AB, Malmö, Sweden

Vibration reduction index (Kij) measurements in the field have some challenges compared to laboratory measurements. Firstly, the measurement requires access to a construction site during the short time span when the cross-laminated timber (CLT) elements are apparent. Secondly, building contractors are often on a tight time schedule. Therefore, it is important to find a solution that minimizes the measurement time on site. Moreover, Kij measurements in the field include several types of junctions with different bearing directions which may be of importance. This paper aims to evaluate two different mounting techniques with accelerometers on CLT elements and to discuss how the bearing direction could affect the vibration level difference of junctions. Measurement data indicates few deviations between mounting techniques with bee wax or double-sided adhesive tape when accelerometers are attached on CLT elements. Furthermore, field measurements indicate that the vibration level will decrease with an increased number of lamellas over the same CLT element. Double-sided adhesive tape is an adequate substitute for bee wax in the field for mounting accelerometers on CLT elements, with some limitations for high frequencies. Measurement data concludes that the bearing direction of CLT elements can influence the vibration reduction index of a junction.

Link to paper
Calculation of Drive-Related Structure-Borne Sound in Electric Driven Trains using Elastic Multi-Body Simulation

Sascha Noack¹, Michael Beitelschmidt¹
¹TU Dresden, Dresden, Germany

The structure-borne sound coming from the drive system defines especially for transient train manoeuvres the experienced interior noise of modern railway traction vehicles. A deeper look at the origin and the transmission of structure-borne sound is therefore of great importance to increase passenger comfort in newly developed trains. The possibility of modelling the vibration behaviour of an electric multiple unit train up to the acoustic frequency range using elastic multi-body simulation (EMBS) has been investigated in a joint research project of the Chair of Dynamics and Mechanism Design at TU Dresden and the company Alstom. Through usage of reduced order models of elastic bodies, the EMBS can be carried out in time domain in a computationally efficient way and non-linear system properties during motor run-up can be easily taken into account. Key research findings with regard to model structure and necessary level of detail of individual components (e.g. tooth contact, electric motor, roller bearings, elastic bodies, hydraulic dampers) of the elastic multi-body model can be shown. For validation purposes, measurements on individual parts, a motor-gear-unit test bench and the electric multiple unit on track have been carried out, results and comparison to simulation results can be presented.

Link to paper
The meaning of sound environment for children with special needs: Action research on room acoustics in the child development support center

Saki Noguchi¹,² Minami Arai², Kanako Ueno², Hisao Funaba¹³, Tomoko Matsumoto⁴, Ryoko Watanabe⁴⁵

¹Acoustic Design for Children, Japan, ²Meiji University, Japan, ³Yokohama National University, Japan, ⁴Nearai Gakuen, Japan, ⁵Hamamatsu Gakuin University, Japan

This study aimed to investigate the meaning of the sound environment for children with special needs. We conducted action research on room acoustics in a child development support center. First, we investigated actual conditions through acoustic measurement, behavioral observation, and interviews with teachers. Results revealed loud voices, for example, crying and screaming voices, as daily sounds. The teachers had awareness of the problems with sound environment. In addition, it was observed that the teacher was personally engaged with the child to support their language development and communication skills. They tried to speak politely, indicating a need for a sound environment that facilitates calm communication with children. Second, we conducted an experiment to improve the sound absorption performance in the classroom. The effects of the alleviation of noisiness and enhancement of calmness were confirmed in the sound environment. From the interviews, we discovered that experiencing an environment with different reverberations was an opportunity for teachers to become aware of their own voices.

Link to paper
An air flow going through an axisymmetric cavity can interact with the acoustic modes of this cavity and produce loud self-sustained acoustic oscillations. Acoustic measurements reveal that the nature of the acoustic mode undergoes complex dynamics, alternating between phases where we observe a spinning wave with periodic inversions of its rotation direction, and phases where a high-amplitude mode is constantly spinning in the same direction. Stereoscopic particle image velocimetry gives the 3 velocity components in a 2D plane, allowing to identify the main hydrodynamic structures involved in the instability and the interactions of these structures with the mean flow and the acoustic oscillations.

Link to paper
Vibration Isolation in Plates Using Flexural Cloaking

Aidin Nojavan¹, Sabine Christine Langer¹

¹Institute for Acoustics, TU Braunschweig, Braunschweig, Germany

Cloaking is a novel idea, where the incident waves are guided around a space called the core. The cloaking concept can be realized by engineering the material matrix around the core. Cloaks can be used to guide waves around an obstacle with minimum reflection and scattering. On the other hand, they can be also used to isolate the middle core space, which makes cloaking an innovative potential noise control measure at challenging lower frequencies. Space isolation using cloaks can be beneficial for different applications such as architectural noise control or soundproofing the cabin in automotive and aerospace industries. However, this interesting aspect of cloaking has not been investigated in the literature yet. In this study, a flexural cloak in a thin plate is modeled using finite element method to investigate the impact of cloaking on isolation of the middle core numerically. The effect is examined using plane waves as well as concentrated force excitation. Moreover, the dependency of the isolation effect on the geometrical size of the core and the cloak is investigated with regard to the wavelength.

[Link to paper]
Bias-aware thermoacoustic data assimilation

Andrea Novoa\textsuperscript{1}, Alberto Racca\textsuperscript{1}, Luca Magri\textsuperscript{1,2,3,4}
\textsuperscript{1}University of Cambridge, Cambridge, United Kingdom, \textsuperscript{2}Imperial College, London, United Kingdom, \textsuperscript{3}The Alan Turing Institute, London, United Kingdom, \textsuperscript{4}Institute for Advanced Study. Technical University of Munich, Garching, Germany

Ensemble data assimilation algorithms combine experimental data and numerical models to estimate the state and parameters of a system. If the model is unbiased, the estimation concentrates around the true state. Thermoacoustic instabilities are, however, commonly modelled with low-order models, which are biased by definition. We propose the introduction of reservoir computing to represent the model bias. We combine the ensemble square-root Kalman filter with an echo state network to perform, in real time, (1) the estimation of the state of the system, (2) parameter calibration, and (3) model bias estimation. The proposed methodology is tested in a Rijke tube system, with synthetic experimental data from a high order model.
Inverse scheme for sound source identification in a vehicle trailer

Jonathan Nowak\textsuperscript{1}, Reinhard Wehr\textsuperscript{1,3}, Manfred Haider\textsuperscript{3}, Manfred Kaltenbacher\textsuperscript{2}

\textsuperscript{1}TU Wien, Vienna, Austria, \textsuperscript{2}TU Graz, Austria, \textsuperscript{3}AIT, Austria

Tire/road noise is a highly relevant topic for improving the comfort and experience of drivers and residents living in high-traffic areas. With the growing numbers of electric cars, the relevance of tire noise even increases since it is the dominant sound source in the middle-speed range.

We investigate acoustic sources relevant to tire/road interactions. In doing so, we apply different sound source localization algorithms to measurement data acquired inside a large measurement trailer equipped with microphone arrays. The methods for sound source identification used are well-known beamforming-based algorithms and inverse schemes based on finite element or boundary element simulations. The latter schemes require the identification of the acoustic properties of the trailer in the stationary case. In this contribution, we present the characterization process and the results of the sound source localization in this stationary case.

Link to paper
Sound absorption of porous composites with heated impervious inclusions

Gabriel Ignacio Núñez Gómez¹, Rodolfo Venegas¹, Claude Boutin²

¹University Austral Of Chile, Institute Of Acoustics, P.o. Box 567, Valdivia, Chile, ²Université de Lyon—Ecole Nationale des Travaux Publics de l’Etat, LGCB/LTDS UMR-CNRS 5513/CeLyA, Rue Maurice Audin, Vaulx-en-Velin, France

This paper investigates the sound absorption properties of porous composites with solid impervious heated inclusions, i.e. heat sources, which allow the temperature tuning of the porous constituents and the control of the pressure diffusion phenomenon. By means of the two-scale asymptotic method of homogenisation, the wave equation in the composites with heated impervious inclusions is derived, allowing the material to be modelled as an equivalent fluid with effective density and compressibility. Analytical and semi-analytical models for the acoustical properties of porous composites with inclusions of different geometries are developed, which are also numerically validated using the finite element method. This work demonstrates that adjusting the temperature of the porous constituents can provide an alternative way of controlling the absorptive properties of hard-backed porous composite layers, and highlights the dependence of pressure diffusion on temperature.
Bringing the Tranquillity Rating Prediction Tool (TRAPT) Indoors – A Case Study at The Warren, Hull

James Oatley\textsuperscript{1,2}, Mark Swale\textsuperscript{1,2}
\textsuperscript{1}Cirrus Research Plc, Filey, United Kingdom, \textsuperscript{2}The Warren, Hull, United Kingdom

Tranquil environments are considered quiet, peaceful places where people can get away from everyday life, and for many years the University of Bradford’s Tranquillity Rating Prediction Tool (TRAPT) has been used to successfully predict the perceived tranquillity of outdoor spaces as a function of their auditory and visual modalities. The Warren, Hull, established 1983, is a citywide free project for marginalised and vulnerable young people aged 14-25 that helps to encourage and support them to take control of their lives and futures by engaging them in all of the decision-making that has impact upon the strategic and day to day running of project. Staff at The Warren have noticed that the young people often gather around a large public fountain to socialise and relax; the same fountain is due to undergo major work in 2022 and will be sectioned off from the general public for months. This paper addresses the challenges associated with bringing tranquillity indoors via considered and experimental application of the TRAPT tool to indoor spaces, and via empowerment of the young people to introduce tranquil auditory and visual changes to multiple spaces in The Warren.

Link to paper
The soundscape approach, as understood by the ISO 12913 series, is most applied in urban settings, aiming beyond noise control in order to holistically employ its quantitative and qualitative facets. On the other side, the current understanding of the soundscape concept in bioacoustics and acoustic ecology is less focused on perception. There is generally a lot of public interest in how to preserve the opportunity for people to experience the “natural quiet” and “the sounds of nature”, and the need to balance that with the protection of the natural areas and national parks from the noise that the visitors themselves generate while on site. However, specific investigations in these environments are scarce in the UK. Moreover, while there might be acoustic environments and sound sources that people identify with national parks, they are not systematically documented nor implemented in the national parks’ management plans. Therefore, we propose a framework starting with a quasi-crowd-sourced acquisition of soundscape data and mapping those to a freely accessible GIS platform such as Google Earth, leading towards identifying soundscape conservation targets and management tools for the UK national parks, further raising the awareness of the value of sound as a resource.
Hybrid space filling curve metamaterials for transmissive flow in Jet Engine inlets

Jennifer Glover¹, Dan O'Boy¹
¹Loughborough University, Loughborough, United Kingdom

Acoustic metamaterials research has grown exponentially in the past 10 years driven by the advances in manufacturing and an increased understanding of damaging environment noise. 2050 was the first noise reduction target as set by Advisory Council for Aircraft Research and Innovation in Europe with a relative 65% decrease. This ambitions target will not be met by current engine noise control technology; however, metamaterials offer an encouraging alternative. Space Filling Curves (SFC) have the potential to provide a lightweight, thin, high performance acoustic liner. SFC have a history in mathematical geometry dating back to the 1890’s but are a comparatively new addition to acoustics. They are designed with a sub-wavelength curled cross-section creating a maze-like pattern which slows acoustic wave propagation through the liner, enabling characteristics such as negative refraction and low frequency attenuation. This paper contains unique hybrid designs combining some of the most promising SFC metamaterial acoustic liner designs, in terms of the fundamental theory of the design category and a discussion of the reflection, absorption and transmission characteristics in terms of a grazing flow conditions. Experimental impedance tube testing compares 3D printed designs to the traditional Helmholtz resonator. The paper concludes with future application for aeroacoustics with particular focus on the engine inlet.
Basic investigation of sound field inside and outside ear canal under ultrasound irradiation

Yuya Ogawa¹, Ayumu Osumi¹, Youichi Ito¹
²Nihon University, Mitaka-shi, Japan

In recent years, high-intensity airborne ultrasonic waves applied technology has been developed actively. Accordingly, there are concerns about the effects of sound wave exposure by high-intensity airborne ultrasonic waves. The sound wave intensity is different near the entrance of the ear canal and near the eardrum, because the wavelength is short in the ultrasonic region. Therefore, it is necessary to know accurately the sound pressure at the eardrum position in considering the effects of sound waves exposure by ultrasonic waves. However, it is difficult to measure sound pressure near the eardrum with a probe microphone because it may damage the ear canal and eardrum. Against this background, we have studied the sound pressure characteristics inside and outside the ear canal when airborne ultrasonic waves are exposed to the mannequin head (KEMAR) with a pseudo-ear canal created to imitate the dimensions of the human ear canal. And, we have attempted to estimate the sound pressure value near the eardrum using the sound pressure in the ear canal. In this report, we verified the sound field inside and outside the ear canal and the sound pressure near the eardrum, when ultrasonic waves (frequency:20 kHz) were irradiated to the mannequin head.

Link to paper
Sound power level properties of hovering UAVs (drones) in a semi-anechoic room

Gyu-in Oh¹, Yonghee Kim¹, Jang-won Lee¹, Bon-su Koo¹, Dae-gwan Won¹, Seung-soo Lee², Sang-ho Kim³
¹Y'su Youngsan University, Junamro 288, Yangsan, South Korea, ²Korea Conformity Laboratories, Nambusunhwanro 319-gil 7, Seocho, South Korea, ³Konkuk University, Neungdongro 120, Kwangjin, South Korea

This paper investigated sound power level characteristics of various unmanned aerial vehicles (UAVs, drones) hovering at 0.5 m in a semi-anechoic room as a preliminary experiment to develop a standardized noise level measurement procedure. Eight types of quadcopter drones were used in the experiment, and its weight with battery ranged 85 g to 5.91 kg. In addition, effects of optional safety guards or low-noise type propeller were evaluated. Firstly, the measurement methods from ISO 3744 and ISO 3746 were considered, however it was not applied due to interference between top microphones and flying UAVs. Therefore, in the experiments, measurement radius of 3 m and 6 essential measurement points were selected based on Directive 2000/14/EC for the noise radiation characteristics of equipment used outdoors. A-weighted sound power levels of the tested UAVs were calculated using energy-averaged surface sound pressure levels. As a result, the sound power levels of the tested UAVs ranged 72.8 to 97.5 dBW. The correlation coefficient between the sound power levels and the weights with battery was 0.83. For the UAVs with the weight less than 1.5 kg, the correlation coefficient increased to 0.87. Additionally, the influence of optional parts on noise characteristics of the UAVs were discussed.

Link to paper
Machine-learning-based estimation of absorption coefficients from transfer functions modeled by equivalent sources

Yukiko Okawa¹, Haruka Matsuhashi, Izumi Tsunokuni, Yusuke Ikeda, Yasuhiro Oikawa
²Tokyo Denki University, 5, Senju-Asahi-Cho, Adachi-ku, Japan

In the field of room acoustics, it is important to find the absorption coefficients of the wall surface, which is a boundary condition for modeling the room acoustic field. However, it is not easy to measure the acoustic impedances of the entire room because it requires many measurement points near the wall surface. Recently, a method to estimate the acoustic impedance and absorption coefficients by using both measurement and simulation methods has been proposed. However, a large number of measurement points are required to obtain sufficient estimation accuracy.

In this study, we proposed estimation method of the sound absorption coefficients using machine learning with virtually increasing the number of microphones. First, the transfer functions at the virtual microphones are obtained from small number of transfer functions based on the sound field modeling by sparse equivalent sources. Then, the both transfer functions at the virtual and real microphones are used as the training data for machine learning. To evaluate estimation accuracy of the proposed method, we conducted the two-dimensional simulation experiments based on the boundary element method.

Link to paper
Examining the Difference Between Laboratory Measurements and Calculation Results in Impact Sound Insulation

Mehmet Okay¹, Mehmet Nuri İlgürel², Rahmi Güçlü³
¹Yıldız Technical University, Istanbul/Besiktas, Turkey, ²Yıldız Technical University, Istanbul/Besiktas, Turkey, ³Yıldız Technical University, Istanbul/Besiktas, Turkey

Architectural structures are designed and built to provide a comfortable living space to their users due to their function. One of the most important comfort expectations in buildings is acoustic comfort. Since the impact sound insulation between floors, which is one of the sub-headings of acoustic comfort, is evaluated together with the floor covering, resolving the discomfort caused by incomplete or incorrect evaluations during the design phase can be both more difficult and more costly during operation. In practice, it has been observed that there are differences between the laboratory measurements made according to the EN ISO 10140-3 standard and the calculations made according to the EN ISO 12354-2 standard for impact sound insulation. This difference can lead to an uncomfortable living space as the targeted acoustic performance cannot be achieved. This situation creates the need for a calculation model that gives more realistic results during the design phase. In this study, the variables that cause the difference between laboratory measurements and calculation results in impact sound insulation will be examined and improvement suggestions will be developed for the calculation of impact sound insulation according to the EN ISO 12354-2 standard.

[Link to paper]
Sound perception of the space inhabited during COVID-19 pandemic in Brazil: relations with demographic data

Poliana Oliveira¹, Erasmo Felipe Vergara, Gildean Almeida, Maria Lúcia Oiticica, Jordana Silva, Elisabeth Gonçalves

¹University of Santa Catarina, Florianópolis, Brasil

Changes in the sound environment of cities during COVID-19 pandemic period are consequences caused by the distance restrictions implemented by public administrators. However, how can we better qualify and/or understand this casualty in the sound perception of environment in a context of social distancing? In this sense, the present work aims to analyze the impact of social distancing on the sound perception of the inhabited environment in Brazil, investigating the relations between sound perception and demographic data. In this work, an online questionnaire was elaborated and applied using digital tools in order to obtain 1,769 participants from the five Brazilian regions, from May to June 2020. The results show that temperature and noise were the most uncomfortable aspects for the participants during the isolation period. However, according to the sound perception of the inhabited environment, approximately half of the interviewees pointed out that the noise decreased, both inside the building and in the surroundings. Therefore, it was possible to establish a relationship between noise reduction and Brazilian regions with stricter social distancing requirements. This work is expected to obtain contributions on the possible effects of the pandemic in the inhabited environment.
A high-order stabilized finite-element model for the Linearized Navier-Stokes equations

Simone Olto$^{1,2}$, Hadrien Bériot$^{1}$, Sophie Le Bras$^{1}$, Hervé Denayer$^{2}$

$^{1}$Siemens Industry Software NV, Leuven, Belgium, $^{2}$KU Leuven, Leuven, Belgium

A numerical approach based on high-order stabilized finite elements is proposed to solve thermo-acoustic and visco-acoustic problems accounting for non-uniform mean flow effects. The approach is based on the Linearized Navier-Stokes equations written in conservative form in the frequency domain. An adaptive polynomial Finite-Element Method (FEM) using hierarchic shape functions is applied for accuracy and ease-of-use. A new enrichment strategy, inspired by the extended Finite Element Method (X-FEM), is developed to resolve the finer scales near the walls at a reasonable computational cost. It relies on a re-orthogonalization procedure proposed to preserve both the continuity of the solution and the conditioning properties of the discrete model. The performance of the method is first evaluated by performing two-dimensional simulations of acoustic waves affected by visco-thermal wall losses and mean flow effects while propagating in a duct. Numerical results are in good agreement with the analytical solution. The applicability of this new methodology is then demonstrated by computing the sound absorption of an acoustic liner installed in an impedance tube in the presence of a grazing flow in 2D. Numerical predictions of the sound pressure levels in the tube are compared to experimental data from the literature.

Link to paper
APPLICATION OF TAGUCHI METHOD FOR INVESTIGATING THE ACOUSTICAL PROPERTIES OF SYNTHETIC FOAM COMPOSITE STRUCTURE

Nursah Oner¹, Sinem Ozturk¹, Sevinc Aycan Yetim¹, Ugur Tatlier¹
²Istanbul Technical University, Istanbul, Turkey

In this paper, the Taguchi method was used to optimize the parameters for determining the acoustical properties of synthetic foam composite structures. Synthetic foam consists of glass micro balloons, resin and epoxy. Two types of composite structures have been studied; synthetic foam composite structures reinforced with silicon carbide nanopowders and multi-walled carbon nanotubes. As optimization parameters, thickness of composite structure (up to 12 cm), glass micro balloon volume ratios (up to 50%), silicon carbide nanopowder volume ratios (up to 1.5%) and multi-walled carbon nanotube volume ratios (up to 1.5%) were determined. The optimal parameters for synthetic foam composite structures were obtained by the Taguchi method. The samples were prepared using the optimal parameters for constructing synthetic foam composite structures. The acoustical properties of samples were examined in the frequency range up to 6400 Hz.

Link to paper
Modelling of Train Floor Sound Transmission using Coupled FE-SEA analysis

Ulf Orrenius¹, Mark Teschner², Torsten Kohrs³

¹Akustikdoktorn Sweden, Stockholm, Sweden, ²Dassault Systems, Hamburg, Germany, ³Alstom, Hennigsdorf, Germany

A hybrid FE-SEA numerical method is applied to calculate transmission and radiation properties of periodic structures typical for railway design. Train floor structures made from extruded aluminium profiles with and without interiors are analysed. Such structures are common in rail vehicle design, in particular for high speed vehicles, and are typically subject to various noise control measures. Accurate and effective simulation models are key to reaching the acoustic design targets while respecting weight and cost budgets.

The simulation concept applied, rests on that an accurate Statistical Energy Analysis (SEA) representation of the structure is determined from a small FE model consisting of a few cells of the periodic structure. The FE model can be kept small and computationally efficient and the system model can for this reason be used for parametric studies of the effect of design changes. Calculated transmission loss results are found to compare well to measured data. Also, mechanical power inputs due to point force excitation as well as radiation efficiencies are calculated and compared to measured data.

Link to paper
In-situ measurements at gymnasiums for sound absorption characteristics of building materials using the ensemble averaging technique

Toru Otsuru¹, Reiji Tomiku¹, Noriko Okamoto¹

¹Faculty of Science and Technology, Oita University, Oita, Japan

The applicability of the in-situ measurement method for sound absorption characteristics of materials using the ensemble averaging technique, i.e. EA method, is examined. A series of in-situ measurement are conducted at two gymnasiums located in Oita-city, Japan. Two kinds of building materials are measured: one is a small sized glass-wool panel which is brought around from one gymnasium to the other; and the others are building materials installed on the floors/walls of each gymnasium. The glass-wool panel has the dimensions of 0.5 m by 0.5 m by 0.05 m and with the density of 32 kg m^(-3). Several measurements are conducted during badminton plays are undergoing. Measured sound absorption coefficients of the glass-wool panel revealed that most results agree well with those measured in reverberation rooms and that measured values of floors and walls show acceptable consistencies.
Investigation of the applicability of recurrent neural networks for structural health monitoring in the frequency domain

Lukas Outzen¹, Tobias P. Ring¹, Sabine C. Langer¹
¹Technische Universität Braunschweig, Braunschweig, Germany

Structural health monitoring (SHM) aims to detect or predict state changes or damages in engineering structures. In order to discriminate between various damage characteristics and locations, the SHM system requires relevant information about the structure as well as a suitable method to evaluate these. This paper explores a data-driven SHM approach that models damage processes using recurrent neural networks. As model input data, the machine learning algorithm uses sequential frequency domain data at consecutive steps during the advancing damage process. From the change in transfer functions that occurs during structural changes, the model derives information about the state of the monitored object. In order to discuss the potentials and limitations of this modeling approach, a simple bolted structure with non-trivial changes in the frequency response is employed. A gradual damage process is simulated by incrementally loosening one of the joints. The resulting sequences of transfer functions are used as input to the recurrent neural network model and related to the respective preload force. By varying the data sequences used for model training and application, the functioning of the modeling process is investigated. The possibility of inversely learning from the model about damage indicators by analyzing effective input values is discussed.
Physics-aware learning of nonlinear limit cycles and adjoint limit cycles

Defne Ege Ozan¹, Luca Magri¹,²
¹Department of Aeronautics, Imperial College London, United Kingdom, ²The Alan Turing Institute, United Kingdom

Thermoacoustic oscillations occur when the heat released by a flame is sufficiently in phase with the acoustic pressure. Under this condition, the linear instability can saturate to a nonlinear self-excited oscillation with a large amplitude. A typical nonlinear regime is a limit cycle, which is characterised by a periodic orbit in the thermoacoustic dynamics. In this paper, we develop a physics-aware data-driven method to predict periodic solutions using forward neural networks. The physics is constrained in two ways. First, the training is informed by a physical residual, which penalises solutions that violate the conservation of mass, momentum, and energy. Second, periodicity is imposed by introducing periodic activation functions in the neural network. We test the algorithm on a nonlinear time-delayed model of a Rijke tube. Adjoint methods offer a cheap and easy way to calculate the gradients with respect to design parameters, hence we extend our study to learning the adjoint variables of the Rijke system, which also settle onto periodic oscillations. We find that (i) periodic solutions of thermoacoustic systems can be accurately learned with this method, (ii) for periodic data, periodic activations outperform conventional activations in terms of prediction capability beyond the training range, and (iii) under the physical constraints, fewer data is sufficient to achieve a good performance. This work opens up possibilities for the prediction of nonlinear thermoacoustics by combining physical knowledge and data.
A Study on Multimodal Behaviour of Plate Absorbers

Mehmet Sait Özer\textsuperscript{1}, Friedrich Beyer\textsuperscript{1}, Sebastian Merchel\textsuperscript{1}, Ercan Altınsoy\textsuperscript{1}

\textsuperscript{1}Chair of Acoustics and Haptics, TU Dresden, Dresden, Germany

Membrane absorbers, which are commonly used types of resonance absorbers, convert sound energy into thermal energy by exploiting vibrations that occur on oscillating panels. Those types of absorbers are generally tuned to be efficient in a very narrow frequency range. However, if plates are used as the front panel, it is possible to broaden the effective absorbing frequency bandwidth by exciting multiple modes. This study is devoted to investigating the multimodal behaviour of plate absorbers with closed back volumes in low-frequency range. In the numerical part of the study, the box-shaped plate absorbers are modelled using a combined BEM/FEM approach. The results are validated with measurements conducted in an anechoic chamber. In addition, the sound absorption characteristics of the plate absorbers are obtained from an experimental study conducted in a reverberation chamber. The obtained results reveal that the plate absorbers can be effective in wider frequency ranges.

[Link to paper]
The Sound Characteristics Of The Baglama With Respect To Different Chest Shapes

Sinem Ozturk¹, Filiz Gurer Yucel², Ozay Onal²
¹Istanbul Technical University, Istanbul, Turkey, ²Music and Fine Arts University, Ankara, Turkey

Baglama is the most common folk string instrument in Turkey. It has a bowl-shaped resonator box called a chest which amplifies the sound. The chest can be constructed in various forms by the luthiers. This study aims to determine the sound characteristics of the baglama associated with different chest forms. First, a prototypical baglama was modeled and analyzed numerically with the SolidWorks, HyperMesh and Actran software programs. Operational Deflection Shape (ODS) measurements of the baglama were also carried out experimentally. The numerical results were compared with the experimental ones and had an excellent agreement. Using this experimentally validated numerical model, the natural frequencies, mode shapes and sound propagation properties of the baglama were investigated for chests of different geometries.

Link to paper
Investigation of electric vehicle noise sources on low-noise road surfaces

Marie-agnès Pallas\textsuperscript{1}, Simon Bianchetti\textsuperscript{1}, Adrien Le Bellec\textsuperscript{1}, Julien Cesbron\textsuperscript{2}
\textsuperscript{1}UMRAE, Univ Gustave Eiffel, IFSTTAR, CEREMA, Univ Lyon, F-69675 Bron, France, \textsuperscript{2}UMRAE, Univ Gustave Eiffel, IFSTTAR, CEREMA, F-44344 Bouguenais, France

Electric vehicles (EVs) constitute an increasing share of the vehicle fleet, in particular regarding light vehicles. This ratio may be significantly enhanced in urban areas that favour access to low-emission vehicles. Acknowledged to be quieter than conventional vehicles due to a lower propulsion noise, EVs feature a comparatively heightened tyre-road noise contribution, further reduction of which can be achieved by selecting appropriate low-noise road surfaces. These factors may result in modified noise source distributions on the vehicles. In the framework of the LIFE E-VIA project, noise source contributions have been investigated on several light EVs from different segments on a reference ISO road surface, by using a microphone array with dedicated processing. Wide ranges of speeds and driving conditions were considered. In a second step, particular focus has been placed on the road surfaces, comparing the noise sources of selected EVs either driving on the ISO road surface or on low-noise prototypes optimized for EVs and developed within the project. These are two similar versions of a very thin asphalt concrete 0/6, one containing crumb rubber. The presentation gives an overview of the EV noise source behaviour and their ranking with regard to the various situations tested in the project.

[Link to paper]
Assessment of annoyance and cognitive fatigue of open-plan office occupants subjected to noise from two different activities

Lucas Lenne\textsuperscript{2}, Etienne Parizet\textsuperscript{1}, Patrick Chevre\textsuperscript{2}

\textsuperscript{1}Lva - Insa Lyon, Villeurbanne, France, \textsuperscript{2}INRS, Vandoeuvre les Nancy, France

An open-plan office can be organised into zones, in which different activities can take place (focused individual work, collaborative work, phone communication...) The ISO 22955 (2021) standard recommends acoustic attenuation values between zones that varies according to the activity of the emitting zone (which influences the noise emitted by the occupants of this zone) and that of the receiving one (in which the necessary concentration may vary).

The objective of this study was to evaluate the relevance of these target attenuation values. 32 participants who had to carry out a focused individual activity (writing a press review) were submitted to two types of noise environment (representing the noise emitted from a breakout area or that coming from an area where people mainly have telephone conversations), at four signal-to-noise ratios (in relation to the own noise of the reception area). The exposure time was approximately 35 min, and participants completed questionnaires on their perception of the noise environment, cognitive fatigue (MFI) and mental workload (ICA).

The presentation will show the results of this experiment and the practical consequences for the target values of the ISO 22955 standard, in the case of these two disturbing noises.
Contribution analysis of road noise with transfer path analysis based on neural network

Uyeup Park¹, Yeon June Kang¹
¹Department of Mechanical Engineering, Seoul National University, Seoul, Republic of Korea

This paper introduces a new approach to transfer path analysis (TPA) combined with neural network technique. To obtain a large amount of operational data for training the neural network model, various operating conditions are considered, and the long term time domain data is converted into complex-valued frequency domain data according to the acquisition block. The number of layers and nodes of the model are determined by considering the physical characteristics of the system, and hyper-parameters such as learning rate and momentum are adjusted to improve convergency and efficiency. The reliability of the model is verified by comparing the estimated contribution and transmissibility with the existing methods. Unlike the existing TPA methods, only the operational data is needed to perform the neural network based TPA. This proposed method reduces the cost of measurement step such as impact test to identify the propagation paths of the noise.

Link to paper
The impact of the COVID-19 pandemic on community noise

Sang Hee Park¹, Hye-Kyung Shin¹, Kyoung-Woo Kim¹
¹Korea Institute Of Civil Engineering And Building Technology (KICT), Goyang, South Korea

The COVID-19 pandemic has caused considerable changes in our lives. It has influenced our society, education, economy, and environment as well as our lifestyle. We have got used to wearing facemasks daily. Working or studying from home is not an unusual thing anymore. On the other hand, some that we used to regard as normal, such as travelling abroad, have become less normal in this era. These changes subsequently influenced the acoustic environment in our community. Countries have closed their borders, set travel restrictions, and ordered their residents to stay home. Due to the reduced number of travelling, recent studies have noticed changes in traffic noise exposure. In addition, people gather less (e.g. at pubs or social events) during the pandemic — it also has an impact on the acoustic environment in our community. This paper provides a review of the literature on the effects of the COVID-19 pandemic on community noise. Based on the review, this paper concludes with suggestions for future research directions to create a better acoustic environment in the post-COVID era.

[Link to paper]
HEALTH & WHOLE LIFE COST BENEFITS OF HIGHWAYS NOISE BARRIERS

Giles Parker

Sound Barrier Solutions Ltd, Coventry, United Kingdom

As with any asset on the highways network, it is common sense to allow for realistic maintenance costs when choosing and procuring a noise barrier system. A short-term approach of focussing on newly installed prices alone creates a false economy and potentially stores up financial hardship for the future. The adverse impact of road traffic noise on public health is also long appreciated. Being able to quantify in financial terms not the only perceived annoyance but also the long-term damage to health due to traffic noise helps to justify why one particular noise barrier design will benefit the community more than another over its life-cycle.

Link to paper
“Eyes don’t say it all” – Communication challenges while wearing facemasks in class

Katarina Paunović1,2, Danka Vukašinović1,2, Katarina Đurđević1,2, Ana Jovanović1,2, Maja Miloradović1,2

1Faculty of Medicine, University of Belgrade, Belgrade, Serbia, 2Institute of Hygiene and Medical Ecology, Belgrade, Serbia

Facemasks are personal protective equipment worn to reduce the risk of the transmission of Covid-19. University students and teachers/lecturers in Serbia are required to wear facemasks in class at all times. However, such practice may cause challenges in student-teacher communication. We present students’ experiences regarding speech intelligibility in the educational setting. We distributed an anonymous online questionnaire among students from various universities. Speaking with a facemask in class creates communication challenges for teachers and students alike. Students claim that teachers often have difficulties understanding students who speak wearing masks; teachers often ask students to repeat the sentence, and teachers often ask students to speak louder. Similarly, when teachers talk with their facemasks, students often report not hearing or understanding teachers back. In turn, students would ask teachers to repeat the sentence and raise voices. Students pay more attention to teachers’ facial expressions, hand gestures, body language, and tone of voice. Students tend to engage their non-verbal interaction skills more often to facilitate communication. We further discuss the differences regarding students’ gender and the type of facemask typically worn. We express concern that the inability to communicate clearly may cause annoyance and frustration in the academic setting.
New soundscape after the Covid-19 lockdown

Katarina Paunovic$^{1,2}$, Branko Jakovljevic$^{1,2}$, Radmila Mircic$^1$, Dragan Pajic$^3$, Milan Konatarevic$^3$

$^1$Faculty of Medicine, University of Belgrade, Belgrade, Serbia, $^2$Institute of Hygiene and Medical Ecology, Belgrade, Serbia, $^3$City Institute for Public Health, Belgrade, Serbia

We present a pilot study on the perception of noise and noise annoyance from various environmental sources after the COVID-19 lockdown in Serbia. We used an online platform to conduct an anonymous survey on about 190 respondents aged 15 to 75 years from all over the country. After the lockdown, there was a significant increase in the proportion of respondents who were highly annoyed by noise from the typical environmental sources, such as road traffic, air traffic, industrial facilities, and construction works on the streets, compared to the time during the lockdown. At the same time, the proportion of respondents who were highly annoyed by the sirens of ambulance vehicles decreased significantly. However, the most annoying environmental sound during and after the lockdown was that emitted by the ambulance vehicles, which respondents described as “unpleasant”, “horrifying” and “irritating”. The perception of the sounds of nature and church bells dropped significantly after the lockdown, whereas the perception of noise from the neighbors, household members, and indoor sources remained the same. In summary, after the lockdown, respondents perceive the new soundscape as louder, burdened with a cacophony of noises, and subsequently more annoying.

[Link to paper]
Design, construction and commissioning of a reverberation room

John Pearse¹, Aaron Healey

¹University Of Canterbury, Christchurch, New Zealand

In this paper we discuss the design, construction and commissioning of a reverberation room that meets the requirements of ISO 354:2003. The new room was built using lightweight double walls rather than the more usual monolithic construction. We present an analysis of measurements made during the commissioning of the room and discuss these results; these measurements include the effect of adding various diffusing elements, lighting and heating. We made measurements of the sound absorption coefficient of different materials in the commissioned room and these are compared with measurements of the same materials in two other reverberation rooms that also comply with the requirements of ISO 354:2003.
Unified low-order modeling approach to can-annular combustors

Tiemo Pedergnana\textsuperscript{1}, Nicolas Noiray\textsuperscript{1}
\textsuperscript{1}ETH Zürich, Zürich, Switzerland

We present a unified, physics-based low-order modeling approach to can-annular combustors, combining a linear stability analysis and a nonlinear Langevin approach to unravel the highly complex, multi-physical dynamics in this type of system. In the linear part, Howe's Rayleigh conductivity model is combined with the projected Helmholtz equation and a Bloch wave ansatz to arrive at a single equation for the frequency spectrum of an N-can combustor. Starting from first principles, we illustrate and give a physical explanation for the coupling-induced amplification and suppression of thermoacoustic instabilities. Adding another layer of complexity, we then take into account nonlinearities in the flame response and the aeroacoustic coupling. The nonlinear dynamics of a symmetric model combustor are explored by exploiting the gradient structure of the averaged slow-flow dynamics. We obtain exact analytical expressions for the steady-state statistics, highlighting the connection between different emergent patterns and the resistive coupling between the cans. We leverage our analysis to explain the intermittent energy transfer between Bloch modes observed in real-world gas turbines.

Link to paper
Noise limits and indicators for intermittent indoor low frequency noise

Frank Pedersen¹

¹The Danish Environmental Protection Agency, Tolderlundsvej 5, 5000 Odense C, Denmark

In Denmark indoor low frequency (LF) noise is measured with the indicator LAeq, 10 min in the frequency range 10-160 Hz. Recent complaints related to short intermittent low frequency noise events (sounds from underground metro, light rail, neighbouring fitness centre…) could indicate that the correlation between measurements of LAeq and the experienced annoyance is poor. A literature study for LF descriptors and noise limits in other countries has been made. Listening tests on annoyance of various types of intermittent indoor LF noise types is ongoing and the results will be correlated with alternative relevant noise indicators. The results of the literature study and the listening tests are presented in this paper.

Link to paper
Classification of noisy vehicles from unsupervised measurements

Bert Peeters¹, Ard Kuijpers¹
²M+P, Vught, Netherlands

The NEMO-project (https://nemo-cities.eu/) aims to identify noisy and polluting road and rail vehicles, using remote sensing technology. Noise levels from individual road vehicles are measured from the roadside, in normal traffic. Road authorities may use these data to enforce noise limits, to limit access to Low Emission Zones or to influence driving behaviour. Whether a vehicle is a 'high noise emitter' is a complex question, as the noise level depends on vehicle type and condition, driving style, weather and location-specific characteristics. From a legal perspective, the question may be answered in relation to type approval noise limits, or in relation to local noise disturbance regulations.

Within NEMO, a classification model is developed from a large dataset of unsupervised pass-by noise measurements, from different locations. The model labels noisy vehicles based on the noise measurements, technical vehicle data, driving conditions, and external factors. Several modeling and machine learning techniques were evaluated, to find the most accurate solution. This paper presents the results, and it looks forward to how the technological solution could be applied to enforce regulations, leading to a reduction of traffic noise annoyance.

[Link to paper]
Investigation of potential benefits and functionality of a vibroacoustic camera by combining results of a common beamforming and nearfield holography acoustic camera and a highspeed camera, allowing to visualize structural vibration (optical flow tracking).

Johannes Pehe\(^1\), Dirk Döbler\(^2\), Daniel Herfert\(^2\), Christof Puhle\(^2\)

\(^1\)gfai tech Gmbh, Berlin Adlershof, Germany, \(^2\)Gesellschaft zur Förderung angewandter Informatik e.V., Berlin Adlershof, Germany

In this paper potential benefits and functionality of a vibroacoustic camera are investigated by combining results of a common beamforming and nearfield holography acoustic camera using the software NoiseImage and a highspeed camera, allowing to visualize structural vibration (optical flow tracking) using the software WaveImage. Both results can be used to calculate color maps – mapped parameters are sound pressure, vibration displacement and its derivatives. The authors will investigate how the combination of methods might enhance understanding and interpretation of the vibroacoustic behavior of specimens in the overlapping frequency range.

At low frequencies, the beamforming approach is limited due to main lobe width and array size. While the limits for source localization can be offset employing nearfield acoustic holography, those methods can be time consuming and might fail for complex 3-dimensional structures. It was also previously shown that mode shapes of 2-dimensional structures can be reproduced using nearfield acoustic holography (SONAH). The highspeed camera results present a way to provide positions of local vibration maxima and operating deflection shapes without accessing the acoustic nearfield. Accordingly, the approach could be viewed as a potential extension of the frequency range in which meaningful visualization of vibroacoustic data can be achieved from a single far field measurement from 0 Hz to the ultrasound frequency regime.
Noise mapping and acoustic evaluation of different pavements in the city of Fortaleza, northeast Brazil.

Nara Gabriela de Mesquita Peixoto¹, Carla Marília Cavalcante Alecrim², Gleidson Martins Pinheiro³, Verônica Teixeira Franco Castelo Branco², Paulo Henrique Trombetta Zannin⁴

¹Faculty of Architecture and Urbanism, University of São Paulo, São Paulo, Brazil, ²Department of Transportation engineering, Federal University of Ceará, Fortaleza, Brazil, ³Department of Mechanical engineering, Federal University of Santa Catarina, Florianópolis, Brazil, ⁴Department of Mechanical engineering, Federal University of Paraná, Curitiba, Brazil

The Climate Action Plan developed by the Brazilian city of Fortaleza has encouraged active mobility aiming pedestrians’ prioritization, thermal and drainage benefits, which has led to replacement of Asphalt Concrete (AC) surface layers by Interlocking Concrete Pavers (ICP) and Porous Friction Course (PFC). This work aims to evaluate the impact of these infrastructure changes on environmental noise levels. As a case study, 25 measurements on an urban avenue were made in 6 road sections with AC, ICP and PFC pavement surfaces. It was modeled in CADNA-A software and some scenarios with different traffic conditions were compared. The results showed that the use of PFC led to a noise attenuation of 3 dB(A) in LAeq when compared to AC. A reduction in the maximum speed limit from 60 kmph to 50 kmph led to a noise attenuation of 1.2 dB(A). In the section with ICP, measured data showed reduction in speed and traffic flow when compared to other pavements. Thus, despite the higher tire/road noise caused by the ICP, its application on urban roads led to a similar LAeq. The authors conclude that the application of these alternative pavements, when accompanied by traffic calming strategies, can reduce road traffic noise.

[Link to paper]
Finite element modelling of airborne sound insulation in single and double cross laminated timber panels

Maria Pettersson, Fredrik Ljunggren
*Luleå University Of Technology, 97187 Luleå, Sweden

Cross laminated timber, CLT, is manufactured with an odd number of layers of wooden boards glued together orthogonally. Compared to concrete or brick, CLT has low mass, which makes it subject to poorer sound insulation, particularly at lower frequencies. Sound insulation predictions of CLT panels are a challenge due to its origin (wood) and different manufacturing methods. Upgraded prediction tools could optimize the design of CLT panels and further increase its use. In this work, single and double CLT panels, with air and mineral wool respectively in the cavity, are modelled homogeneously in thickness using the finite element method. A hybrid 2D-3D finite element model is introduced which rotates the panels to capture a diffuse-like sound field, which greatly reduce the computational time compared to a full 3D model. The purpose is to present a model that can predict airborne sound insulation for single and double CLT panels for a set of typically used configurations within apartment buildings. The frequency range of interest is 20–3150 Hz. The goals are to predict the weighted sound reduction indexes Rw and Rw+C50–3150 and to see the response as the material and dimensions alter. For single panels, the differences regarding Rw and Rw+C50–3150 are within ±2 dB compared to analytical calculations and laboratory measurements. The proposed 2D-3D hybrid finite element model is suggested to be used for predicting R in one-third octave bands, Rw and Rw+C50–3150. For double CLT panels, the proposed model can provide an indication of the airborne sound insulation and serve as a tool for relative comparisons between various configurations. Due to the lack of comparative data for double panels, the single number ratings for the configurations may be considered as indications rather than exact results.
Sonic Boom over land avoidance and the impact on economic feasibility

Holger Pfaender

Georgia Institute Of Technology, 270 Ferst Dr, Atlanta, GA, 30126, United States

There has been renewed interest in commercial supersonic air travel in recent years with a number of new efforts being pursued by several companies. They currently advertise entry into service of these new concepts within the next decade. Current regulations do not permit overland operations for supersonic vehicles due to the sonic booms produced during flight. In order to capture a favorable market share, these vehicles will need to serve routes while abiding with the over land boom restrictions. This study presents a comprehensive approach to overland-prohibited supersonic flight routing and route-specific demand forecasting for commercial supersonic air travel, in order to assess the expected market. This also includes the need for the seasonally dependent need to avoid secondary sonic boom exposure of land.
Towards high frequency boundary element methods for multiple scattering

Simon Chandler-wilde, Stephen Langdon, Oliver Phillips

1University of Reading, Reading, United Kingdom, 2Brunel University, Uxbridge, United Kingdom

Standard Boundary Element Methods (BEM) for time-harmonic acoustics, using piecewise polynomial finite-element type approximation spaces, have a computational cost that grows rapidly with frequency, to ensure at least a fixed number of degrees of freedom per wavelength. Hybrid Numerical-Asymptotic (HNA) BEMs, based on enriched approximation spaces consisting of the products of piecewise polynomials with carefully chosen oscillatory functions, have a computational cost that is almost frequency-independent for some problem classes (e.g. Chandler-Wilde, Graham, Langdon, Spence, Acta Numerica 2012), but the technology is largely undeveloped for problems where multiple scattering is important. In this paper we present computational experiments, supported by mathematical analysis, which suggest that multiple scattering configurations may be within reach. Specifically, we solve, by a HNA BEM, scattering by a pair of screens in an arbitrary configuration, which we anticipate may serve as a building block towards algorithms for general multiple scattering problems with computational cost independent of frequency. The specific configuration considered, as we discuss, is relevant to the efficient simulation of multiple outdoor noise barriers.
Using clustering methods to detect quality data in a smartphone-based crowd-sourced database for environmental noise assessment

Ayoub Boumchich¹, Judicaël Picaut¹, Erwan Bocher²

¹UMRAE, Univ Gustave Eiffel, IFSTTAR, CEREMA, Bouguenais, France, ²CNRS, Lab-STICC, U6285, Université Bretagne Sud, Vannes, France

Environmental noise is a major source of annoyance with serious effects on health. Therefore, noise assessment is crucial to reduce these impacts. An alternative approach has been developed (i.e. noise measurement with smartphones) to overcome the limitations of classical assessment methods (e.g. simulation tools or noise observatories). In this way, the NoiseCapture application consists of measuring and sharing data, in order to produce community noise maps. Nevertheless, collected data may suffer from problems such as a lack of calibration, which lowers its quality. Quality control is therefore very important to enhance the data analysis and the relevance of the noise maps. Having trustworthy data as a reference can help in assessing the database, for example using machine-learning methods. With NoiseCapture, such data can be collected thanks to a NoiseCapture Party, an organized event, on limited space/time (i.e. a cluster of data). Because not all events are known by the people in charge of NoiseCapture, and since the corresponding data can be considered of better quality, so their detection is a relevant task to increase the trust database. In the present communication, a clustering methodology is then proposed to automatically detect data that could be produced in such events.

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Auralisation of combined mitigation measures in railway pass-by noise

Reto Pieren¹, Fotis Georgiou¹, Giacomo Squicciarini², David J. Thompson²
¹Empa, Dübendorf, Switzerland, ²ISVR, University of Southampton, Southampton, UK

To reduce noise exposure along railway lines various combinations of noise mitigation measures can be considered. However, predicting and assessing their effects is non-trivial and the potential need for multiple measures is difficult to communicate to stakeholders. Auralisation is a promising tool that can help to support communication and decision-making, and enable psychoacoustic evaluations. This paper presents developments of a physics-based auralisation model for train pass-bys that allows various mitigation measures to be included. The work is conducted within the European research project SILVARSTAR. The proposed model includes contribution from rolling noise, impact noise, traction, auxiliary systems, and aerodynamic noise. It is physically based and allows a direct assessment of pass-by parameters such as speed, roughness, wheel flats and track design. Based on the TWINS model, five structural transfer paths for rolling noise are considered to integrate mitigation measures such as wheel and rail dampers. Shielding by noise barriers is simulated with analytical models. Reflection at different ground types is considered and can account for track embankments. The results can be coupled to an immersive Virtual Reality environment, by first panning the synthesised sounds to a small virtual speaker array and subsequently dynamic binaural rendering for headphones.

[Link to paper]
Limitations of FxLMS in Feedforward Active Vibration Control of a Nonlinear Two-Degree-of-Freedom System

Xander Pike¹, Jordan Cheer¹

¹ISVR - University of Southampton, Southampton, United Kingdom

Active control systems are often used to surmount the challenges associated with passive noise and vibration control measures to control low frequency disturbances, since they achieve control without the application of large or heavy control treatments. Historically, linear active control strategies have been used in feedforward control systems to drive the control source to minimise the signal measured at the error sensor. Amongst the various control algorithms available, the Filtered-reference Least Mean Squares (FxLMS) algorithm has become extremely popular in the last few decades due to its relatively good performance and high level of robustness, as well as simplicity in both design and application. However, when the system under control contains nonlinearities, either in the primary or secondary paths, the performance of the FxLMS algorithm can degrade dramatically. This paper explores the performance limitations of the FxLMS algorithm when applied to the control of a two degree of freedom mass-spring-damper system with linear and cubic nonlinear stiffness terms. The aim of this study is to improve understanding of and inspire better design of nonlinear control systems. The statistical uncertainty present in the linear plant model and control filter is discussed, as well as the effect of this on control performance and control effort. The effect of nonlinearity on the maximum convergence parameter of the algorithm is also discussed.

[Link to paper]
Virtual sound source perception challenges of binaural audio systems with head-tracking

Vedran Planinec¹, Kristian Jambrošić¹, Petar Franček¹, Marko Horvat¹
¹University Of Zagreb Faculty Of EE And Computing, Zagreb, Croatia

With the recent leaps in spatial audio technology, the use of binaural head-tracking for spatial audio can revolutionize the way how music and audio are experienced. Moreover, to research noise-related perception in laboratories, binaural head-tracking is frequently used as an audio reproduction system. Although this technology is getting significantly better in recent years, signal processing of binaural audio is often experiencing problems such as non-adequate sound source externalization and unacceptably high values of system response time since it influences the usability of the technology at fast head rotation. In this paper, the results of an experiment are presented, in which test subjects are determining the direction of a virtual sound source in the horizontal plane with multiple parameter changes. The experiment is done in a controlled environment in a listening room with known acoustical properties. Parameter variation includes: hardware head-tracker variation (commercial one and head-tracker based on simple embedded system), various software solutions for real-time binaural synthesis, and variation in the used Head-Related Transfer Functions. The problem of externalization of a virtual sound source via headphones is discussed, and possible solutions to the problem are given. Results of the experiment and recorded data are presented.

Link to paper
Assessment of wind turbine noise in laboratory conditions

Dariusz Pleban¹, Grzegorz Szczepanski², Agnieszka Wludarczyk³, Adrian Alikowski³, Krzysztof Lada³

¹Central Institute for Labour Protection - National Research Institute, Warsaw, Poland

The development of wind energy is accompanied by an increase in the number of people whose workplaces and/or places of residence are located near wind farms as well as is accompanied by numerous questions about the influence of wind farms on human. Among the factors related to the operation of wind farms, wind turbine noise has to be seen as a source of annoyance for both people living and working near wind farms. A test bench to conduct noise annoyance tests of different types of wind turbine noise in laboratory conditions have been developed at the Central Institute for Labour Protection - National Research Institute. The test bench is based on a multi-channel sound reproducing system using the DANTE network and is compiled in the acoustic test chamber. The test bench consists of 18 speakers (including studio monitors and woofers) and a laboratory source of infrasound. During exposure to 6 different virtual acoustic environments, representing different wind turbine noise, 40 participants assessed wind turbine noise annoyance. The paper describes the test bench and the results of the studies concerning the assessment of wind turbine noise annoyance.

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Creating a new research community on detection and classification of acoustic scenes and events: Lessons from the first ten years of DCASE challenges and workshops

Mark Plumbley\textsuperscript{1}, Tuomas Virtanen\textsuperscript{2}
\textsuperscript{1}University of Surrey, Guildford, United Kingdom, \textsuperscript{2}Tampere University, Tampere, Finland

Research work on automatic speech recognition and automatic music transcription has been around for several decades, supported by dedicated conferences or conference sessions. However, while individual researchers have been working on recognition of more general environmental sounds, until ten years ago there were no regular workshops or conference sessions where this research, or its researchers, could be found. There was also little available data for researchers to work on or to benchmark their work. In this talk we will outline how a new research community working on Detection and Classification of Acoustic Scenes and Events (DCASE) has grown over the last ten years, from two challenges on acoustic scene classification and sound event detection with a small workshop poster session, to an annual data challenge with six tasks and a dedicated annual workshop, attracting hundreds of delegates and strong industry interest. We will also describe how the analysis methods have evolved, from mel frequency cepstral coefficients (MFCCs) or cochelograms classified by support vector machines (SVMs) or hidden Markov models (HMMs), to deep learning methods such as transfer learning, transformers, and self-supervised learning. We will finish by suggesting some potential future directions for automatic sound recognition and the DCASE community.

\href{https://link.to.paper}{Link to paper}
Audio augmentation of car journeys to improve occupants’ well-being

Zuzanna Podwinska¹, Lara Harris¹, Andrew Jackson², Connor Welham¹, Andrew Elliott¹

¹University of Salford, Manchester, United Kingdom, ²Bentley Motors Limited, Crewe, United Kingdom

Car interiors are often designed with the aim of being as quiet as possible. This has the benefit of eliminating most of the unwanted sound such as engine or tyre noise, but it also blocks out environmental sounds which might be perceived as positive and even desirable. Bringing in some of these positive sounds—particularly of nature or human activity—could enhance the experience of both the driver and the passengers. The literature has shown that being exposed to pleasant soundscapes has the potential to aid recovery from stress and is associated with lower heart rate than being exposed to unpleasant soundscapes. Therefore, increasing pleasantness of the sound environment in the car could lead to improved well-being. We will report on an immersive audio-visual listening experiment investigating how listeners perceive journeys augmented with realistic soundscapes. To increase realism and ecological validity, the experiment uses spatial audio, 360-degree videos presented through a virtual reality headset, and a car seat with vibrations corresponding to the presented drive.

Link to paper
Respite from aircraft noise: consolidation of current understanding in relation to airspace design

Richard Norman², Nicole Porter¹, Andy Knowles¹, Robin Monaghan¹

¹Anderson Acoustics Ltd, 3, Trafalgar Mews, 15-16 Trafalgar St, Brighton BN1 4EZ, United Kingdom, ²Heathrow Airport Ltd, United Kingdom

Most UK flight paths were designed decades ago, at a time when aircraft and navigation were much less sophisticated than today. A nationwide airspace modernisation programme is therefore underway across UK airports. The Government has embarked on its airspace modernisation strategy with its overall objective to deliver quicker, quieter, and cleaner journeys and more capacity for the benefit of those who use and are affected by UK airspace. The UK’s Airspace Modernisation Strategy is part of ICAO’s Global Air Navigation Plan.

For this process, Anderson Acoustics Ltd (funded by Heathrow Airport Ltd) are consolidating current knowledge on respite, particularly in relation to Airspace design and this paper will report on progress. The work intends to continue the journey towards understanding respite and its effective implementation, linking together past, current, and potentially future activities, providing timelines, signposting to other reports and work. It explores the key questions around the concepts and implementation of an effective respite strategy. It will present a high-level overview of the journey to date on building our knowledge on respite, and uses this information to present a summary of the key elements to consider for appraising options in the ACP programme when designing for respite.
Low-noise friction courses containing treated and un-treated crumb rubber to mitigate tyre/road noise in urban contexts

Filippo G. Pratico¹, Filippo G. Praticò¹
¹University Mediterranea Of Reggio Calabria, Via Graziella - Feo di Vito, Reggio Calabria, Italy

Tyre/road interaction is one of the main causes of traffic noise. This generates health, social, and environmental issues. Low-NMAS mixtures containing crumb rubber (CR) can be used to mitigate the aforementioned issues both in the short and long period. The main objective of the study presented in this paper is to investigate the variation of volumetric, surface, mechanical, and acoustical properties of friction courses due to the presence of treated and un-treated CR. Low-noise mixtures were designed during the ongoing project “E-VIA” (LIFE18 ENV/IT/000201) and were used to pave a street in Florence. Several samples were created using the Superpave Gyratory Compactor (AASHTO T-312, UNI EN 12697-31). The first set of specimens, consisting of asphalt concrete, with NMAS=6 mm and bitumen in the range 5-7%, have been used as a reference. Other two sets of specimens were created adding treated and un-treated CR to the reference mixture and using the dry method. Results show how the different compositions taken into account affect the properties and performance of the mixtures under investigation. Correlations, equations, and main trends were derived. Future studies will include the comparison between the in-lab produced specimens (herein analysed) and the cores extracted from the aforementioned street.

[Link to paper]
Numerical investigation of the effects of model and operator uncertainties on component-based transfer path analysis methods with substructuring applied to aircraft-like components

Simon Prenant¹, Thomas Padois¹, Thomas Dupont¹, Olivier Doutres²
²Éts, 1100 Rue Notre-dame Ouest, Canada

Hydraulic pumps are considered to have a major contribution to the structure borne noise generated inside aircrafts. Methods such as Component-Based Transfer Path Analysis (CB-TPA) are promising tools for aircraft manufacturers to build internal processes for the specification, design and validation of the impact of vibrating systems on new aircrafts. However, the experimental applicability of these methods remains limited due to some experimental difficulties. CB-TPA’ formulation is based on dynamical quantities, which require the determination of terms related to rotational degrees of freedom. Virtual Point (VP) or Equivalent Multi-Point Connection (EMPC) methods are commonly employed for this purpose, but both result in more cumbersome experimental set-ups and increased measurement uncertainties. The implementation of these methods is difficult in the case of a flat and thin receiving structure as commonly encountered in aircraft applications, since in-plane translational excitations have to be applied and the access to the vibrating system/structure interface points is limited. In this work, a decoupling procedure is used to overcome these issues. A numerical model is used to investigate the influence of model and operator uncertainties on the CB-TPA’ predictions, when the dynamical quantities are provided by VP and EMPC methods including the decoupling procedure.

Link to paper
Noise emission and noise exposure – an approach to improve the link

Wolfgang Probst¹
¹Datakustik GmbH, Gilching, Germany

A lot of work was spent by acousticians the last decades to reduce the noise caused by technical products. Important steps on that way were the description of the sound emission of these products and facilities by unambiguously defined quantities – the A-weighted sound power level and the emission sound pressure level. With a framework of standards for measurement and declaration we supported the buyer of such products in his purchase decision. The emission values of different machine groups were published – in standards and guidelines in anonymous form – and the buyers were encouraged to select from possible alternatives those that offer the lower noise emission in their declaration. But since many years we hear in this buy quiet sessions that the declared emission values are often not very reliable – and they are not understandable for those affected by the noise. This can be improved by establishing a strong link between the emission and the noise impact. Some strategies and tools are shown and recommendations for the development of supporting standards are given. Some examples about the advantageous use of emission values are demonstrated.
Effect of presence of furnishings on designed and measured reverberation time in school spaces

Elena Prokofieva
1

1Edinburgh Napier University, Unit 1, 7 Hills Business Park, Edinburgh, United Kingdom

According to Building Bulletin 93 (BB93), reverberation times for teaching and study spaces are expected to be assessed to comply with the pre-set requirements, when the room is finished and unfurnished. Presence of furniture and people is considered as a changed variable and therefore not included into assessment. Typically the teaching spaces are modelled by acousticians at the design stage (at RIBA Stage 3 and 4), taking into account only geometry and any surfaces’ treatments proposed. During site visits (at RIBA Stage 5), when sample testing is conducted (especially in large halls or halls of complex geometry to confirm the necessary treatment), the spaces are not furnished. However during the testing, most of teaching spaces are fully furnished, and it seems impractical to test without the furnishings. The ways of taking into account the furniture and occupancy into reverberation time calculations and measurements, and recommendations on which stage it should be introduced into the design process are discussed in this paper. Examples of compliance on-site tests are provided.
Narrowing the knowledge gap - solving the problems that occur when teaching the theory of acoustics in a higher education course

Elena Prokofieva

\textsuperscript{1}Lecturer, acoustic consultant, Edinburgh Napier University, Unit 1, 7 Hills Business Park, Edinburgh, United Kingdom

In many academic institutions across UK it is currently popular to offer the higher education degrees to the people who are working in industry. The students are able to develop the industry skills in their job whilst studying for a university degree.

For people working in audio industry or in building acoustics, it is highly beneficial to their day-to-day jobs that they will become educated on the theory of acoustics.

When teaching at the graduate apprenticeship scheme, or the higher education diploma in acoustics, it is always important to study what is the background of the individual students. If the group of students has mixed educational/ experience backgrounds, the strategy of teaching the theory of acoustics has to be re-developed by the tutor to ensure the maximum involvement of the students as a group, as well as to include the purpose-built individual exercises for the students who need an additional support. The examples of the strategy evolvement would be demonstrated.

It is important that the tutors either know engineering subjects or are adaptive to learn quickly to be able to accommodate the needs of the industry and the desire of the students to study.

[Link to paper]
Prediction of combustion instabilities based on the Green’s function in a three-dimensional annular combustor with multiple flames

Lei Qin, Xiaoyu Wang, Guangyu Zhang, Xiaofeng Sun

1Research Institute of Aero-engine, Beihang, Beijing, China, 2Research Institute of Aero-engine, Beihang, Beijing, China, 3Research Institute of Aero-engine, Beihang, Beijing, China, 4School of Energy and Power Engineering, Beihang, Beijing, China

The prediction of combustion instabilities is essential for modern annular combustors fed by multiple flames. This paper develops a model based on Green’s function to study the interaction of multiple flame responses with different types in a three-dimensional (3D) geometry. The flame responses are described by flame transfer functions and are recognized as monopole sources in 3D cavities. Then the dispersion relation equation in the form of matrix is performed with the condition of equality of pressure. Thermoacoustic complex frequencies, mode structure, as well as the stability behaviors in combustor can be obtained in this model and the analysis is accomplished using Rayleigh index. The results are compared to the values of existing theoretical models and a good agreement is achieved. Furthermore, the effects of non-identical flame responses on complicated slanted mode under the condition of asymmetric are studied. In addition, the combustion instabilities of radial mode can be predicted by this model when the radial position distributions of the heat sources move in the case of small ratio of inner wall to outer wall.

Link to paper
Effects of aircraft noise on psychophysiological feedback in under-route open spaces

Fei Qu¹, Qi Xie¹
²Shenzhen University, Shenzhen, China

Aircraft noise pollution is getting increasingly severe due to striding development of worldwide air transport. In high-density cities, a large number of residential areas are exposed to airport routes where flight-over noise poses a serious threat to public health. However, most existing research is limited to the thresholds for annoyance lacking in-depth exploration into the psychophysiological mechanisms that induce health responses. This study aims to examine the health effects of aircraft noise on both subjective evaluation and objective physiological indicators in a laboratory setting. Aircraft noise samples were collected in the under-route open spaces and their effects on annoyance and physiological feedback, including Skin Conductance Response (EDA) and Heart Rate Variability (HRV), were examined using listening experiment and ErgoLAB electrophysiological response monitoring. The study analysed the relationship between psychophysiological responses and subjective annoyance. The psychoacoustic parameters that induced emotion-related feedback were also identified. The results are expected to provide indicators to assess and improve the health of under-route communities.

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The influence of the modes of surrounding buildings on the ground vibration from railways

Xiangyu Qu¹, David Thompson¹, Evangelos Ntotsios¹, Giacomo Squicciarini¹
²Institute of Sound and Vibration Research, University of Southampton, Southampton, United Kingdom

To improve the accuracy of railway induced ground vibration predictions, the influence of surrounding buildings should be considered. For this reason, a fast semi-analytical model is developed to investigate the vibration of the ground and the influence of a nearby building. The model contains two sub models: a finite element model which can simulate the building, and a semi-analytical model which can simulate the infinite free-field ground. The dynamic stiffness matrix method is used to simulate the ground as a homogeneous or layered half-space. The ground model works in the frequency-wavenumber domain and is based on the Green’s functions developed for a half-space. Focusing on a building with a piled foundation, the coupling forces due to soil-structure interaction at coupled pile nodes are calculated assuming that the soil and pile displacements are identical. The results from the proposed model show that the vertical modes of the building, especially those that involve the vertical movement of the floors, can significantly influence the vibration of the surrounding ground. The findings suggest that when predicting the ground surface response induced by the railway, the surrounding buildings and their vertical modes should be included in the calculations.

Link to paper
Valve noise at high pressure ratios

Erika Quaranta¹, Malcolm Smith¹
²ISVR Consulting, University of Southampton, Southampton, United Kingdom

When high pressure air expands through an orifice it can be an intense noise source, which may be hazardous for nearby personnel if it occurs in an unexpected or uncontrolled way. This paper describes a set of measurements that were carried out to validate and calibrate the well-known Beranek semi-empirical prediction method. A number of valve mockups were tested over a range of mass flow rates with pressure ratios up to 11 Bar, so that the model could be used with confidence to extrapolate up to much higher pressures and larger valve sizes.

Interpretation of the measured noise data is carried out using an isentropic analysis of the flow, assuming choked conditions in the orifice to infer a jet Mach number and mass flow rate for each test condition. Based on this inferred flow data the sound power scaled as expected with 8th power of jet Mach number, although there were some deviations at high frequencies and for particular valve configurations. It is also shown that for all valves the sound power varied as 1.5th power of mass flow rate, which is in reasonable agreement with the law that is implicit in the Beranek model, and provided a good basis for extrapolating to larger devices.

[Link to paper]
Influence of contact parameters on the radiated noise from an automotive drum brake

Ananthapadmanabhan Ramesh¹, Aditya Rangamani², Sriram Sundar¹

¹Indian Institute of Technology Tirupati, India

Drum brakes are the major source of noise and vibrations in the automobile as the drum acts as a significant source of the noise. High-frequency noises are generated at the interfacial contact between the brake shoe and brake drum. Hence, the variation in the contact parameters (friction, contact stiffness, and contact damping) will significantly affect the vibro-acoustic noise emanating from the drum brake. The current work quantifies the variation in vibro-acoustic noise due to an asymmetry in the contact of leading and trailing shoes with the drum. The overall sound pressure level is estimated numerically using a finite element model of the drum brake. Multiple spring-like components in parallel between the brake shoe and the drum imitate the contact in real drum brakes. The numerical model predicts the noise generated by a symmetric system (without any asymmetry defects) and a system with controlled asymmetric defects introduced into the model. The results show that the overall sound pressure level is a strong function of the contact parameters. The current research is envisioned to better the selection of contact parameters and hence the drum and shoe properties.

Link to paper
On the optimization of sonic crystal acoustic noise barriers

David Ramírez-Solana\textsuperscript{1,2}, Javier Redondo\textsuperscript{2}, Maria Pia Fanti\textsuperscript{1}, Agostino Marcello Mangini\textsuperscript{1}, Jaime Galiana-Nieves\textsuperscript{2}

\textsuperscript{1}Department of Electrical and Information Engineering, Politecnico Di Bari, Via Edoardo Orabona, 4,70126 Bari, Italy, \textsuperscript{2}Instituto de Investigación para la Gestión Integrada de Zonas Costeras, Universitat Politècnica de València, Paranimf 1, Grao de Gandia, 46730, Spain

Acoustic noise barriers based on sonic crystals constitute one of the most promising innovative bets of recent years in the field of environmental noise control. Sonic crystals are defined as metamaterials formed by periodic arrays of acoustic rigid scatterers embedded in a fluid (usually air). Furthermore, Helmholtz resonators can be added with the purpose of increase the acoustic isolation of the barrier. Helmholtz resonances and multiple scattering are both noise control mechanisms of the sonic crystal noise barrier (SCNB). During last decades several authors have used genetic algorithms to optimize the performance of these devices showing its huge potential. In this work we present new strategies in order to improve the performances of the approaches presented in the related literature.
Structural design optimization of a high-speed rotor system for mechanical vibration mitigation

Liaoyuan Ran¹, Dunant Halim¹, Chung Ket Thein², Michael Galea³

¹Department of Mechanical, Materials, and Manufacturing Engineering. The University of Nottingham Ningbo China, Ningbo, China, ²School of Aerospace. The University of Nottingham Ningbo China, Ningbo, China, ³Department of Industrial Electrical Power Conversion. University of Malta, Msida, Malta

This work proposes a design optimization approach for a high-speed rotor system, commonly used in a wide range of industrial applications, in order to address the issue with the flexural flexibility of a rotor system which can cause significant vibration and noise problems due to shaft whirl. For this purpose, the numerical modeling of a flexible rotor system was used to carry out the optimization process considering the effects of the mass and transverse natural frequency to the optimized design. Torque and geometrical sizing were also incorporated as the constraints in the optimization. The rotor system was modeled as a multi-disc Jeffcott rotor system that allows a rapid design optimization process. A case study on a high-speed rotor was carried out to demonstrate the effectiveness of the developed optimization approach, yielding the reduction of the rotor mass by at least 45.6%, while the fundamental transverse natural frequency has been increased by 2.91% as the result.

Link to paper
An in-plane flexible ring model for the analysis of the free and forced response of a rolling tyre

Luca Rapino¹, Ivano La Paglia¹, Francesco Ripamonti¹, Roberto Corradi¹, Simone Baro²
¹Politecnico Di Milano, Via La Masa 1, 20156, Milano, Italy, ²Pirelli Tyre S.p.A., Viale Piero e Alberto Pirelli 25, 20126, Milano, Italy

The increased demand for vibroacoustic comfort as well as regulations on noise and vibration levels have made the NVH (Noise, Vibration, Harshness) performances of a vehicle to become one of the fundamental design criteria. Therefore, predictive models for the analysis of noise and vibration transmission mechanisms represent interesting tools to support the R&D department of the automotive companies.

Focusing the attention on passenger’s comfort, the vibrations induced by the tyre/road interaction propagate from the contact area to the hub and finally inside the cockpit through structure-borne transmission paths. This can be regarded as one of the major contributors to the car cabin interior noise at low frequencies (between 20 and 500 Hz).

Simplified models able to interpret the waves propagating inside the tyre structure and influenced by the angular speed may support the studies in this research field. To this end, an analytical model based on the theory of the flexible ring on elastic foundation has been developed. It allows analysing the tyre dynamics in both static and rolling conditions. Model parameters have been calibrated based on an Experimental Modal Analysis of the static tyre. The free response of the tyre shows the bifurcation effect at different rolling speeds, while a cleat test simulation has been carried out to investigate the forced response of the tyre.

[Link to paper]
Combined acoustic testing of home appliances: a case study

Luca Rapino¹, Ivano La Paglia¹, Francesco Ripamonti¹, Roberto Corradi¹, Antonio Acri²

¹Politecnico Di Milano, Via La Masa 1, 20156, Milano, Italy, ²Haier Europe, Via Privata Eden Fumagalli, 20861, Brugherio, Italy

To improve the comfort of the domestic environment, the acoustic performances of home appliances need to be optimised. During the product development stages, manufacturers typically carry out acoustic measurements to validate design strategies and to perform troubleshooting. Moreover, several experimental techniques can be used depending on the target of the analyses. In this paper, the sound field radiated by an operating washing machine is investigated. A combined acoustic testing is carried out by means of a sound intensity probe and a microphone array. The details on the tests’ execution and the data processing are presented. The experimental results are discussed, providing a synthesis of the two sets of measurements.

Link to paper
Noise from ventilation systems in dwellings – Regulations and field test procedures in selected countries in Europe

Birgit Rasmussen¹, Teresa Carrascal García
¹BUILD, Department of the Built Environment, Aalborg University, Copenhagen, Denmark

In most countries in Europe, regulatory noise limits apply for service equipment in housing. During the last few decades, mechanical ventilation with heat recovery (MVHR) has become increasingly prevalent in new and retrofitted housing in Europe. The MVHR systems supply fresh air to obtain good indoor air quality, with minimal heat losses. However, the systems may operate continuously 24 hours/day and transmit noise into and between rooms by many possible paths. In practice, many people get annoyed or disturbed by the noise, especially during nighttime or when having quiet activities.

Some countries have lower service equipment noise limits for continuous sources than for non-continuous sources, and lower limits also apply for the upper quality classes in acoustic classification schemes. Thus, both design and measurements become challenging.

The aim of this paper is to investigate the noise limit values and descriptors applied to ventilation systems in housing in selected countries in Europe and compare limit values, field test and rating procedures as well as operating conditions and enforcement related to the limit values. Indications of typical design methods will also be included.
Wavenumber spectrum determination for aeroacoustic applications using FISTA

Hans-Georg Raumer¹, Carsten Spehr¹
¹German Aerospace Center (DLR), Göttingen, Germany

This conference paper deals with computational methods to determine the wavenumber spectrum of acoustic data measured by a phased microphone array. Such problems occur e.g. within the analysis of pressure fluctuations due to a turbulent boundary layer on a surface such as a wind-tunnel wall or the skin of an aircraft. The problem is closely related to the deconvolution of dirty beamforming maps in wavenumber domain, which seeks to determine the wavenumber spectrum by removing the influence of the shift-invariant point spread function from the beamforming result. Firstly, we recall how this task can be formulated as a minimization problem and then discuss a specific solver for this problem, provided by the framework of the generalized FISTA algorithm. The resulting method takes advantage of the convolutional structure of the gradient of the data misfit functional and allows further for a flexible regularization with L1 and L2 penalties as well as a nonnegativity constraint. Finally, the presented algorithmic framework is demonstrated with numerical examples.
Structureborne noise transmission from sports court

Wayland Dong¹, Samantha Rawlings¹, John LoVerde¹
¹Veneklasen Associates, Santa Monica, United States

The authors recently investigated a multifamily high-rise building that included a sports court. Noise from bouncing basketballs and similar sources generated undesirable noise transmission in adjacent units. While that was not surprising, the pattern of transmission throughout the building was not as expected. Vibration measurements taken in the building are compared to predicted impact flanking transmission to evaluate the vibration paths through the building. While sports courts are not that common, the results are also applicable to impacts from fitness center sources, and even to prediction of impact noise in lateral and diagonal directions.
Characterisation of time-varying structure-borne sound sources using a reception plate to predict maximum Fast time-weighted levels in buildings

Steffi Reinhold¹,², Carl Hopkins¹
¹University of Liverpool, Liverpool, UK, ²Hochschule für Technik Stuttgart, Stuttgart, Germany

Structure-borne excitation from many mechanical appliances leads to structural vibration which can be transmitted to nearby rooms and cause annoyance for building occupants. The reception plate method provides a simplified characterisation procedure to obtain the power input for SEA prediction models. Empirical corrections based on the relationship between Leq and LFmax are introduced to predict sound transmission from time-varying source vibrations in buildings. For this purpose, the reception plate method is used to capture the maximum power input. Using different ramped noise signals as idealised versions of time-varying signals from machinery has allowed empirical corrections to be identified such that short Leq measurements can be used with the reception plate. When using SEA or EN12354 it is shown that LFmax in a room can be predicted for a time-varying structure-borne sound source with one-third octave band errors within ±3 dB. Similar results occurred for predicted LAFmax levels calculated from frequency-dependent A-weighted LFmax. A case study with a toilet flush was performed on the reception plate to replicate the empirical corrections derived from ramped noise signals which resulted in close agreement.

Link to paper
Non-normative sonic space: exploring the divergent capacities of soundscape design in the built environment

William Renel\(^2\)
\(^2\)Royal College Of Art, London, United Kingdom, \(^2\)Touretteshero CIC, London, United Kingdom

This paper aims to situate disabled and neurodivergent people’s experiences at the heart of research concerning human perception and response to soundscape design in the built environment. The paper outlines the process and insights gained through a series of participatory binaural soundwalks held in London between 2016 – 2019. Each soundwalk invited a disabled and/or neurodivergent person to discuss their experiences of and responses to soundscape and acoustic design whilst walking through a public environment such as a gallery, café or theatre. The chapter uses a multimodal framework for discourse analysis to analyse the soundwalk data, highlighting the divergent and non-normative affective potential of sound in socially public spaces. Findings consider elements such as how changes in reverberation time may trigger involuntary words and noises for people with Tourettes and how a lack of understanding of noise levels might increase anxiety for people with post-traumatic stress disorder. By generating new knowledge and understanding of the divergent capacities of soundscape design to affect and be affected by people within the built environment, the chapter aims to increase the opportunity for researchers across disciplines to think critically about the societal repercussions of design that privileges a normative ear, body and mind.

[Link to paper]
The quality of green spaces in Cáceres (Spain) when compared to those in other cities

Guillermo Rey Gozalo¹, Juan Miguel Barrigón Morillas¹, David Montes González¹, Carlos Iglesias-Merchan², Pierre Aumond³, Rosendo Vilchez-Gómez¹, Pedro Atanasio Moraga¹, José Manuel Pérez Pintor¹, Laura Muñoz Bermejo¹, Silvia Merino-de-Miguel²

¹Universidad de Extremadura, Cáceres, Spain, ²Universidad Politécnica de Madrid, Madrid, Spain, ³Unité de Mixte de Recherche en Acoustique Environnementale (UMRAE) - Université Gustave Eiffel, Nantes, France

According to the policies of the European Union, the increase of green spaces is proposed by city managers in their programmes because of their benefits on the well-being and quality of life of citizens. Urban parks can also bring economic and environmental advantages. However, the extent of new green space is limited in increasingly densely populated cities. Therefore, small green spaces isolated or, even better, connected through pedestrian zones are becoming more and more common. The city of Cáceres plans in the coming years to increase the number of green spaces, the connectivity between them and the pedestrian areas. In this sense, if different indicators for the quality of these areas are not considered, the obtained results may not be as good as expected. We believe that the sound environment is a key factor in the quality of these spaces. In this study, the situation of some green areas in the city of Cáceres is compared with that of other cities in order to quantify their quality.
A methodological proposal to measure rolling noise under real road use conditions

Pedro Atanasio Moraga¹, Manuel Sánchez Fernández¹, Guillermo Rey Gozalo¹, David Montes González¹, Rosendo Vílchez-Gómez¹, Alicia Bachiller León¹, Juan Miguel Barrigón Morillas¹
¹Universidad de Extremadura, Cáceres, Spain

The consideration of temperature as a factor influencing the sound power generated by tyre contact with the road has been known for several decades. However, the introduction of this effect in the methods recommended for the elaboration of strategic maps is very recent. So far, this issue has been studied in the scientific literature, in most cases using different standardised methods. They generally involve controlled conditions for different variables, for example, the type of tyre. On the other hand, studies presenting methodologies for measuring the effect of temperature on rolling noise, under normal road use conditions and using the basic indicators for the preparation of noise maps, are very recent. This study presents a methodological proposal to evaluate the effect of air and pavement temperature on rolling noise. The spectral results obtained in two measurement campaigns are compared. The most important differences between the two campaigns have been observed in the low frequency bands. Moreover, in this frequency range, variations are observed with respect to the results reported in the literature for controlled conditions and also with the CNOSSOS-EU recommendations.

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Assessing the coupling strength between subsystems in (hybrid deterministic) statistical energy analysis

Edwin Reynders¹, Cédric Van hoorickx¹
²KU Leuven, Leuven, Belgium

Statistical energy analysis (SEA) is a standard approach to high-frequency vibro-acoustic analysis that relies on a conceptual division of the system into subsystems that are assumed to carry a diffuse field and to be weakly coupled. The weak coupling assumption means that the exchange of energy between subsystems can be described in terms of their uncoupled free vibration modes. In this work, a criterion is derived for assessing the coupling strength in the general case where the subsystems are rigidly coupled and/or via deterministic linear dynamic components. The criterion is elaborated such that it can be directly evaluated from quantities that appear in the SEA power balance. In this process, the hybrid deterministic-SEA approach is employed such that subsystems and connections of arbitrary complexity can be tackled in a rigorous way. In one of its approximate forms, the proposed general coupling strength criterion reduces to the gamma criterion that has appeared in the literature for assessing some special cases of coupling. The criterion is validated with a numerical example involving two diffuse plate subsystems connected via a deterministic beam, whose dynamic behaviour influences the coupling strength.

Link to paper
Environmental quality or behavioural cognitions? Identifying variables that can be used to classify intended civic engagement against transportation noise exposure

Natalie Riedel, Emily Mena, Heike Köckler, Birgit Reineke, Annette Peters, Lars Schwettmann, Kathrin Wolf, Gabriele Bolte, Ute Kraus

1University of Münster, Münster, Germany

The European Environmental Noise Directive opens the door for the public to participate in the development and review of noise action plans. Regarding health inequities related to environmental noise exposure, we aimed to identify determinants that influence residents’ civic engagement against transportation noise exposure. We defined four variable groups representing either environmental quality with indicators of (1) noise exposure and (2) environmental resources or behavioural cognitions with indicators related to (3) civic engagement and (4) generalised emotions and cognitions. We used data collected from 3,743 participants in the population-based KORA study in the Augsburg region, Germany, and employed Conditional Inference Trees (CIT) to identify variable sets within these four groups that are most likely to classify civic engagement intentions. A final CIT model encompassed all variables. Participants’ social characteristics were included in each of our CIT models. Results suggest interactions between environmental quality (related to sound/atmosphere in the sleeping room) and income and between income and emotions (positive affectivity) with respect to engagement intentions. When considered simultaneously, engagement-specific cognitions appeared as more relevant for engagement intentions than environmental quality. This finding indicates that noise action planning should take behavioural cognitions into account when designing participation processes.

Link to paper
Exploring the relationship between acoustic environmental quality and civic engagement against environmental noise: Outline of a study design from an equity perspective

Natalie Riedel

1University Of Münster, Münster, Germany

Intractable noise exposure has been related to lacking perceived noise control that may deter residents from adopting active coping strategies, e.g. civic engagement against environmental noise. Conversely, environmental stimuli conferring perceived environmental control could be conducive for cognitive resources relevant for civic engagement. Given unequal noise exposures and coping options, civic engagement and participation in planning processes are crucial for environmental justice, however. Exploring the relationship between acoustic environmental quality and civic engagement could therefore deliver an intervention point to achieve more environmental justice. In response to local specifics in the City of Münster, this project shall develop a study design that elaborates on (1) residents’ controllability perceptions at home and engagement-specific cognitions, (2) the qualification of ‘restorative’ as places of behavioural controllability, and (3) the potential compensatory impact of restorative places on uncontrollability perceptions at home and behavioural sequelae. In view of the research objective, the study itself shall contribute to residents’ empowerment, thereby increasing procedural environmental justice. The study design involves information and communication technologies in order to enhance social inclusion. In this contribution, we aim to discuss our study design from an equity perspective and will present preliminary results of our feasibility test.

Link to paper
Unsteady FW-H Simulation of the Aerodynamic Noise of a High Speed Train Bogie

Martin Rissmann¹, Romain Leneveu¹, Claire Chaufour², Alexandre Clauzet², Fabrice Aubin²

¹Vibratec SA, Ecully, France, ²SNCF VOYAGEURS - SNCF MATÉRIEL INGÉNIERIE DU MATÉRIEL – CENTRE D’INGÉNIERIE DU MATÉRIEL, Le Mans, France

Aerodynamic noise is generated by interaction of the air flow with an object and within the turbulent flow itself. In railways it becomes an important noise source for speeds above 250 kph and major areas of noise generation on trains, in particular high speed trains, are the train head, the leading and second bogie, the pantograph and the gaps between trailers. In this presentation a numerical simulation approach based on CFD/CAA techniques aiming to predict aerodynamic noise of different components of SNCF’s TGV high speed trains. The approach is based on an unsteady DES flow simulation combined with the Ffowcs-Williams and Hawkins (FW-H) analogy for the acoustic part. In order to develop the method different models are implemented and the leading bogie was selected as an application case. A simplified symmetric model will be compared against a full, higher resolved model in order to see if computation time gains are feasible. Results of this simulation, in terms of sound power and directivity, are already used by SNCF noise experts in order to estimate pass-by noise levels of TGV high speed trains. Furthermore, noise mitigation solutions can be tested virtually with the suggested approach before being tested with a prototype.
Laboratory measurements on replaceable jack-up systems

Marina Rodrigues\textsuperscript{1}
\textsuperscript{1}Cdm Stravitec Nv, Reutenbeek 9-11 B - 3090 Overijse, Belgium

Floating floor systems are part of state-of-the-art modern building technology. They are an efficient option to improve the acoustical performance of buildings and can be part of box-in-box systems installed in high-performance spaces. There are many types of high-performance floating floor types, one of which is a jack-up system that guarantees that the floor is decoupled from the structural floor. With these systems, once the concrete has cured, the isolated slab is raised off the structure to the required void depth using pre-cast boxes. These boxes allow for easy adjustment of the final floor height and, if the use of the room or load conditions change in the future, can also allow the replacement of the isolators inside them.

Replaceable and inspectable acoustical floor systems are perceived as systems with lower sound insulation (airborne noise) than traditional floating floor or non-replaceable jack-up systems.

To measure airborne sound reduction and impact noise isolation of replaceable jack-up systems and confirm factors that can influence its performance, CDM Stravitec invested in a testing campaign where measurements were made considering many variables, such as: concrete floating slab thickness; bearings type, air void depth, steel lid installed on top of each box and insulation material installed in the air void. This paper will present the findings of our testing campaign.

[Link to paper]
Constrained layer damping concept used on isolated gym floors. Better than Concrete?

Marina Rodrigues

CdM Stravitec Nv, Reutenbeek 9-11 B - 3090 Overijse, Belgium

As the global fitness trends continues in a post-pandemic world, intra-building disruptions from high-energy fitness create serious acoustical challenges. Solutions from simple roll-out mats and rubber tiles to concrete floating floors supported by spring jack-up isolators are used to achieve acoustical separation for gyms.

Understanding the sources of sound and vibration produced in fitness environments and finding effective solutions was a journey that CDM Stravitec began in the 1970s and this area of the acoustics industry has been intensively researched as part of the development of our range of lightweight floating floors.

As part of this research, we extensively investigated how the concept of constrained layer damping (CLD) could be employed to mitigate vibration radiation through structures. In the application of fitness flooring, the CLD functions to restrict the physical movement between the rigid board layers decreases the area of influence from the impact, reduces the energy radiation through the composite panel system to its support and subsequently reduces the energy transfer into the structure.

Our research has also shown that elastomeric supports balance low-resonant frequency performance to prevent energy build-up at the driving frequencies and can achieve high levels of transmission loss which are comparable to concrete based solutions.

Link to paper
Self-tuning vibration control using piezoelectric patches and RL shunts set to maximise electric power absorption

Gabriel Rodrigues¹, Paolo Gardonio¹, Loris Dal Bo¹, Emanuele Turco¹

¹Università degli Studi di Udine, Udine, Italy

This paper presents experimental results on the flexural vibration response of a thin plate structure subjected to a stochastic disturbance. The plate is equipped with five piezoelectric patches connected to shunt circuitry to reduce the resonant response of a target flexural mode. The shunts are synthesized digitally to mimic a resistor-inductor connected in parallel. Firstly, the study assesses the vibration control effects produced by the shunts, contrasting the time-averaged flexural kinetic energy of the panel and the time-averaged electric power absorbed by the shunts filtered in a narrow band centred on the resonance frequency of the target mode. This analysis shows that both cost functions results on the same optimal tuning parameters, which provides a benchmark for the vibration control. Next, it investigates the online tuning of the resistive and inductive components of the shunt by implementing an extremum seeking algorithm set to maximise the time-averaged electric power absorbed locally by the shunt filtered in a narrow band centred on the resonance frequency of a target mode. The study shows that indeed the resistive and inductive components in the shunts connected to the five patches converges to the optimal values with the application of extremum seeking algorithm and this leads to a minimisation of the spectral flexural response vibration at the resonance frequency of the target mode by 18 dB.
Acoustic satisfaction for residents despite entertainment sound impact: can a soundscape approach reveal the positive strength of non-acoustic factors?

Peter Rogers¹, J Harvie-Clark², R Hinton², J Hill², D Cordes¹

¹Sustainable Acoustics Ltd., Winchester, United Kingdom, ²Apex Acoustics Ltd, Newcastle upon Tyne, United Kingdom

A hypothesis for a new concept influencing the control of sound from entertainment affecting residential accommodation is explored in the Ouseburn Valley, Newcastle upon Tyne. UK planning policy protects new residential accommodation from unsuitable living conditions, whilst protecting existing businesses from unreasonable restrictions. There is a reluctance from planning authorities to accept sealed facades due to the lack of amenity for residents. Where entertainment noise emanates from outdoors areas, especially in the post-Covid era, large areas of land can be sterilised for residential development as a result of this conflict. This case study explores the opportunity to introduce a new way to manage sound in this locality, which is rich in cultural character. The existing cultural venues co-exist with some recent residential accommodation, without formal complaints, despite being subject to music noise levels that would not normally be permitted. The paper explores factors including the strength of community cohesion, engagement by the local venue in enabling conflicting uses. A soundscape approach is used to understand residents’ perception, investigating the mitigating effect of non-acoustic factors, exploring a new type of mitigation for music noise impact on residential accommodation. If successful, this has very wide potential application in creating more sustainable communities.
The evolution of a lexicon for Sustainable Acoustics

Peter Rogers\textsuperscript{1}
\textsuperscript{1}Sustainable Acoustics Ltd., Winchester, United Kingdom, \textsuperscript{2}FIOA,

Articulating how sustainability and acoustics fit together has been a challenge, with acoustics facing the image problem that it can’t solve climate change or global overcrowding of the planet, creating a perceived lack of importance in the big picture. This paper focuses on understanding the ubiquitous nature of acoustics is central to a sustainable future, relying heavily on acoustics solutions as a tool to tackle problems faced by humanity on land, air, water. Sound has provided humanity’s first early warning system and listening from space is an example of exactly how acoustics can do more in its many areas of influence, when considering healthy cities, natural capital and the need to monitor and adapt to extreme events. Lindsay’s Wheel has served acoustics well, explaining how such a broad field connects up, but is in isolation from the central existential threats humanity now faces in climate change and determining what sustainable living for humanity means for the future. To evolve and expand the understanding of how acoustics can help deliver sustainable outcomes a new version of the lexicon is proposed, intended to aid the paradigm shift and acceleration needed of acousticians to engage in the local and global solutions needed.

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Gym Acoustics Guidance - the standardised UK approach

Peter Rogers¹, Sebastian Woodhams²
¹Sustainable Acoustics Ltd., Winchester, United Kingdom, ²FIOA,

A drive for low to net zero carbon structures has required a change of direction for Modern Construction Methods to lighter weight buildings, which need to be suitable for many uses over its lifecycle. Gym’s present one of the more challenging uses within a building, especially when in close proximity to residents, which is a desirable aim for sustainable living close to facilities that are positive for health and wellbeing. A standardised approach has therefore been developed for assessing the suitability of buildings for Gym uses, bringing together the experience of those acoustic professionals working in this area in the UK. The results of this collaboration by a working group of the Association of Noise Consultants, with other professional bodies are discussed, with a working draft document now available ahead of its publication. A look at the approaches it contains include a standardised measurement approaches for heavy drops, a practical prediction method, advice for developers and Local Authorities, with insights of the thinking behind it. This paper shares the UK’s approach to this challenge, which is an important future noise control solution for the sustainable future of multi-use buildings.

Link to paper
Citizen Science and Soundscape Perception during Covid restrictions in the UK

Peter Rogers¹, Jim Smith¹, Ben Ward²

¹Sustainable Acoustics Ltd., Winchester, United Kingdom, ²Winchester Science Centre, Winchester, United Kingdom

Winchester Science Centre in Southern England hosts a significant number of informative exhibits pertaining to principles of acoustics; one such example being on the subject of euphony. In a period of time between the first and third COVID lockdowns, visitors to this exhibit were asked what sounds they noticed more or less of, and what their favourite and least favourite sounds were during this period. The results are shared with two-fold benefit: to assist the public perception of noise and euphony, and to capture the aural response of the public to the 2020 COVID restrictions. This paper explores these results, but also the potential for conducting research from a larger cohort of visitors using a citizen science approach to deliver big data sets, to further explore the perception of sound in the environment with regard to its context.
In September 2021, the document that develops an acoustic classification scheme was approved in Spain. It is the UNE 74201 standard that is described in this paper. The Spanish ACS is applicable to new and existing buildings for private or public residential use, for health/hospital and educational use. The development of this document has been a challenge which, requested by the construction sector, has been completed after 5 years of collaborative work, within the Technical Committee CTN74/SC2 - Building Acoustics of the Spanish Standardisation Body, UNE. It's been achieved an ACS compatible with the “DB HR” Spanish building acoustics regulations and, in turn, in agreement as much as possible with ISO/TS 19488:2021. The standard defines different levels of noise protection by using a system of six classes for the requirements, A to F, where Class D defines the minimum requirements for acoustic quality that are mandatory to fulfil in the building code. Criteria for airborne, impact and façade sound insulation, for service equipment noise and for reverberation time are included. This paper shows in detail the verification, sampling and class assignment procedures developed in the standard. A comparison of the most general aspects with other European schemes is also shown.
Reflections on burden of disease and health impact assessment methods for noise

Martin Röösli¹, Danielle Vienneau¹
¹Swiss Tropical and Public Health Institute, Kreuzstrasse 2, CH-4123 Allschwil, Switzerland

Burden of Disease (BoD) assesses the noise impact on health at a given time and in a given population, whereas Health Impact Assessments (HIA) are conducted in the frame of decision-making to evaluate health effects of a policy, programme or project. In a 2020 report, the European Environmental Agency estimates transportation noise exposure in Europe annually results in 22 million highly annoyed, 6.5 million highly sleep disturbed, 48,000 cases of ischemic heart diseases and 12,000 deaths, and 12,400 children with cognitive impairments. These are based on END exposure assessment and exposure-response functions from the WHO noise guidelines 2018. Many more regional or national HIA and BoD studies have been conducted, and common methods across future assessments for consistent communication are needed. Given the rapid developments in noise research, current BoD and HIA are also partly outdated. Critical methodological issues will be discussed using national and regional examples with a focus on Switzerland. This includes the selection of noise sources, relevant health outcomes and corresponding exposure-response functions. Derivation of the lowest effect noise threshold, potential double-counting, and communication of results are also discussed with the aim toward a common understanding for the conduct of future BoD and HIA.
Human diversity in acoustics. Towards a more inclusive sound environment.

Carmen Rosas-Pérez¹, Laurent Galbrun²

¹Heriot-Watt University, Edinburgh, United Kingdom

The study of human responses to sound generally recognises the great importance of taking into account the diversity existent in sounds and acoustics environments, but it rarely adopts the same approach with respect to the diversity in human beings and their responses, providing results as averages meant to represent the ‘normal’ response, and disregarding discrepancies as ‘outliers’. In this paper, neurodiversity and autism is presented as part of the aural diversity factors that can lead to having different experiences of sounds, and an ongoing doctoral research project aiming at representing autistic people’s experiences of the acoustic environment is introduced. Differences in perception of sounds can entail different challenges and needs, that are not currently contemplated in acoustics and soundscape research. The authors believe that all these aspects ought to be considered to widen our understanding of the field, to improve research and practice, and to create acoustic environments that are not just designed for a limited part of the population.

Link to paper
Can you really put a price on a good night’s sleep?

Lukáš Zelem¹, Arnon Vandenberghe³, Andrea Vargová¹, Vojtech Chmelík¹, Monika Rychtáriková²
¹STU in Bratislava, Radlinského 2766/11, 810 05, Slovakia, ²KU Leuven, Hoogstraat 51, 9000 Gent/Paleizenstraat 65, B1030 Brussel, Belgium, ³KU Leuven, Kasteelpark Arenberg 1 box 2200, B-3001, Heverlee, Belgium

This article focuses on estimation of willingness of people to pay extra price for increased sound insulation quality. As a case study a typical 3 room apartment in Bratislava was chosen. Online listening tests were used as a tool to understand the preferred price-quality ratio. The primary financial value of a case study apartment was estimated on real estate market in the third quarter of 2020. Later, nine (9) different variants of sound insulation of partition walls separating dwellings were considered. These walls were chosen on basis of different construction system (1) heavy weight brick walls, (1) light-weight gypsum board walls and (2) double walls. Each construction base was divided into three categories of defined by weighed sound transmission index Rw (53 dB, 55 dB and 59 dB). The four types of sounds (pink noise, cough, quarrel, party noise) were filtered through the frequency spectra R(dB) of chosen walls. These sounds were presented during the online listening test along with a total price for the particular apartment. The test subjects were asked to decide, which apartment they would choose based on an increased acoustic comfort and increased price of the apartment. In total, 60 subjects performed the test.

Link to paper
Explaining inconsistent uncertainty quantification in neural network models of nonlinear flame response.

Marcin Rywik¹, David da Cruz¹, Wolfgang Polifke¹

¹Technical University Munich, Munich, Germany

Neural network models, thanks to their flexibility and ability to approximate any function, are gaining popularity across all research fields. In thermoacoustics, one of their applications is modelling of a nonlinear flame response, learned from a single broadband forcing time series obtained through a computational fluid dynamics simulation. However, the investigations on this flame modelling approach conducted by Jaensch et al. [1] and Tathawadekar et al. [2] report contradictory results, concerning the performance and uncertainty of the derived multi-layer perceptron networks, despite using identical training data. This paper reevaluates their findings and aims to reconcile the opposing conclusions. This work demonstrates the reason for the different network performances, by reviewing the data split policies and identifying shuffling as a detrimental factor. Additionally, in this study different regularisation techniques such as L1 and L2 regularisation as well as network size reduction are considered. Those are compared against the previously tested implementation of dropout [2], which was believed to be responsible for the difference in the results between the two studies.

Link to paper
Validation of calculation method of road traffic noise behind building complex in ASJ RTN-Model 2018 by field measurements

Shinichi Sakamoto¹, Wenrui Xu², Taiki Fukuda², Miki Yonemura¹

¹Institute of Industrial Science, The University of Tokyo, 4-6-1, Komaba, Meguro, Japan, ²Graduate School of Engineering, The University of Tokyo, 7-3-1, Hongo, Bunkyo, Japan

Road traffic noise calculation method behind the buildings included in the ASJ RTN-Model 2018 is an empirical model formula based on experimental results of a scale model. Therefore the scope of the calculation method is formally limited in terms of building height, density, and distance from the road, dependent on the range of experimental conditions. However the roadside conditions in Japanese urban and suburban areas are diverse and it is necessary to quantitatively investigate the validity of the calculation in such various conditions in order to widely expand the applicability of the calculation method. The authors have been studying an efficient estimation method of road traffic conditions in a viewpoint of noise emission from the roads. In order to create accurate noise maps, continuing from the study, an accurate estimation method of noise propagation in various build-up areas is expected. Therefore, in this study, we examine the validity of the road traffic noise calculation method in building complex by comparing the actual measurement results in some build-up areas around arterial roads.

[Link to paper]
Characteristics of powders that cause sound absorption in the low frequency range due to longitudinal vibration in lightweight and fine powders

Shuichi Sakamoto1, Ren Saito1, Keisuke Jindai1, Koki Ikeda1
1Niigata University, Niigata, Japan

In this paper, focus is placed on "lightweight and fine powders" which have small particle size and bulk density and exhibit unique sound absorption characteristics at low frequencies due to longitudinal vibration of powder particles. Theoretical analysis of the sound absorption coefficient of powder layers requires the peak frequency of sound absorption measured experimentally. In this study, we clarified the relationship between powder properties and sound absorption characteristics, and predicted the sound absorption coefficient of the powder layer from the experimental equation based on the accumulated data. This made it possible to classify powders in which sound absorption due to longitudinal vibration occurs based on the relationship between the "areal density per particle layer," which is indicated by "particle size multiplied by bulk density," and the peak sound absorption value. Moreover, from the plot of "areal density per particle layer" and "first-order sound absorption peak frequency from experiment," the experimental formula for the first-order sound absorption peak frequency was regressively obtained. By using the experimental equation obtained in this study, it was possible to show how to estimate the sound absorption coefficient from the properties of each powder alone.
Enhanced 3D (three dimensional) acoustic scene analysis based on sound arrival direction for automatic airport noise monitoring.

Keishi Sakoda¹, Ichiro Yamada
²Rion Co., Ltd., Kokubunjishi, Japan

To deepen our understanding of the spatial and temporal distribution of various sound sources of environmental noise, which is observed by unattended aircraft noise monitors, we have been developing a method of acoustic scene analysis based on information on the 3D sound arrival direction. In the congress of INTERNOISE 2021 last year, we reported the basic idea of this method and some examples of the analysis. The method of acoustic scene analysis, named static mode and dynamic mode, is based on the information of the direction of arrival and sound pressure level of the sound in three dimensions from time to time. Since the moving path was limited to the one satisfying the specified preconditions, there were restrictions on the sound sources moving in the sky to be applied. Therefore, we decided to improve the versatility of the dynamic mode acoustic scene analysis method by adding a sensor that observes the direction of sound arrival. In this paper, we report the results of our experiments and analysis.

Link to paper
Investigation of nonlinear propagation effects on sound from supersonic bullets

Erik Salomons¹, Frits van der Eerden¹, Frank van den Berg¹
²TNO, The Hague, Netherlands

ISO standard 17201-4 is a calculation method for sound levels generated by supersonic bullets. The standard takes into account nonlinear propagation effects, including broadening of a sound pulse with increasing propagation distance. Two elements of the ISO method are investigated in this paper: i) the accuracy for various Mach numbers, and ii) the effect of noise barriers. For the first element, calculation results are compared with measurement results. In general the agreement is good, but large deviations occur at Mach numbers near unity. Calculation parameters were varied in order to find an explanation for the deviations. For the second element, propagation paths along the horizontal top edge and the vertical side edges of a barrier of finite length are considered. For the path over the top edge, a possible approach is developed to account for the expected reduction of nonlinear propagation effects in the shadow region behind a barrier. For the paths along the vertical side edges, a simulation model with a dense distribution of point sources is employed. The three propagation paths are explained in terms of pairwise cancellation of Fresnel zones. The results of the simulation model are compared with results of an engineering model.

Link to paper
Towards bridging nano- and macroscale acoustics of porous solids

Alan Sam¹, Marina Barbagero¹, Rodolfo Venegas², Benoit Coasne¹

¹Laboratoire Interdisciplinaire de Physique (LIPhy), Université Grenoble Alpes, Grenoble, 38402, France, ²University Austral of Chile, Valdivia, Chile

This work presents results towards the bridging of nano- and macroscale acoustics of porous solids. We use molecular dynamics (MD) simulations to estimate the mechanical parameters of a nanoporous solid. These simulations consist in applying tensile and shear deformation to a zeolite material and calculate the mechanical properties from the linear regime of the stress-strain curve. The specific outcome of the simulations are phase velocities and mechanical parameters that can be used as inputs in meso/macroscopic models. To further exemplify the proposed nano-macroscale modelling strategy, wave propagation in a tube with an array of zeolite-made plates is studied, thereby providing a novel approach to the acoustic modelling of multiscale metamaterials.

Link to paper
Reduced basis methods with parameterized boundary conditions for room acoustics

Hermes Sampedro Llopis1,2, Allan P. Engsig-Karup3, Cheol Ho Jeong2, Finnur Pind4, Jan S. Hesthaven5

1Rambøll, Copenhagen, Denmark, 2Acoustic Technology, Department of Electrical Engineering, Technical University of Denmark, Lyngby, Denmark, 3Department of Applied Mathematics and Computer Science, Technical University of Denmark, Lyngby, Denmark, 4Treble Technologies, Reykjavik, Iceland, 5Chair of Computational Mathematics and Simulation Science, Ecole polytechnique federale de Lausanne, Lausanne, Switzerland

Room acoustic simulations can be performed by means of numerical methods, which typically solve the wave equation in an enclosure using discretization techniques. These methods provide high-fidelity solvers that include all the wave phenomena but are computationally costly. This paper presents the potential of a reduced basis method for simulating room acoustics when the boundary properties are changed iteratively, e.g., design changes in rooms where different boundary properties are simulated, which increase the computational cost when using traditional high-fidelity solvers. The presented framework allows reducing the computational burden by applying reduced basis methods and solving the problem in a reduced low-dimensional subspace where the absorption properties of complex boundary conditions are parameterized, e.g., the thickness of a porous material. The potential of the proposed framework is analyzed in terms of computational efficiency, accuracy and storage requirements. We show a computational reduction of two orders of magnitude for a 2D case with an upper frequency of 2 kHz and three orders of magnitude for a 3D simple case with an upper frequency of 1 kHz showing a potential of having an increase in terms of speedup when increasing the size of the domain. The storage requirement for a 2D case with an upper frequency of 8 kHz is 10.8GB while for a 3D case with an upper frequency of 1 kHz is 8GB.

Link to paper
Acoustic effects of elevated platforms for standing audiences in an indoor music venue

Rebeca Sánchez¹, Luis Gomez-Agustina²
²London South Bank University, London, United Kingdom, ¹London South Bank University, London, United Kingdom

The live music industry has grown significantly over the last decade, making live music not only an important component of the cultural scene but also a major economic engine. There is little research or guidance regarding acoustic design for amplified music venues, especially for improvements in the design of the indoor standing audience area. This investigation aimed to determine the acoustic effects and potential benefits to the audience, of elevated platforms in an indoor music venue. Objective parameters such as reverberation (T30), Early Decay Time (EDT), Clarity (C80), Definition (D50), and Sound Pressure Levels (SPL) were analysed through computer simulations for twelve platform arrangements of different platform heights and audience densities. Results from all possible combinations were compared and evaluated for improved acoustical and sound quality. It was shown that the use of elevated platforms reduced reverberation time parameters and increased C80 and D50. These changes in acoustic parameters appeared also to be dependent on audience density. It is expected that the novel information and guidance provided by this research will assist acoustic designers, sound engineers, and other relevant decision-makers to improve the audio-visual experience of standing audiences.

Link to paper
The EU Tyre Noise Label: The problem with measuring the noise level of only a few of all tyre variants

Ulf Sandberg\textsuperscript{1}, Piotr Mioduszewski\textsuperscript{2}

\textsuperscript{1}Swedish National Road and Transport Research Institute (VTI), Linkoping, Sweden, \textsuperscript{2}Gdansk University of Technology, Gdansk, Poland

The STEER project, described in another Inter-Noise 2022 paper, has evaluated the performance of the noise label of the European tyre label. The major finding was that uncertainties of the tyre/road noise measurements were higher than should be accepted. One of the worst uncertainty sources was found to be the common practice to measure only some tyres of all sizes or variants within a tyre line, to save money. Generally, only the noisiest tyre(s) is/are measured individually and other tyres in that line get the same level, which means that many if not most tyres are labelled with too high noise levels. Then consumers cannot find the quietest tyres. STEER lacked resources to study this problem, but a Swedish project supported STEER in this respect, by making it possible to measure noise of 53 tyres selected from tyre lines of three major tyre manufacturers. The results showed that even though tyres in each line were labelled with the same noise level, in practice they differed up to 6 dB in noise emission. To avoid this very serious source of uncertainty, a special simplified test is suggested in order to be able to label tyres correctly without too much extra effort.

[Link to paper]
The effect of corrugations on the crackle noise in under-expanded impinging jets

Debivarati Sarangi\textsuperscript{1}, Karthik R\textsuperscript{2}, Srinivasan K\textsuperscript{3}
\textsuperscript{1}IIT Madras, Chennai, India, \textsuperscript{2}IIT Madras, Chennai, India, \textsuperscript{3}IIT Madras, Chennai, India

The present study investigates crackle noise of the impinging jet over the flat and corrugated plate. The experiments are conducted using a 10 mm diameter (d) orifice for jet production. The standoff distance is varied from 1.5d to 6d, incrementing 0.5d. The nozzle pressure ratio (NPR) is varied from 4 to 5.6 with a step size of 0.2. Results are discussed by plotting the probability density function of normalized pressure data and measured skewness values. For the flat plate, the positive skewed pressure data associated with strong compression and expansion is observed for all NPRs, and the skewness value increases with an increase in NPR. The crackle noise is absent in the corrugated plate for most NPRs and standoff distances, although it is observed within a short duration at some NPRs. In contrast, the crackle noise is persistent for the flat plate throughout the time range and is observed at a skewness value of 0.1391, which is less than that of the free jet.
Evaluation of flyover auralisations of today's and future long-range aircraft concepts

Beat Schäffer¹, Lothar Bertsch², Ingrid Le Griffon³, Axel Heusser¹, Catherine Lavandier⁴, Reto Pieren¹

¹Empa, Swiss Federal Laboratories for Materials Science and Technology, Dübendorf, Switzerland, ²German Aerospace Center (DLR), Göttingen, Germany, ³Office National d’Études et de Recherches Aérospatiales (ONERA)—Paris Saclay University, Châtillon Cedex, France, ⁴ETIS laboratory, CY Cergy Paris University, ENSEA, CNRS, UMR8051, Cergy, France

The European research project ARTEM (Aircraft noise Reduction Technologies and related Environmental iMpact) develops innovative aircraft noise reduction technologies such as advanced engine fan lining, metamaterials and low-noise high-lift systems applied to a vehicle with enhanced shielding of the engine noise, namely, a blended wing body. Using aircraft flyover auralisation in laboratory listening experiments, such future technologies can be evaluated with respect to human sound perception. To assess the reliability of such perception-based evaluations, the simulation chain should be validated with existing aircraft flyovers. This contribution presents a systematic and rigorous hierarchical validation of auralisations of current jet aircraft using field recordings. Uncertainty in the source modelling is considered by using two different prediction tools for partial sound sources. In addition to comparing computed noise indicators, a psychoacoustic validation is done in laboratory listening experiments with a 3D loudspeaker array. The validation comprises three levels: (i) direct comparison of auralisations with recordings to study the identifiability of auralisations, (ii) ranking of auralisations and recordings regarding plausibility, and (iii) subjective annoyance ratings to test whether auralisations and recordings differ with respect to noise effects. Further, first results on the comparison of a future concept with a current aircraft are presented.
Calculation of annual aircraft noise exposure for Geneva and Zurich airports with the next-generation program sonAIR – first results

Stefan Schalcher¹, Christoph Zellmann¹,², Jonas Meister¹, Jean-Marc Wunderli¹, Beat Schäffer¹
²Empa - Swiss Federal Laboratories for Materials Science and Technology, Dübendorf, Switzerland, ²n-Sphere AG, Zürich, Switzerland

The next-generation aircraft noise simulation program sonAIR was designed to precisely predict single flights with the scope of investigating and optimizing noise abatement flight procedures. Recently, sonAIR was implemented in a geographic information system (GIS) to make it suitable for noise mapping calculations of entire airport scenarios. In this study, we conducted first calculations of annual aircraft noise exposure with sonAIR for Geneva and Zurich airports, Switzerland, for the year 2017, simulating several 10'000 single flights and accounting for real conditions in great detail (e.g., detailed emission modelling and considering ground cover in the sound propagation calculation). Our calculations proved the ability of sonAIR to do annual aircraft noise calculations with many simulated flights. Comparing the results to those obtained with the best-practice program FLULA2, which is currently used for official aircraft noise calculations in Switzerland, we found that the noise contours differ on average little in areas with legally relevant noise exposure. However, locally larger differences may occur, primary due to varying ground cover and more detailed sound emission modelling. In this contribution, we present the process of sonAIR for annual aircraft noise calculations, show the most important results and discuss implications for future aircraft noise calculations around airports.

[Link to paper]
Uncertainty of structure-borne sound source quantities and the installed power from interlaboratory test results according to EN 15657

Jochen Scheck¹, Volker Wittstock, Michel Villot
²HFT Stuttgart, Stuttgart, Germany

Structure-borne sound sources affect the acoustic quality inside buildings. Based on many years of research, methods have been standardised to characterise structure-borne sound sources in the laboratory (EN 15657) and to predict the sound transmission from these sources when installed in buildings (EN 12354-5). This contribution is about the uncertainty of the source descriptors used in EN 15657 and the predicted installed sound power which is the input quantity for EN 12354-5. Recently an interlaboratory test with 7 participating laboratories has been performed. The task was to measure the blocked force, free velocity and mobility of an artificial source and the blocked force of the ISO tapping machine. From the evaluation of the measurement results estimates for the uncertainties of the source quantities and the installed power could be deduced.

Link to paper
Annoyance of rotorcraft sounds in urban background noise

Josef Schlittenlacher¹, Karine Wales¹
¹University Of Manchester, Manchester, United Kingdom

Scenarios of urban air mobility see electric vertical take-off and landing aircraft (eVTOLs) operating within cities. Rotorcraft sounds are typically characterised by short bursts of noise, although eVTOLs offer more opportunities for a quieter sound design. We asked participants to compare the annoyance of a reference sequence of bursts of noise with a burst duration of 20 ms with that of a test sequence for which the burst duration was 1 or 5 ms. There were 20 bursts/s. A two-interval, two-alternative forced-choice task and a 1-up/1-down procedure was used. Both sequences were played in background noise that had either the same root-mean-square (RMS) level as the sequence of bursts or 10 dB less. The results were similar to those for loudness: On average, sequences with 1-ms bursts needed 6-7 dB less RMS level to sound equally annoying as the 20-ms bursts, and sequences with 5-ms bursts needed 3 dB less. This suggests that psychoacoustic annoyance is mainly explained by loudness and that the RMS level is an insufficient descriptor. Compared between the two background noise levels, the level difference for equal annoyance between short and 20-ms bursts was 1.5 dB larger in the louder background, which was statistically significant.
Experiences with source characterization methods within and beyond the scope of EN 15657

Fabian Schöpfer¹, Tobias Kruse¹, Johanna Weinzierl¹, Andreas Mayr¹, Ulrich Schanda¹
¹Rosenheim Technical University Of Applied Sciences, Hochschulstr. 1, 83024 Rosenheim, Germany

Prediction of machinery noise in buildings requires knowledge about the airborne sound radiation and the structure-borne sound excitation from the source of interest. Laboratory methods to determine the airborne sound power of sources are well established since many years. However, standard methods for the characterization of structure-borne sound from building service equipment were first described in EN 15657-1:2009 which was then superseded by EN 15657:2017. In recent years the test methods described in this standard were applied in several research and development projects in the laboratory for sound measurement (LaSM) at Rosenheim Technical University of Applied Sciences. For this purpose the experimental equipment and the facilities of the laboratory were expanded which involves a variable reception plate test rig that was built in 2017. This paper describes the experience with test methods within and beyond the scope of the EN 15657:2017 using the available laboratory resources.
The role of sound emergence for aircraft noise annoyance

Dirk Schreckenberg¹, Christin Belke¹, Jördis Wothge², Rainer Guski³

¹ZEUS GmbH, Hagen, Germany, ²Germen Environmental Agency, Dessau-Roßlau, Germany, ³Ruhr-University Bochum, Bochum, Germany

The metric emergence relates source-specific sound levels to background noise. The approach of subtracting a residual sound level (total sound level without the level of a specific source) from the total sound level follows the definition of emergence in ISO 1996-1. Using exposure and survey data of the German NORAH study, the impact of emergence on aircraft noise annoyance was analysed.

As total background sound levels were not available, information about source-specific and combined noise levels was used instead. For participants exposed to aircraft and road traffic noise for the emergence substitute es(air/road), road traffic sound levels for daytime (LAeq,road,day) of the home address of survey participants were subtracted from the combined sound levels of aircraft and road traffic noise (LAeq,air+road,day) with road traffic noise regarded as a proxy for background noise. Similar, for participants exposed to aircraft and railway noise, LAeq,rail,day were subtracted from LAeq,air+rail,day to obtain es(air/rail). The percentage of people highly annoyed (%HAV) by aircraft was predicted by LAeq,air,day for subgroups with es(air/road) and es(air/rail) ≥ 3 dB and es(air/road) / es(air/rail) < 3 dB.

Results: Particularly in low aircraft noise-exposed areas, %HAV is higher for those with higher values of es(air/road) and es(air/rail), respectively.

[Link to paper]
Acoustical properties of alternative sleepers: experimental testing

Wout Schwanen¹, Nils Yntema²
¹M+P, Vught, Netherlands, ²ProRail, Utrecht, Netherlands

ProRail, the Dutch infrastructure manager, started a project to test alternative, sustainable, sleepers. A test setup was achieved along the line from Zwolle to Heino in the Netherlands, where six test sections were constructed. Two reference sections with standard concrete sleepers and four sections with alternative sleepers.

During one day we performed simultaneous sound pass-by measurements at the six test sections. In addition, we measured the rail roughness and the track decay rate of each test section. The results clearly show that an alternative sleeper influences the track decay rate of the track. This difference in track decay rate leads to different pass-by sound levels. This paper shows the results of the experiments.

[Link to paper]
Application of sound absorption measurements according to EN 1793-5 on gabion walls

Wout Schwanen\textsuperscript{1}, Willem Jan van Vliet\textsuperscript{2}
\textsuperscript{1}\textit{M+P, Vught, Netherlands, 2Rijkswaterstaat Grote Projecten en Onderhoud, Utrecht, Netherlands}

The standard EN 1793-5 describes a method to determine the sound reflection index of road traffic noise reducing devices under direct sound field conditions in-situ. The method is commonly used to assess the intrinsic characteristics of conventional, absorptive noise barriers and yields results with a limited measurement uncertainty. Recently, the sound reflection index of a gabion wall was determined by means of the in-situ measurement method leading to unexpected results. An in-depth analysis was made of the results of the in-situ measurements on a conventional noise barrier and on a gabion wall. The main conclusion of this comparison is that application of the in-situ method on a gabion wall has a much higher measurement uncertainty than to be expected.

\textbf{Link to paper}
Role of stretch on the flame dynamics of laminar premixed flames

Edoardo Scoletta¹, Wolfgang Polifke¹
¹Technical University of Munich, Garching, Germany

Flame transfer functions (FTF) of laminar premixed flames acoustically forced are analytically investigated and modelled. The study is based on the linearized G-equation, which is used to kinematically track the flame front. In order to incorporate combustion properties, the laminar consumption speed is considered varying depending on the flame front stretch. Once written in dimensionless form, the G-equation reveals that the FTF depends on 3 dimensionless parameters: a Strouhal number (St₂) that accounts for the convective time of the flow perturbation along the flame-front, the flame aspect-ratio (Lf/R) and the dimensionless Markstein length, adimensionalized by the injector radius. It is shown that the latter term is responsible for a flame-flow feedback that acts as damper or amplifier of the flame perturbation, respectively for thermodiffusively stable or unstable flames. A LOM FTF is derived both for Conical and V-flames, highlighting the impact of stretch for each configuration. Ultimately the obtained FTFs are compared to previously proposed analytical FTFs from the literature, underlining the importance of stretch at high frequency.

[Link to paper]
Objective and subjective analysis of the acoustic performance of a ZEB test-building

Chiara Scrosati¹, Fabio Scamoni, Michele Depalma, Ludovico Danza
²ITC CNR, viale Lombardia 49, San Giuliano Milanese (MI), Italy

The paper describes an experimentation campaign, including both objective and subjective analysis, carried out in a Zero-Energy full-scale test building and aiming at analysing the acoustic performance of the construction and the acoustic comfort of the rooms. The objective analysis consists of sound insulation measurements of facades and partitions, noise level measurements of service equipment and environmental noise level monitoring. The subjective analysis is based on a survey carried out on 100 participants to collect the answers about their evaluation of the acoustic quality in two different test rooms. The outcomes of the questionnaire were compared to the outcomes of the measurements in order to find a relationship between the subjective and objective data.

[Link to paper]
Resolving clashes between net-zero energy and acoustics engineering specifications, to enhance low-carbon building performance, regulatory compliance and future skills. Laws and standards comparison between Italy and UK

Ludovico Danza¹, Chiara Scrosati¹, Lorenzo Belussi¹, Fabio Scamoni¹, John Currie³, Sean Smith²

¹Itec Cnr, Via Lombardia 49, Italy, ²University of Edinburgh, Edinburgh, Uk, ³Edinburgh Napier University, Edinburgh, UK

Under the CNR (Italy) and RSE (Scotland) joint scientific cooperation agreement, the present project deals with the development and enhancing understanding of the technical clashes and engineering solutions required to deliver net-zero outcomes across diverse construction systems both in new build and retrofit. This paper relates to the comparison between the two research groups about the acoustic and energy standards and low carbon measures in force in the both countries. The sound insulation requirements for residential buildings are mandatory in both Scotland and Italian building regulations. Sound insulation performance compliance is undertaken via on-site testing after completion of construction works whether new build or conversion/change of use. Importantly the specification for energy efficiency changes (and improvements) to the fabric of buildings often clash in terms of the material properties and performance functions for sound insulation. Thus, it is critically important for the specification changes in building materials for energy efficiency do not negatively impact noise and vibration sound insulation and vice versa. This can lead to non-compliance resulting in noise disturbance complaints by building occupants or loss of performance for energy efficiency. The paper characterises some of the regulatory factors, clashes in material outcomes and recommends the importance of multi-factor knowledge and understanding across building performance measures.

[Link to paper]
We develop room acoustic prediction and evaluation tools for designers to be used in halls and conference areas where the design of acoustical performance is essential. The designers, with no specialized knowledge of acoustics, are able to examine the tools at an early stage of the project. The interface tool consists of the 3D CAD software—Rhinoceros, and its plug-in tool—Grasshopper. The designers first build a room model on Rhinoceros and locate the sound source and the receiver points in the model. They then set the calculation conditions via Grasshopper, such as room use and type of interior finishes. Next, room sound propagation is calculated using the ray tracing method in the external python programs. Then, acoustic indices, such as the average sound absorption coefficient and clarity, are predicted. These indices are automatically evaluated according to the room use, and the evaluated results are visualized in the room model on Rhinoceros. This paper outlines these tools and exhibits the agreement of predicted and measured indices in a small hall. These tools are applied to a lecture room with complicated ceiling ribs, and an office with a stairwell, which are difficult to examine by the conventional reverberation formula.
Serial recall performance under different room acoustic conditions

Jan Selzer¹, Florian Schelle¹, André Fiebig²

¹Institute for Occupational Safety and Health (IFA der DGUV), Sankt Augustin, Germany, ²Technische Universität Berlin, Berlin, Germany

In office workplaces high demands on the concentration of employees are set. This is contrasted by the effect of irrelevant speech, which has been shown to decrease working memory performance.

The presented survey investigates the impact of different room acoustic conditions on the irrelevant speech effect. To address this question, the decrease of performance was investigated by a serial recall test using a within-subject design. Six stimuli were used for the experiment: silence as reference, pink noise, two speech signals with different degrees of fluctuation strength, each presented in room acoustic conditions with long and without reverberation. Each stimulus is used in twelve trials. One trial consisted of the representation phase of nine digits, sequentially presented in random order and the recall phase.

Furthermore, different test designs were used. In the first design the playback of the stimulus was continuing during twelve trials. In the second design each trial had a randomised stimulus playback.

In addition, the annoyance was assessed, and a closing interview conducted. The results of the study with 44 participants are presented and discussed in this contribution. Overall, a significant decrease in performance is observed in the speech conditions compared to the reference condition.
Modal analysis of Free Vibration of an Extremely Lightweight Panel Model for Bridge Bearing Applications

Pasakorn Sengsri¹, Sakdirat Kaewunruen¹
²Laboratory for Track Engineering and Operations for Future Uncertainties (TOFU Lab), School of Engineering, The University of Birmingham, Edgbaston, Birmingham B15 2TT, UK, United Kingdom

This paper reports a novel extremely lightweight panel model under free vibration. This novel model is likely to be used for railway/highway bridge bearing applications due to its high performance to weight ratio, which offers superior mechanical properties, such as sound and vibration attenuation, rigidity, and energy absorption. The structure of the model is based on triply periodic minimal surfaces (TPMS) conceived by observing the scales of butterflies’ wings. The vibration behaviours of this novel panel model used as bridge bearings are not well-known and have never been fully investigated under free vibration. Therefore, it is important to comprehend the free vibration behaviours of the model and to identify its dynamic modal parameters. In term of modelling, a TPMS sandwich panel finite element (FE) model and a typical bridge bearing FE model under free vibration for bridge bearing applications are designed and examined with a computational method. In general, FEA predictions of the free vibration behaviours of the novel panel model compared to a conventional bridge bearing model provide very good results. These results can be implemented to better generate design standards of extremely lightweight sandwich structures under different vibrations for bridge bearing applications in the near future.

[Link to paper]
Periodic flank modifications for optimal excitation behavior of practical gear geometries

Sebastian Sepp

Technical University Of Munich - Gear Research Center (FZG), 85748 Garching (Munich), Germany

The design of modern transmissions faces new challenges regarding the main design principles efficiency, service life and noise emissions. These challenges are further intensified by the progressing electrification of vehicle drive systems and the associated trend towards higher rotational speeds. In order to achieve the design objectives at the level of flank modifications, the microgeometry has to satisfy partially competing requirements. Most present gears are designed with combinations of standard modifications to obtain the best possible compromise between the competing goals. The application of periodic modifications provides a possibility to avoid particularly the trade-off between the two design principles load carrying capacity and excitation. The periodic modifications directly compensate the alternating part of the elastic deformations in the mesh without changing the load distribution. They can be used to optimize the excitation behavior independently of the load carrying capacity. Theoretical studies show the potential of periodic modifications to optimize the excitation behavior for a special target load or even for broad load ranges. Experimental investigations at two test rigs of the Gear Research Center (FZG) verify the effectiveness of these flank forms to optimize the excitation behavior for different practical gear main geometries.

Link to paper
Study On the Effect of Operating Conditions on Acoustic Three-Port Measurements of Perforates in presence of Grazing Flow

Shail Shah¹, Hans Bodén¹, Susann Boij¹
²KTH Royal Institute of Technology, Stockholm, Sweden

Different impedance eduction methods have been previously used to study the acoustic properties of perforated plates in the presence of grazing flow, giving varying results. The work presented here is to contribute to the ongoing experimental research on the acoustic behaviour of perforates under different acoustic excitations and flow conditions. Here, a three-port technique is used to study the aero-acoustic properties of perforates, which allows to observe the acoustic field on both sides of the perforate. Experimentally determined characteristics of the perforate are dependent on the operating conditions like grazing flow speed, microphone distances, standing wave pattern, and temperature. This study aims to provide the experimental analysis on the effect these factors have on the calculated perforate properties, namely the transfer impedance and the scattering matrix. Global sensitivity analysis is performed to study the individual effect of these factors in the post-processing, as well as the overall effect of error in the determination of these operating conditions.

[Link to paper]
Flow Acoustic Interaction In A Rectangular T-Junction With Mounted Perforate Using Acoustic Three-Port Measurements

Shail Shah¹, Hans Bodén¹, Susann Boij¹
¹KTH Royal Institute of Technology, Stockholm, Sweden

Varying acoustic behaviour of perforates in presence of grazing flow and under acoustic excitation from different directions has been under research since mid-1950s. Empirical and semi-empirical studies have shown differing behaviour of the perforate transfer impedance in presence of grazing flow. Studying a perforated plate in a rectangular T-Junction, this study aims to study the perforate from three acoustic incidence directions. Scattering matrix and the acoustic transfer impedance are determined experimentally under the presence of external grazing flow to characterise the perforate and the T-Junction. In accordance with previous research, an oscillating behaviour of amplification and attenuation is observed in the empty T-Junction. Results obtained of the perforate show a similar oscillating behaviour. Comparing with the rectangular T-junction, the similarity in the flow acoustic behaviour of a perforate is shown.
The impact of covid-19 restrictions on complaints of noise made to a local authority in Northern Ireland - a case study.

Lindsay Shaw¹, Paul McCullough

¹Ulster University, Belfast, United Kingdom

The covid pandemic with national lockdowns and restrictions profoundly affected people’s lives in many ways including the experience of neighbourhood noise. While initial research indicated a rise in noise complaints at the start of restrictions in London during Spring 2020 (Tong, 2021), a case study involving a single local authority in Northern Ireland indicates a different experience when the full 2020 year was analysed. Total number of complaints did not see a statistically significant increase when compared to the 5-year average. While there were increases in some categories of noise of interest (loud music and parties, noise associated with anti-social behaviour), the comparison with the 5-year average did not show a statistically significant difference. The only category of noise that seen an increase of significance was noise complaints relating to retail. This may be explained by increased demand in essential food retail as well as social distancing requirements, limitations to customers inside premises and changes made as the retail sector adapted. A wider study involving local authorities across Northern Ireland, the UK and across countries that experienced lockdown measures may reveal a more accurate picture of the impact of neighbourhood noise experienced during the covid pandemic.

[Link to paper]
One of the latest trends in noise control relating to aeroacoustics is to mimic the silent flight capability of owls. Particularly, porosity is most often applied on cascades in ducts with axial flows, such as stator structures in an aero-engine. However, current acoustic scattering models of perforated cascades are based on two-dimensional methods without including the three-dimensional effects. In this paper, we present a fully three-dimensional acoustic scattering model for perforated cascades based on the lifting surface theory in which the dominant sound source reduces to dipoles alone under the thin airfoil assumption. Accordingly, the acoustic scattering of perforated cascades with single-mode incident wave was studied and obvious noise reduction was observed. The optimum Rayleigh conductivity and the maximum noise-reducing capability of the porosity varied substantially with different incident duct modes, whilst a larger cascade chord-length could achieve more noise reduction at optimum porosity. With a background flow, the Kutta condition can greatly influence the overall distribution of the unsteady loading on vanes. Additionally, the unsteady vortex shedding at the trailing edge offers extra sound energy dissipation mechanism. Therefore, the implementation of porosity on cascades is much different to the design of a traditional acoustic liner.
Implementations of wireless active noise control in the headrest

Xiaoyi Shen¹, Dongyuan Shi, Santi Peksi, Woon-Seng Gan
¹Nanyang Technological University, Singapore, Singapore

Working from home went from a temporary result of the pandemic to a way of life. However, peace and quiet are hard to come by. To get rid of distraction, Active Noise Control (ANC) particularly the ANC headphones are widely used to attenuate the undesired noise in daily life. While it works, the prolonged usage of headphone can cause some discomfort. This work describes a wireless ANC system implementation designed for the headrest to reduce the noise distraction while doing away with discomfort caused by prolonged usage of headphone. Wireless microphones are utilized to pick up the noise with a high reference-to-interference ratio, which helps in improving the noise reduction performance of the ANC headrest. This paper investigates the feedforward, feedback, and hybrid ANC structures’ noise reduction performances in the ANC headrest. Comparative experimental results shown in this paper indicate the effectiveness of the proposed approach in reducing noise around the headrest.
Low-frequency vibration of a timber joist floor section connected by metal screws: experimental validation of FEM models

Xiaoxue Shen¹, Carl Hopkins¹
²University Of Liverpool, Liverpool, United Kingdom

The structural dynamics of a timber floor junction (six pieces of chipboard plate screwed to a single timber joist) have been investigated experimentally in a frequency range up to 200Hz. Experimental Modal Analysis (EMA), transfer mobilities and velocity level ratios between the chipboard walking surface and the joist were measured with 12 or 24 screw connections between the joist and the chipboard. These experimental data were used to validate Finite Element (FE) models that focussed on the interaction between the chipboard and the joist due to the screws. The aim is to develop validated FE models for timber floors that can be used to assess heavy impacts (such as the rubber ball impact source) and act as a reference for the future development of TSEA models for lightweight structures. The screws were modelled using both rigid connections and springs. For the latter, each point connection was modelled by four springs with stiffness (three coordinate directions and one rotational direction), with model updating using a Deep Neural Network (DNN). A comparison of mode frequencies and mode shapes from EMA and FEM will be made along with forced vibration of the structure.

Link to paper
Diesel Engine Noise Source Visualization by Using Compressive Sensing Algorithms

Tongyang Shi\textsuperscript{1}, J. Stuart Bolton\textsuperscript{2}, Frank Eberhardt\textsuperscript{3}
\textsuperscript{1}3M Company, Woodbury, United States, \textsuperscript{2}Purdue University, West Lafayette, United States, \textsuperscript{3}Cummins Inc., Columbus, United States

To identify sound source locations by using Near-field Acoustical Holography (NAH), a large number of microphone measurements is generally required in order to cover the source region and ensure a sufficiently high spatial sampling rate: it may require hundreds of microphones. As a result, such measurements are costly, a fact which has limited the industrial application of NAH to identify sound source locations. However, recently, it has been shown possible to identify concentrated sound sources with a limited number of microphone measurement based on Compressive Sensing theory. In the present work, sound radiation from the front face of a diesel engine was measured by using one set of measurements from a thirty-five-channel combo-array placed in front of the engine. The locations of significant noise sources were then identified by using two algorithms: i.e., l1-norm minimization and a hybrid approach which combined Wideband Acoustical Holography (WBH) and l1-norm minimization. It was found that both algorithms can successfully localize and visualize the major noise sources over a broad range of frequencies, even though using a relatively small number of microphones. Finally, comments are made on sound field reconstruction differences between the two algorithms.
Applying the remote microphone method in the filtered error least mean squares algorithm

Yujie Fu¹, Chunyu Liu¹, Chuang Shi¹
²University of Electronic Science and Technology of China, Chengdu, China

An active noise control (ANC) system generates an anti-noise wave to reduce the noise level at a control point, where the error microphone is conventionally placed. Virtual sensing techniques are developed for situations when the error microphone cannot be permanently placed at the control point. The remote microphone (RM) method is one of the most straightforward virtual sensing methods. Previous studies have demonstrated that the performance of the RM method is influenced by the causality between the physical and virtual error microphones, which can be resolved by introducing a delayed version of the virtual error signal. So far, the RM method has mainly been examined with the filtered reference least mean squares (FxLMS) algorithm. This paper applies the RM method in the filtered error least mean squares (FeLMS) algorithm. The FeLMS algorithm introduces an adjoint filter to reduce the computational complexity of the ANC system. The delay incurred by the adjoint filter is just right to implement the delayed virtual error signal of the RM method.
Determining CNOSSOS-EU Meteorological correction factors in Ireland

Simon Shilton¹, Joshua Nunn²
¹Acustica Limited, Manchester, United Kingdom, ²Noise Consultants Limited, Warrington, United Kingdom

Ahead of the Round 4 strategic noise mapping under the END, TII commissioned a research project to determine the meteorological correction factors required for CNOSSOS-EU road and railway traffic noise calculations across Ireland. Methodologies for determining the percentage favourable propagation were identified under NMPB2008 and NORD2000, and the input data requirements of the methods assessed. Meteo data available from Met Eireann and TII weather stations was collected and collated and compared with the requirements of the two methodologies. The data available in from Irish met stations led to the selection of the methodology from NORD2000 being selected. Thirty years of hourly data was analysed for 26 counties to provide long term weather data for temperature, relative humidity, mean sea level pressure, and percentage of favourable propagation suitable for calculations under CNOSSOS-EU. This paper will present an overview of the methodology, available data and results obtained.

Link to paper
Implementing the CNOSSOS-EU correction near traffic light junctions and roundabouts

Simon Shilton1, Raf Douglas C. Tommasi2
1Acustica Limited, Manchester, United Kingdom, 2Tommasi and Tommasi, Udine, Italy

Under the Environmental Noise Directive (END), the Round 4 strategic noise maps are to be calculated using the methodology set out in Directive 2015/996 (as amended) (CNOSSOS-EU). As part of the road traffic source emission model, a correction for the effect on noise levels due to the acceleration and deceleration of vehicles shall be applied near crossings with traffic lights and roundabouts. As part of the revision of the EPA guidelines on strategic noise mapping in Ireland, a technical investigation was carried out to identify the effect of the correction factor on road traffic noise emissions, and determine whether there was a practical approach to implement the correction factor within the upcoming noise mapping. This paper will provide an overview of the results, including the change in noise level emissions for low speed low flow roads, and high speed high flow road. It will also present a practical approach to preparing the road traffic flow models in GIS based on available datasets.

[Link to paper]
Siebein (2010) identified 5 levels of architectural soundscapes: inspiration; planning; conceptual structure; tectonics; and detail. Case studies of the use of the levels are presented to illustrate how architects often use inspiration and planning metaphors to begin the design of a building. A conceptual structure is the underlying set of principles and ultimately geometries that form the basis for the intellectual and formal aspects of the project. Tectonics are the elements that form the architectural system that the soundscape occurs within. Details are the connections among the tectonic elements that support and express the inspiration and the conceptual structure of the project. The case studies illustrate how these levels define the places in the design process where soundscape theory can be effectively implemented to become an integrated part of the creation of architectural space. The case studies provide a working model for the creation of architectural spaces with designed soundscapes that occur as part of an integrated, participatory design process. These are parts of the process that are philosophical and abstract in nature where one seeks the poetic expression of the essence of the project prior to the beginning of traditional design.
Reconstruction of acoustic fields via physics-informed neural networks

Camilo Fernando Silva Garzon¹, Philip Bonnaire¹, Nguyen Anh Khoa Doan², Camilo Fernando Silva¹

¹Technical University of Munich, Munich, Germany, ²Delft University of Technology, Delft, Netherlands

Acoustic measurements, obtained by microphones positioned at strategic places, are of great utility for the monitoring of a given acoustic system and for its protection in case large pressure fluctuations are measured. Such strategies are reliable as long as the microphones are properly positioned, which is not evident: in some cases the excited acoustic modes are not known beforehand.

In this work, we proposed a method based on physics informed neural networks (PINN) in order to reconstruct the entire acoustic field of a given acoustic element, provided some acoustic measurements at some few locations. Such a method makes use of a feed forward neural network, where the cost function is taken as the residual of the acoustic wave equation. Such a residual is computed exploiting the automatic differentiation property of neural networks, in order to obtain the corresponding spatial and time derivatives. Additionally, the measurements of the aforementioned microphones are gathered and used also for the calculation of additional terms in the PINN cost function. By doing so, the most adequate acoustic state is obtained, which satisfy both measurements and the acoustic wave equation. In other words, the acoustic field within the system is reconstructed.

[Link to paper]
Noise characterization and mitigation of a shrouded propeller for vertical lift vehicles

Frank Simon¹, Noah H. Schiller², Nicole Pettingill², Nicolas Zawodny², Matt Galles²

¹Onera, Toulouse Cedex, France, ²NASA Langley Research Center, Hampton, USA

Unmanned aerial vehicles (UAVs) are currently being used for reconnaissance missions, tactical surveillance, and infrastructure inspection. When legislation allows it, these devices will provide additional services close to inhabited areas, which could lead to noise complaints. On most UAVs, the propellers are the dominant source of noise. As a result, researchers have studied the impact of propeller shape and blade count on noise. Much of this work, however, has focused on isolated propellers. While different UAV concepts are equipped with ducts for aerodynamic and protection reasons, few studies focus on the acoustic benefit of ducts, as is achieved, for example, on turbofan aircraft.

The objectives of this paper are: first, to simulate the noise radiation of a UAV propeller in static conditions based on its location in a hard wall duct; second, to analyze the contribution of the different acoustic source components (i.e., thrust, torque, and thickness); and third, to validate the approach with experiments conducted in the NASA Small Hover Anechoic Chamber over a range of propeller rotation rates. In this experiment, it is shown that the best attenuation is achieved when the propeller is centered, axially, in the duct because of interference between upstream and downstream radiated waves.
A repeated-measurements study: Annoyance and sleep disturbance due to vibrations from trains

Sendrick Simon, Elise van Kempen, Arnaud Kock, Nick Mabjaia, Irene van Kamp

RIVM, Antonie van Leeuwenhoeklaan 9, Netherlands

Despite a call for attention already for years, the health effects of vibrations due to rail traffic have been understudied. In the meanwhile, rail traffic (passenger and freight) is increasing and regulations for vibration need to be adapted accordingly. In order to fill this gap and with the aim to better inform policy, a baseline survey was performed in 2013 among people of 16 years and older living within 300 meter from a railroad track (N= 4927). Based on the results and in view of the railroad expansion, monitoring was advised. In 2019 and 2021 the measurements were repeated in participants who indicated that they could be contacted again. This resulted in 1349 and 784 participants in measurement 1 and 2 respectively. This allows studying trends in effects while accounting for co-determinants and changes in exposure, providing the building blocks for further development of policy and regulations on railway vibration. We are currently analyzing the data, and will present the first results at the conference.

Link to paper
Flat Fresnel-spiral acoustic metamaterials composed of several arms ventilated metamaterials for simultaneous broadband sound absorption and air circulation

Sanjeet kumar Singh¹, Shantanu Bhattacharya¹
¹Indian Institute Of Technology Kanpur, Kanpur, India

With a steep rise in the urban population requiring an increased number of buildings, public and private transport systems, urban noise is posing a serious environmental problem affecting health. To attenuate the effect on the well-being of human health, a variety of conventional sound-absorbing materials suitable at mid and higher-frequency noise absorption are commonly being used but low and mid-frequency noise remains a challenge. These applications are further limited by the acoustic performance and ventilation efficiency in conventional noise barrier limits of their fields. Acoustic metamaterial presents a unique solution as an artificially designed material showing low-frequency noise mitigation. A novel subwavelength device having thickness of 15mm (<2 cm), with potential application in noise mitigation and air ventilation solution is presented herein. In this study, the design and fabrication of a small prototype based on a Fresnel-spiral shape composed of several arms are performed. Numerical and experimental investigations were carried out to determine the acoustical properties of the proposed ventilated metamaterial in terms of sound absorption and sound transmission loss. The experimental investigation shows significant sound absorption with a high bandwidth (more than one octave in the range of > 900 Hz), acoustic properties leading to potential applications in urban noise control for low and mid-frequency ranges.

Link to paper
Development of a relation between traffic variables and environmental noise descriptors for four-lane National Highways

Ashish Singh¹, Elangovan Rajsekar², Manoranjan Parida³

¹Indian Institute of Technology Roorkee, India, ²Indian Institute of Technology Roorkee, India, ³Indian Institute of Technology Roorkee, India

In India, transportation sector is quickly expanding. The heterogeneity of traffic plays a vital role in shaping noise ambience in vicinity of highways. This study aims to evaluate the factors that contribute to traffic noise along four-lane divided National Highways. Data were collected at 4 locations with free-flowing traffic on the National Highway 334 in India. The parameters included traffic noise levels, classified traffic volumes, vehicular speed, and geometry of highway cross-section. Traffic volume and composition were captured using videography, while traffic speed was measured using radar gun. Single octave spectral characteristics of the traffic noise were measured using a multi-channel noise spectrum analyser. The data was sampled at 15 minutes intervals and measurements carried out for 3-hour duration during peak and off-peak periods weekdays and weekends. Noise descriptors such as equivalent noise level (Leq), 10 percentile sound level (L10), 50 percentile sound level (L50), 90 percentile sound level (L90) were estimated from the measured data. Effect of traffic characteristics on the traffic noise levels was established through regression analysis. The study concludes that traffic volume, percentage of heavy vehicles, and traffic speed are the major factors influencing noise levels.
The application of wavy geometries for the reduction of trailing edge instability noise

Tom Smith\textsuperscript{1}, Yiannis Ventikos
\textsuperscript{1}University College London, London, United Kingdom

Trailing edge instability noise can occur in a wide range of applications, including wind turbines and small aerial vehicles. It can be characterised by a high amplitude tonal or narrowband sound resulting from instability waves in the boundary layer scattering as they are convected over the trailing edge. In this study, a hybrid aero-acoustic model is used to demonstrate how wavy geometries can be used to successfully reduce trailing edge instability noise. The hybrid model uses incompressible large eddy simulations to compute acoustic source terms, which are then mapped onto a larger domain using radial basis functions. The acoustic perturbation equations are then solved on this larger domain to obtain the 3-dimensional acoustic field. The study uses a modified NACA0012 wing, where the surface contains spanwise waves of different wavelengths.

The results show that there is an optimal wavelength that produces the greatest noise reduction for a given flow speed and Reynolds number, and that this relates to wavelengths of the dominant structures within the boundary layer. This shows that by understanding the spectral character of the boundary layer, one can design optimal geometries for reducing this important source of fluid-induced noise.

\textbf{Link to paper}
Role of community engagement in soundscape design of rural areas

Julija Smyrnova1, Gillian Brown1

1Environment Agency, United Kingdom

This paper presents results of questionnaires adapted from ISO 12913-2 distributed among the residents of a rural area, following numerous complaints of noise and other pollution from a recently build waste transfer station in the UK. Based on acoustic measurements, specific sound levels from the industrial site were predicted at each of the respondents’ assessment location. Participants included those who lived as close to the site as 200m where the sound from the site was +15dB above background sound level (BGL), and as far as 800m with the sound from site -10dB above BGL. Surprisingly, all the respondents indicated that they could hear sounds from the industrial site to a higher or lower extent, they were all extremely stressed and annoyed by it and they all desired it to be supressed. The outcomes of the study demonstrate that (1) soundscape is a multidisciplinary approach, (2) soundscape assessment in rural areas may vary from those designed for urban areas, and (3) early engagement with local residents when introducing a new industrial sound to the soundscape in a rural area may result in a better chance of approval, particularly for a site with potential economic benefits for the community.

This paper also discusses how the soundscape approach, alongside tackling conventional noise problems, may contribute to environmental management and local planning in rural areas, particularly focusing on introducing and managing sounds from industrial sites.

Link to paper
Applicability of ISO 16283-3 for field measurement of sound insulation of partially open windows

Lars Sommer Søndergaard¹, Birgit Rasmussen², Rune Egedal¹, Rasmus Stahlfest Holck Skov³

¹FORCE Technology, Aarhus, Denmark, ²BUILD, Aalborg University, Copenhagen, Denmark, ³FORCE Technology, Hørsholm, Denmark

Façade sound insulation regulations are typically focused on closed windows. However, many people prefer open windows for ventilation purposes, or simply because of the psychological effect of having an open window. As such it is important to be able to correctly quantify the sound insulation, also with open windows. The international standard ISO 16283-3 describes a field method for test of façade sound insulation of facades or façade elements, e.g. a window, which is further explained in the scope: “The element methods aim to estimate the sound reduction index of a façade element, for example, a window. The most accurate element method uses a loudspeaker as an artificial sound source. Other less accurate element methods use available traffic noise”. However, the standard is probably primarily meant for closed windows, and not for open windows. The applicability of ISO 16283-3 for open windows is therefore under investigation for such conditions which are included in an additional Danish environmental noise guideline. Generally, it can be concluded that the traffic noise method is applicable, but care should be taken by using the loudspeaker method for partially open windows, since the results depend highly on the window opening position compared to the loudspeaker position.

[Link to paper]
Listening Difficulty of Public Announcement at Subway Platform with Long Reverberation Time

Eun Sung Song¹, Su Hong Kim¹, Jeong Hun Kim¹, Song Mi Lee¹, Do Kyung Kim¹, Chun Won Eom¹, Jong Kwan Ryu¹
¹Chonnam National University, buk-gu Yong Bong-ro 77, South Korea

The subway platform is a unique spaces where the reverberation time (RT) is extended depending on the distance from the sound source. Moreover, various noise sources is being occurred at the subway platform such as the train approaching noise, crowd noise, and so on. The purpose of this study is to determine which factor affects the listening difficulty of announcement through listening test based on the acoustical data from on-site measurements. The results of listening test show that the difference according to the types of noise sources, S/N ratio, and RT was found to be significant. In particular, the difference between RT of 2.2 s and 3.6 s showed the largest difference of up to 65.1 % in listening difficulty rating. In addition, the influence of noise type on listening difficulty rating was found in the condition of RT 2.2 s, but not in RT 3.6 s. Announcement combined with the crowd noise was to be the most difficult to listen to among noise types in the better acoustical condition.
A general stable approach to modeling and coupling multilayered systems with various types of layers

Guochenhao Song¹, Graduate Zhuang Mo¹, J. Stuart Bolton¹
¹Ray W. Herrick Labs, Purdue University, West Lafayette, United States

In this article, a general method is proposed to model layered systems with two-by-two transfer matrices, and further, to solve for the acoustic absorption, reflection, and transmission coefficients. Since the proposed method uses the matrix representation of various layers and interfaces from the Transfer Matrix Method (TMM), the equation system can be established efficiently. However, the traditional TMM can lose stability when there is a large disparity between the magnitudes of the waves traveling in opposite directions within the layers (i.e., at higher frequencies, for a thick layer, or for extreme parameter values). In such cases, the contribution of the most attenuated wave can be masked by numerical errors and can induce instability when solving the system. Therefore, in the proposed method, to stabilize the calculated acoustic properties of the system, the principle is to ensure the accuracy of the wave attenuation terms by decomposing each layer’s transfer matrix and reformulating the equation system. This method can couple different layer types in a general way and is easy to assemble and implement with numerical code. The predicted acoustic properties of layered systems calculated using the proposed method have been validated by comparison with those predicted by other existing methods.

Link to paper
Effect of the microstructure on the acoustic performance of porous material liner in the duct

Xiang Song¹, Jingjian Xu¹, Tianyue Yuan¹, Dan Sui¹, Heye Xiao², Jie Zhou¹
¹School of Aeronautics, Northwestern Polytechnical University, Xi’an, China, ²Unmanned System Research Institute, Northwestern Polytechnical University, Xi’an, China

Acoustic liners can efficiently reduce the sound pressure level in the duct. The porous material liner has recently received wide attention for the excellent attenuation performance at mid- to high- frequencies. However, more attention was paid to the sound attenuation of the given porous material liner in the duct rather than the design of the porous material liner for a duct noise problem. In this work, from a micro perspective, the influences of the average fiber radius and gap of the porous material liner on the acoustic field in a duct are systematically analyzed, based on the bottom-up method and Johnson-Champoux-Allard model. The multimodal method is utilized to evaluate the duct acoustic field. The work may guide the selection and design of the porous material during the application of the porous material in the duct noise problem.

Link to paper
A traffic big data analysis on relationships between urban planning and traffic noise level—taking Dongguan Demonstration Area, China as an example

Jiaxun Song¹, Qi Meng¹, Jian Kang²
¹Key Laboratory of Cold Region Urban and Rural Human Settlement Environment Science and Technology, Ministry of Industry and Information Technology, School of Architecture, Harbin Institute of Technology, 66 West Dazhi Street, Nan Gang District, Harbin, 150001, China, ²UCL Institute for Environmental Design and Engineering, The Bartlett, University College London, Central House, 14 Upper Woburn Place, London WC1H 0NN, United Kingdom

With the promotion of smart city research, traffic big data has become a new way to study urban traffic noise. Taking Dongguan Demonstration Area, China as an example, this research discussed the relationships between traffic noise levels and urban plannings using geographic information science (GIS), global positioning system (GPS) techniques and OpenITS Organization OpenData. The results showed that, for the whole area, some planning factors, say global integration, local integration (R=500m), global betweenness, local betweenness (R=500m) and number of points of interest (POIs) had significant positive correlations with the daytime traffic noise levels. Among them, the number of POIs had the strongest correlation with the traffic noise levels (r=0.560 p<0.01). However, the degree of influence of each variable on traffic noise levels can be changed with geographical locations. This research also identified specific areas where traffic noise levels were negatively correlated with local integration and local betweenness, which had great potential to provide a recreational and peaceful place for people to walk. Therefore, the urban areas' centers and fringes can be studied separately to effectively control traffic noise by changing the urban plannings.

Link to paper
A time delay estimation approach with low computational complexity for speaker localization

Bangguo Song¹, Hongsen He¹, Tao Yang¹
¹Southwest University of Science and Technology, No. 59, Middle Qingdong Road, Mianyang, China

Time delay estimation (TDE), which aims at estimating the time difference of arrival using the signals captured by an array of microphones, plays an essential role in hands-free speech communication systems for localizing and tracking speakers. The sparse linear prediction model, which is based on the L1-norm optimization with respect to the prediction-error vector and the coefficient vector of the linear predictor, can be effectively used to prefilter the microphone signals so as to establish a time delay estimator robust to background noise and reverberation. In the course to solve this model, however, a high-dimension cross-correlation matrix has to be inverted, indicating that the corresponding TDE algorithm has huge computational load. In this paper, we propose a new solution approach to this dual L1-norm optimization model. The original prediction-error filter is decomposed by Kronecker product into two short subpredictors. Accordingly, the size of the cross-correlation matrix in the TDE algorithm is degraded, which significantly reduces the computational complexity for prewhitening microphone signals. Simulation experiments in room acoustic environments demonstrate the computational efficiency of the proposed TDE algorithm as well as its estimation precision.
An example of a digital engagement platform for large scale community engagement using auralization.

Alex Southern¹, Brian Bulnes¹, Alan Oldfield¹
²Aecom, Glasgow, United Kingdom

The global COVID-19 pandemic has resulted in social distance restrictions that have limited the ability for transport authorities to undertake in-person community engagement activities and consult on proposed local infrastructure developments. Potential increases in noise levels or change in acoustic environment can often be a key concern for residents living close to a proposed development. This paper documents the approach taken to engage with local stakeholders regarding a proposed new light rail metro line in Toronto, Canada, using an innovative online web-based auralization tool. The tool allows the existing trains and planned new metro trains to be compared interactively in an environmental context and with and without acoustic mitigation interventions. The paper discusses the benefits, challenges and limitations associated with the approach and provides an overview of the auralization approach of the proposed new metro line.

Link to paper
Traffic noise and children's health: New insights from a machine learning algorithm?

Jan Spilski, Christoph Giehl, Hendrieck Boshuizen, Albert Wong, Kirstin Bergström, Thomas Lachmann, Maria Klatte

1University of Kaiserslautern, Center for Cognitive Science, Kaiserslautern, Germany, 2RVIM, Rijksinstituut voor Volksgezondheid en Milieu, Bilthoven, Netherland, 3Facultad de Lenguas y Educación, Universidad Nebrija, Madrid, Spain

Studies on the influence of traffic noise on children's health are usually very comprehensive and collect data on a large number of measured variables in comparatively large samples. In the NORAH Study, for example, almost 700 variables have been considered including more than 100 variables related to traffic noise. With a theory-based approach, the statistical evaluation of that data focused on a limited number of variables to be included in the regression models as predictors, mediators, moderators, or confounders. In contrast, machine learning (ML) methods are able to consider the complete scope of variables in an analysis. Random forest models are one type of ML methods for dealing with possible multicollinearity of predictors or nonlinear relationships. Although these methods can offer advantages, they have hardly been used in relation to traffic noise and children's health. In the EU project EqualLife, random forest models are computed in order to obtain information on the significance of individual exposomes (e.g., traffic noise) for children's health. In the present paper, we compare the results of a regression model and a random forest model using the NORAH Study as an example. Possible advantages and disadvantages of the methods are discussed.
Prediction of turnout support deterioration through dynamic train-track interactions integrated with artificial intelligence

Jessada Sresakoolchai\textsuperscript{1}, Mehmet Hamarat\textsuperscript{1}, Sakdirat Kaewunruen\textsuperscript{1}

\textsuperscript{1}University of Birmingham, Edgbaston, Birmingham, B15 2TT, United Kingdom

Due to the increase of rolling stocks’ speed and limited area for railway project construction which result in sharper curves, vibration perceived by passengers tends to be higher. The higher vibrations negatively affect passenger comfort. In addition, there are different parameters affecting passenger comfort. In this study, track stiffness deterioration is studied to explore the effect on passenger comfort. Track stiffness deterioration can be occurred by different causes such as the exceeded load applying to rail infrastructure, regular application, or extreme events such as flooding. These causes all make the track deterioration and the track stiffness will decrease. Besides the rail infrastructure deteriorates and maintenance needs to be performed which results in cost, it also results in worse passenger comfort because the track infrastructure is less stable. The finite element method is applied to develop rolling stock models and study the effects of track stiffness deterioration on rail passenger comfort. Finite element models are verified with field data to ensure that the results from simulations are reliable. Passenger comfort is evaluated based on accelerations which are the main parameters in many standards.
Prediction of vibration transmission across finite double wall junctions using a hybrid diffuse-deterministic approach.

Wannes Stalmans¹, Cédric Van hoorickx, Edwin Reynders
¹Ku Leuven, Kasteelpark Arenberg 40 Heverlee, Belgium

Predicting the sound insulation between two rooms is a complex problem since not only the direct path through the separating element but also the flanking transmission paths can largely influence the sound insulation of the system. An important parameter for calculating flanking transmission is the vibration reduction index, which relates to the transmission coefficient between the connected plates. The international building acoustics standard ISO 12354-1/2 provides prediction formulas for the vibration reduction index of single wall junctions, but not for double wall junctions.

A new hybrid-deterministic approach is proposed to calculate flanking transmission across double wall junctions. The walls and floors are modelled as diffuse subsystems while the connection between the double wall is modelled deterministically. This approach relies on the diffuse field reciprocity relationship, which relates the vibration transmission to the direct field dynamic stiffness of the subsystems (walls and floors), i.e., the dynamic stiffness of the equivalent infinite subsystem as observed at the junction. In contrast to existing approaches, the finite size of the junction is properly taken into account in this way. The new approach is applied to different types of double wall junctions to determine simplified regression formulas for practical sound insulation design.

[Link to paper]
Influencing companies to purchase lower noise tool consumables?

Chris Steel¹, Antonia Hawker¹
¹HSE, Edinburgh, United Kingdom

This paper shows how targeted basic research and existing regulations can influence duty holders (business owners) to use lower noise consumables on their power tools (saws, drills, grinders). We will show; (1) how existing regulations should change buying habits, (2) why lower noise consumables should be the standard in some industries, (3) how target basic research inform enforcement, (4) how to influence industry through advice and, (5) potential enforcement. New data will show it is possible to get a 5 dB reduction by buying the right combination of grinder products. The paper describes a regulatory method that combines research and enforcement to reduce noise risk. The paper may be of interest to, health and safety regulators, tool manufacturers, noise consultants, and purchasing managers.

Link to paper
Passive amplification of acoustic signals using surfaces with periodic roughness.

Alex Stronach

RSK Acoustics, Manchester, United Kingdom

Experimental and numerical studies using the Boundary Element Method (BEM) of the sound field generated over periodically spaced rectangular strips show that signals at audio frequencies may be passively amplified through interactions between the incident sound field and the rough surface. Roughness with sub-wavelength dimensions give rise to air-borne acoustic surfaces waves which arise when the rough surface has a high reactive component to its surface impedance and are considered as a slit-pore impedance surface with rigid backing. Surface waves result in excess attenuation spectra with anomalous maxima greater than the 6.02 dB associated with construction interference above an acoustically rigid surface. Increasing the roughness dimensions reduces the surface reactance and, therefore, the surface wave magnitude. Enhancements arising for larger spacings can be attributed to effects due to the finite width and periodicity of the array, quarter wavelength resonances within the gaps between elements, and Bragg Diffraction. Excess attenuation spectra and pressure maps of the total field above the rough surface show interesting features at the frequencies of signal enhancement. Investigating the sound field over roughness allows for the surface dimensions to be modified to enhance any frequency of interest and yields deeper understanding of the sound field over roughness.

[Link to paper]
Acoustic Measurements and Psychoacoustic Analyses of Ventilation Diffusers

Lara Stürenburg¹, Philipp Ostmann², Lukas Aspöck¹, Dirk Müller², Janina Fels¹

¹Institute For Hearing Technology And Acoustics, RWTH Aachen University, Kopernikusstr. 5, 52074 Aachen, Germany,
²RWTH Aachen University, E.ON Energy Research Center, Institute for Energy Efficient Buildings and Indoor Climate, Mathieustraße 10, 52074 Aachen, Germany

People in industrialised countries spend most of their days indoors and are often exposed to ventilation sounds. Since ventilation systems are not only used in industry but also increasingly in residential buildings, it is important to study its sound radiation and the consequences for our well-being. This research project aims to identify if geometric features of air diffusers affect the rated annoyance of ventilation systems. It is known that the A-weighted sound serves as a criterion to a limited extent. Therefore, psychoacoustic analyses and evaluations need to be included to find out if there are correlations between psychoacoustic features and flow phenomena caused by the geometric features of the air diffusers. Several air diffusers were acoustically measured in a hemi-anechoic room using a developed mobile ventilation unit that supplied the necessary air volume flow. The ventilation unit could be operated in both supply and extract air configuration of the diffusers. The measured data not only includes the acoustic directivity of the air diffusers but also recordings that are needed to conduct listening tests. To increase the ecological validity and to study the role of the environment, future listening experiments will be also extended to audio-visual experiments in virtual reality.
A study on normal incident sound absorption characteristics of Japanese traditional cedar board, yakisugi

Akiko Sugahara¹, Kentaro Okamura¹, Yasuhiro Hiraguri¹, Noboru Yasui², Chihiro Kaku²
¹Kindai University, Higashiosaka, Japan, ²TEAM SAKURA, Shibuya, Japan

Yakisugi is made by charring the surface of a cedar board to form a thin carbonized layer, which is said to improve durability, weatherability and fire resistance. It is a traditional Japanese exterior material that has become popular overseas due to its performance and visual texture. Recently, it has been attracting attention for its use as an interior material, but its basic performance is still unknown.

In this study, we focus on the sound absorption characteristics of yakisugi as one of the investigations to understand its performance as an interior material.

The carbonized layer of yakisugi is expected to have sound absorbing performance because of its porous nature.

As a basic investigation, the sound absorption characteristics at normal incidence are measured using an impedance tube and compared with the carbonized layer conditions. It is found that yakisugi has sound absorption performance in the high frequency range. Moreover, the characteristics are depending on the thickness and surface properties of the carbonized layer.

Link to paper
Subjective assessments of interference during cognitive tasks in noisy and silent working conditions

Helga Sukowski

1 Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (BAuA), Dortmund, Germany

In a current research project on effects of noise on cognitive performance and wellbeing, some scales for subjective assessments with respect to the task execution are applied. The aim is to gain insight into how participants experience task processing in different background sound conditions.

In the laboratory, participants work on a proofreading task and a concentration task twice within an interval of around one week, once in a silent condition and once in one of various conditions with a background sound.

In both sessions, participants are asked after each task to assess four aspects with respect to task processing: (1) experienced effort, (2) concentration, (3) performance and (4) disturbance by the acoustical condition. The scales range from 0 to 100.

First, data will be analysed regarding the differences between the assessments in the condition with and without background sound for each sound condition and separately for the two performance tasks. Once all sound conditions are completed, the analysis of the comparison between the groups with different background sound conditions will follow. For both tasks, initial findings for the first sound condition suggest significant differences in the assessments of the scales “concentration” and “disturbance” between the condition with and without noise.

[Link to paper]
Nanofluidic Attenuation of Metal-Organic Frameworks

Heting Xiao\(^1\), Hebin Jiang\(^1\), Haixia Yin\(^1\), Yueting Sun\(^1\)

\(^1\)University of Birmingham, Birmingham, United Kingdom, \(^2\)Central South University, Changsha, P. R. China

Porous materials with energy absorption characteristics have been used for attenuation against hazardous vibrations and noises. The intrusion of liquid water and aqueous solutions into hydrophobic nanoporous materials such as metal-organic frameworks (MOFs) present an attractive pathway to engineering new attenuation technologies. In this process, hydrostatic pressure forces water to intrude hydrophobic nanopores, thereby converting mechanical work into interfacial energy through nanoscale interfacial interactions. Once the external pressure is removed, water molecules can flow out of the nanopores spontaneously, making the system reversible. We envision that this mechanism has the potential of innovating attenuation technologies, so in this work we provided a preliminary study in this direction. We investigated a material system consisting of water and a commonly used MOF, zeolitic imidazolate framework-8 (ZIF-8), and demonstrated its reversibility and stability under cyclic pressurization, considered its performance at various peak pressures and frequencies, its tunability in terms of intrusion pressure, and its potential in hydrogel forms. These features are important for potential attenuation technologies based on this novel mechanism.
Experimental vibro-acoustics transfer functions for the system with impact

Kumar Milind Rewanand Shripad¹, Sriram Sundar¹, Saurabh Sanjayrao Suryawanshi¹

¹Indian Institute Of Technology Tirupati, Tirupati, Andhra Pradesh, India, Yerpedu, India

Systems with combined sliding-rolling contacts such as cam-follower, clutches, and gearbox are prone to have clearance(s) as per the design and/or due to manufacturing imperfections or wearing as a result of sliding between components. This clearance non-linearity results in an impact between components, which in turn generates a significant rattle during operation. The noise generation mechanism in rattle is a strong function of impact-velocity and contact forces. The objective of this study is to develop an experimental transfer function to quantify the vibro-acoustics of a cam-follower system with clearance non-linearity. Contact between the cam and the follower is lubricated to minimize the sound generated due to friction. Follower acceleration, reaction forces, and acoustic pressure are measured on a cam-follower setup with combined rolling-sliding contact during impacts under various conditions. Velocity and contact forces are back-calculated using measured signals and the analytical model dynamics. Transfer functions relating the acoustic pressure to velocity and contact forces are estimated in the frequency domain. These transfer functions provide insights into the vibro-acoustic system and can be directly used in conjunction with dynamics models. The output of the study can be used in designing quieter systems with impact.

Link to paper
Enhancing the noise reduction capability of serrations using low-profile vortex generators

Shivam Sundeep¹, Peng Zhou¹, Chuntai Zheng¹, Hanbo Jiang¹, Siyang Zhong¹, Xin Zhang¹,²

¹The Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, China, ²HKUST-Shenzhen Research Institute, Shenzhen, 518057, China

This paper presents an experimental investigation on improving the noise reduction capability of the trailing edge serrations using vortex generators. Experiments were conducted on a 150 mm chord flat plate at four angle of attack between 0° and 9° and flow speeds of 20-50 m/s. The Reynolds number based on the chord length ranges from 2.1×10⁵ to 5×10⁵. Vane type vortex generators with various heights of h/δ = 0.16-0.25 were placed along with the serration roots, where δ is the boundary layer thickness at the trailing edge without the vortex generators. The aeroacoustic measurements were made with a phased microphone array, and the aerodynamic measurement near the trailing edge was measured using a hot-wire. Additionally, the lift and drag forces were measured by load cells. The source integrated noise spectra showed a slight reduction in the trailing edge noise over a broadband frequency range. The generation of streamwise vortices by vortex generators can be identified in the wake measurement. These streamwise vortices were further found to counteract the cross-flow generated at serration roots, hence improving the performance of the serration. Moreover, the presence of low-profile vortex generators was found to have an insignificant effect on the lift and drag coefficients.
Low order modelling of thermoacoustic instabilities in aero-propulsion engines

Aswathy Surendran¹, Charles Boakes², Dong Yang³, Aimee Morgans²

¹Technical University of Munich, Garching, Germany, ²Imperial College London, London, United Kingdom, ³Southern University of Science and Technology, Shenzhen, China

In the present work, we investigate the thermoacoustic stability behaviour of a combustor-heat exchanger assembly pertinent to the Synergetic Air Breathing Rocket Engine (SABRE) of Reaction Engines Ltd. Since the thermoacoustic behaviour of heat exchangers is poorly understood, we have approximated it to a combination of heat transfer/heat sink and aeroacoustic scattering (dissipation) mechanisms. The ε-NTU method is used to characterise the low frequency, linearised unsteady heat transfer (heat exchanger transfer function) behaviour in compact heat exchangers. The aeroacoustic response of the tube row is evaluated from the linearised conservation equations, wherein the hydrodynamics of the bias flow in the tube row is described as being similar to that of an isentropic contraction followed by a sudden expansion. The stability predictions are carried out through low order modelling of the combustor and subsequent eigenvalue analysis. The flame dynamics is approximated using the n-τ law, with τ being a parameter. Stability predictions show that the thermoacoustic response of the heat exchanger was dominated by aeroacoustic dissipation. Only one mode was predicted to be unstable and can be stabilised by moving the heat exchanger upstream. Further work is required to better characterise the flame and the heat exchanger transfer functions.
Adapting a slit model to determine the aeroacoustic response of tube rows

Aswathy Surendran¹, Wei Na², Charles Boakes³, Dong Yang⁴, Aimee Morgans³, Susann Boij⁵

¹Technical University of Munich, Garching, Germany, ²Chalmers University of Technology, Gothenburg, Sweden, ³Imperial College London, London, United Kingdom, ⁴Southern University of Science and Technology, Shenzhen, China, ⁵KTH Royal Institute of Technology, Stockholm, Sweden

Cylindrical tubes in cross-flow, like the ones found in heat exchangers, are excellent acoustic dampers and as such have the potential to mitigate thermoacoustic instabilities. Flow separation and vortex shedding downstream of the tube row are key to significantly enhancing sound attenuation. However, constructing an analytical solution for the aeroacoustic response of tube rows in cross-flow is very challenging owing to the complex flow structure, vortex shedding and coupling with acoustics. To overcome this, we propose the adaptation of a slit model for tube row acoustic scattering (aeroacoustic response) predictions at low Strouhal numbers. The slit model was modified such that the loss coefficients across the slit and the tube row matches. The model is then validated against numerical predictions using Linearised Navier Stokes Equations and experimental measurements. The predictions for both magnitude and phase for transmission and reflection coefficients agree well with the simulations and experiments.

Link to paper

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Sound field reproduction based on Pressure Matching with transfer functions modeled by equivalent sources and image sources

Yukika Suzuki¹, Haruka Matsuhashi¹, Izumi Tsunokuni¹, Yusuke Ikeda¹

¹Tokyo Denki University, 5 senju-asahi-cho, adachi-ku, Japan

Pressure matching (PM) method is an effective method to control a sound field using many loudspeakers. It is difficult to implement PM method because it requires multi-point room impulse response (RIR) measurements. Multi-point measurements are challenging because they require a large number of microphones and a narrow sampling interval when dealing with high frequencies. Therefore, to synthesize a sound field in a local region, we proposed a PM method using estimated RIRs from only a small number of measurements based on the sparse Equivalent Source Method (ESM). In the previous method, we modeled the transfer functions considering only the direct sound from the loudspeaker. However, when the sound field is synthesized in the actual environment, the reflected sounds must be considered. In this study, we propose a PM method using the estimated transfer functions by sparse ESM based on the image source method considering the direct sound and early reflected sounds. In the experiment, we evaluated the accuracies of synthesized sound field by the proposed method compared to the methods only considering the direct sound.

Link to paper
Modeling sound transmission through apertures with diffraction

Peter Svensson¹, Shahin Sohrabi
¹Acoustics group, Dept. of Electronic Systems, NTNU, NO-7491 Trondheim, Norway

Sound transmission through an aperture in a thin wall is a classical scattering problem with various applications in building and room acoustics. In particular, the use of active noise control for open windows can be viewed as an aperture scattering problem. Diffraction-based modeling of scattering is very efficient and accurate for convex scattering objects but has been shown to be less accurate for the transmission through circular apertures, at low frequencies. In this study we investigate the accuracy of edge-diffraction based modeling of sound transmission through rectangular apertures. Reference solutions are computed with a boundary element formulation for this case. Results confirm that the diffraction modeling gives accurate results for mid-to-high frequencies. For low frequencies and skewed transmission angles, the diffraction-based method gives larger errors. For aspect ratios between 1:1 and 10:1, the sound power transmission ratio predicted by the edge diffraction approach is maximally ±1.5 dB in error for very low frequencies.

[Link to paper]
Self-Determined Hearing Through Artificial Intelligence (AI)

Peggy Sylopp
pexlab.space, Berlin, Germany

Due to the wide spread of hearing disorders in the industrialized countries, (approx. 14 million cases in Germany) this is one of the most common diseases. 75% of those affected don’t use hearing aids, accepting consequences such as unemployment, depression and dementia, which results in high economic damage. Studies have proven that individualized sound adjustment can result in greater satisfaction and participation. In the rapidly growing hearable market (hearable are hearing devices like head phones, head sets and hearing aids) sound personalization is an emerging trend. More and more hearables feature user-adjustable sound. Latest, high-priced developments in the field of hearing aids integrate AI based on self-adjustment of sounds. In this talk I introduce new approaches to integrating AI in hearables for more self-determined hearing. I want to discuss the opportunities of these approaches and limitations that still exist as well as the challenges for future developments.

Link to paper
The study of the acoustical properties of a 3D printed noise barrier

Grzegorz Szczepański¹, Marlena Podlesna¹, Krzysztof Lada¹
¹Central Institute For Labour Protection - National Research Institute, Czerniakowska, Poland

According to the data of the Statistic Poland, noise is the most common harmful factor in the work environment in Poland. In 2020, the number of persons exposed to noise was 181.7 thousand person. Reducing the noise hazard is a primary objective of vibro-acoustic research, and modern technology allows to achieve this goal in numerous ways. The most important and widespread technique used to reduce the risk of noise exposure of workers is to place noise absorbing or reflecting elements in the workplace. One of the less conventional methods used to produce such elements is the use of Fused Deposition Modelling. The opportunities that this method presents allow for manufacturing of noise barriers with advanced internal structures, which can reduce the noise transmission or manipulate the propagation of the sound wave. This article describes the study of acoustic properties of a noise barrier made using a 3D printer. The influence of various 3D printing settings on the obtained acoustic properties of the barrier was investigated. By measuring the acoustic pressure level and the particle velocity in three directions, the acoustic properties of the created barrier were determined.
Basic study on the estimation method of burrows on the seafloor using ultrasound

Hajime Tachiki, Haruki Hirasawa, Takumi Asakura, Katsunori Mizuno, Koji Seike

Tokyo University Of Science, 2641 Yamazaki, Noda-shi, Chiba Prefecture 278-8510, Japan,
The University of Tokyo, 5-1-5 Kashiwa no ha, Kashiwa city, Chiba 277-8563, Japan,
National Institute of Advanced Industrial Science and Technology (AIST), 1-1-1 Umezono, Tsukuba, Ibaraki 305-8560, Japan

There is concern about the noise effect of offshore energy facilities. For example, noise generated during construction and operation of them may affect some aquatic species. Aquatic environmental measurements have been conducted to assess this effect. However, the effect under the seafloor remains unknown due to the lack of an efficient method for surveying a wide area. The marine environment is affected by the burrows formed by organisms living on the seafloor. Therefore, it is important to know the shape of the burrows of benthic organisms from the viewpoint of marine environmental conservation. In this study, we investigated a method for estimating the length and diameter of the burrow by transmitting broadband ultrasonic waves into the burrow and measuring, analyzing the echoes. The model experiment and the acoustic simulation using the finite-difference time-domain method were comparatively performed to verify the possibility of estimating the tube length and diameter. It was confirmed that the tube length was estimated with a relative error of about 3% for straight and U-shaped plastic tube models.

Link to paper
Improved acoustics for semi-enclosed spaces in the proximity of residential buildings

Armin Taghipour1, Arnthrudur Gisladottir2, Francesco Aletta3, Matthias Bürgin1, Mohadeseh Rezaei1, Ulrike Sturm4

1Lucerne School Of Engineering And Architecture, The Lucerne University of Applied Sciences and Arts, Horw, Switzerland, 2Department of Civil and Architectural Engineering, Aarhus University, Aarhus, Denmark, 3UCL Institute for Environmental Design and Engineering, The Bartlett, University College London, London, UK, 4Lucerne School of Social Work, The Lucerne University of Applied Sciences and Arts, Lucerne, Switzerland

Continuous urban densification exacerbates acoustic challenges for residents of housing complexes. They are confronted with higher noise immission from railway, road traffic, construction, as well as louder neighborhood acoustic environments. Thereby, not only noise immission indoors is associated with stress, annoyance, and sleep disturbance, but also the immediate outdoor living environment (e.g., courtyards, private gardens, and playgrounds, etc.) can be acoustically unpleasant and annoying. This non-exhaustive narrative review paper elaborates on the role of a number of design parameters on improving the quality of the outdoor soundscape of housing complexes: architectural and morphological design, facade material characteristics, balconies, greenery, ground, background sounds, and several factors concerning quality of sounds (e.g., multisensory perception, holistic design, the relevance of space, context, social factors, co-creation, etc.). It mainly covers literature including both acoustical (e.g., sound pressure level and room acoustical parameters) and human/perceptual (e.g., comfort and annoyance) factors. A series of recommendations are presented here as to how the semi-enclosed outdoor spaces in the proximity of residential complexes can be acoustically improved.

Link to paper
Parametric design of a modular acoustic panel for sound recording space versatility

Stavros Tagios¹, Luis Gomez - Agustina¹
²London South Bank University, London, UK

Increasingly sound recording studios are demanded to host projects of different acoustic needs. However, their sonic character, product of their contents and bulky conventional treatment solutions, usually remains unchanged. This paper reports a modular panel’s early-stage design, aimed at providing flexibility to a group of representative recording rooms. The versatility refers to acoustical (absorption and diffusion), practical (volume and weight), and aesthetic aspects. The geometry and materials of the panel were derived parametrically through computer modelling software, by implementing interdependent and adaptable elements to one unit. Existing recording spaces were recreated into computational acoustic models and tested in two states. Simulations of the rooms’ acoustical behaviour were run in turn, first with the original treatment, then with the panel replacing the treatment. The design goal was to have minimal differences in Reverberation Time, Early Decay Time, Clarity, Room Frequency Response for every room’s two states. Results showed the panel performing better in rooms with larger volume. Overall, the panel matched the original acoustic response and character of the rooms, while providing versatility when compared to traditional acoustic treatment solutions. The development of such a product would allow future studio users fine tune the room’s performance according to their needs.

Link to paper
Wake-adapted ducted propeller for full-scale generic underwater vehicle: parametric study on blade skew for unsteady propeller thrust

Kenshiro Takahashi1, Chris Gargan-Shingles2
1Naval Systems Research Centre, Acquisition, Technology & Logistics Agency, Meguro-ku, Japan, 2Maritime Division, Defence Science and Technology Group, Melbourne, Australia

A parametric study of blade skew for unsteady propeller thrust in the wake of an underwater vehicle (BB2) is presented. Unsteady thrust forces transmit via the propeller shaft and produce undesirable noise and vibration, particularly at frequencies corresponding to multiples of the blade number. The effectiveness of blade skew in reducing noise and vibration has been reported in previous studies, though not for underwater vehicles. The amplitudes of the dominant harmonics of the unsteady propeller thrust are determined using a Fourier series. The balanced skew reduces the dominant fifth harmonic more significantly than the biased skew at identical total-skew angles. The total-skew angle strongly influences the unsteady propeller thrust magnitude for balanced skew designs, whereas the effect of the maximum forward-skew angle is negligible. Significant fluctuations in one-blade loads are observed when the blade passes through the downstream wake of the vehicle’s sail and casing. Increasing the blade total-skew reduces the blade load fluctuation when the blade approaches the top dead centre position, but has limited influence on the fluctuations when the blade moves away from this position. The nominal wake distribution at the propeller plane is analysed, and the fifth harmonic is identified as having the largest amplitude. This suggests that an increase in the number of blades would reduce the unsteady propeller thrust of the full-scale BB2 underwater vehicle.

Link to paper
Practical calibration method of airborne ultrasound measurement system by using acoustic calibrators

Hironobu Takahashi, Koto Hirano, Keisuke Yamada

National Institute of Advanced Industrial Science and Technology, Tsukuba, Ibaraki, Japan

Airborne ultrasonic apparatus, such as haptic devices and parametric speakers, have been actively developed and are becoming increasingly popular. In order to evaluate the performance of these apparatuses and to assess their safety against exposure to airborne ultrasound, quantitative sound pressure measurement of the emitted airborne ultrasound is required. Currently, various instruments are used to measure airborne ultrasound. However, since there is no instrument like a sound level meter that integrates the measurement and the display of the measured value, we need to set up a measurement system and then calibrate the system. For the feasibility of calibration, a system comprising a measurement microphone as specified in IEC 61094-4 and general measuring instruments is more realistic. There are a few possible calibration methods for this system. Considering the calibration effort and the required accuracy in actual measurement, it is practical to calibrate one specific frequency by an acoustic calibrator and the other frequencies by adopting the relative sensitivity curve of the microphone given by a manufacturer or the specification of the instruments. The paper discusses the uncertainty when the measurement system is calibrated as described above.

Link to paper
Automating the assessment of sound power levels of running vehicles using information extracted from a static video camera

Marjorie Takai¹, Miki Yonemura¹, Hyojin Lee², Shinichi Sakamoto¹
¹The University Of Tokyo, Tokyo, Japan, ²Seoul National University, Seoul, South Korea

Noise has become a ubiquitous pollutant in big cities, especially Road Traffic Noise compared with other means of transportation. Several countries/regions have developed road noise prediction models based on local measurements, adjusting their requirements and goals for evaluating this pollutant. Differently than most developed countries, industrializing countries have different characteristics of noise generation due to implied differences, such as degree of maintenance (both vehicle and road conditions) and the driving behavior, for instance.

The data acquisition needed for evaluating the vehicle fleet's sound power emission is expensive and time-consuming. This research proposes using a video camera close to the microphone to automate the data gathering and analysis. Using a Python script, this system extracts the sound pressure, estimates the running speed, assesses the distance from the receiver point, and classifies the vehicle under investigation. In addition, to discard inaccurate data, the expected trajectory and sound pressure are evaluated.

The proposed system's performance was compared against manual measurements. The resulting sound levels differ less than 0.2 dB for most cases. Thus, acquired 3.4 times the amount of data in the same time interval. After this verification, measurements in different conditions and vehicle fleet were tested in Hokkaido, Oita, and São Paulo cities.

Link to paper
Effect of spatial masking release on perception of vehicle's approaching sound in headphone music listening

Reika Takakura\textsuperscript{1}, Masanobu Miura\textsuperscript{2}
\textsuperscript{1}Graduate School of Music, Kunitachi College of Music, Kashiwa-cho 5-5-1, Tachikawa-shi, 190-8520, Japan, \textsuperscript{2}Faculty of Music, Kunitachi College of Music, Kashiwa-cho 5-5-1, Tachikawa-shi, 190-8520, Japan

Since music listening with headphones or earphones disturbs auditory information necessary for safety, pedestrians, for example, have a high risk of causing a severe accident. When listening to music and walking on the road with earphones or headphones, a person may fail to notice approaching vehicles from behind. It is because of the masking by the music played through headphones, which makes it difficult to perceive the sound of approaching vehicles. To improve such situations, the authors aim to actualize a listening environment where pedestrians enjoy listening to music with headphones with perceiving their ambient sounds. As a process, this report deals with a possible methodology to preserve auditory information for safety using sound localization of music. Authors investigate the effect of the music localization played through headphones on the perceptibility of the vehicle's approaching sound. The approaching sound of several types of cars are presented to listeners, who are asked to answer when the cars arrive at their places. The timing when the car reach is measured. The author will demonstrate the result of the investigation at the conference.

[Link to paper]
The soundscape approach for people with dementia; using psychoacoustic parameters to select suitable sounds

Arezoo Talebzadeh¹, Timothy Van Renterghem¹, Pieter Thomas¹, Paul Devos¹, Dick Botteldooren¹

¹Ghent University, Ghent, Belgium

Sound augmentation as an environmental intervention to improve mood and cognitive behaviour illustrated promising results in recent years. The same approach has a positive effect in reducing anxiety, stress, agitation and improving sleep quality in people with cognitive disabilities.

In the soundscape approach, people have agency in evaluating their sonic environment, either a neighbourhood, a hospital or a care unit. This method is hardly possible when designing for people with dementia, as the severity of the disease makes communication incomprehensible in most cases. Therefore, caregivers and nurses are the best sources of evaluation; their familiarity with patients and their knowledge of patients’ behaviour and psychology is crucial to evaluate the soundscape and the environment. This research uses caregivers’ evaluation of a designed soundscape and shows the possible scientific way of selecting a suitable sound by assessing the character of the sound and its psychoacoustic parameter in relation to the caregivers’ and nurses’ feedback.

Using feedback data and psychoacoustic parameters of sounds, a logistic regression model with a single independent variable demonstrated the chance of a positive outcome (sound) versus continuous indicator value (psychoacoustic parameter). The preliminary result revealed a possibility of sound augmentation using psychoacoustic parameters to identify suitable sounds.
ERP components analysis of selective attention to auditory signals in meaningful or meaningless noise using adaptive correlation filter.

Takahiro Tamesue¹
2Yamaguchi University, Ube, Japan

Open offices that make effective use of limited space and encourage dialogue, interaction, and collaboration among employees, are becoming an increasingly. However, productive work-related conversation might actually decrease the performance of other employees within earshot more so than other random, meaningless noises. On the other hands, it is well known that the Event-Related Potential (ERP) in the brain wave elicited by internal or external stimuli are related to the operation of selective attention. The present experiment was designed to determine the effects of meaningfulness of external noise on ERP in the auditory odd-ball paradigms. First, in order to decide on a template of adaptive correlation filter, multivariate analysis such as the Principal Component Analysis (PCA) for ERP components was performed. Next, performance of algorithm on adaptive correlation filter for estimating average waveform of ERPs was evaluated. Furthermore, differences in the ERP components due to the meaningfulness of external noise were examined.

Link to paper
Active nonreciprocal structural control on a flexible plate

Joe Tan¹, Jordan Cheer¹, Steve Daley¹
¹ISVR, University of Southampton, Southampton, United Kingdom

Reciprocity is an acoustic property that describes the symmetry of sound transmission between two points. However, this property is undesirable in certain applications, and this has led to significant interest in the development of nonreciprocal acoustic devices that achieve one-way sound transmission. These devices typically achieve nonreciprocal sound transmission by introducing nonlinearities or directional biasing. Previously proposed nonreciprocal acoustic devices generally have limitations; for example, they may not be fully adaptable, they can introduce signal distortions such as additional harmonics, or they can only exhibit nonreciprocal behaviour over a narrow bandwidth. To overcome these challenges, previous work has demonstrated how an wave-based active control system can be used to drive an array of acoustic sources to achieve reversible and broadband non-reciprocal behaviour. This paper aims to extend this concept to a linear wave-based active structural-acoustic control system that uses an array of structural actuators to control the individual wave components to achieve broadband nonreciprocal transmission through a flexible plate in a three-dimensional environment. The performance of the wave-based active controller has been investigated at a range of incident angles and the limits of this controller have been identified.
Optimizing the performance of a side-branch array duct muffler

Shiu Tang\(^1\), Ho Yu\(^2\)

\(^1\)The University Of Hull, Hull, United Kingdom, \(^2\)The Hong Kong Polytechnic University, Hong Kong, China

Recent studies of the authors show that muffler formed by putting together narrow side-branches in array form can offer strong and broadband sound attenuation in low Mach number flow ducts. It is also found that such muffler with the increasing branch length in the direction of duct flow has stronger resilience to flow excitation and thus can maintain its sound attenuation performance unless the duct flow is high. However, the arrangement of the branch length has not been optimized. Numerical investigation is carried out using finite-element computation in the present study to further understand how the branch length variation is affecting the overall sound attenuation of the side-branch array muffler. For simplicity, a branch length variation is assumed to follow a power law of the branch order. A power law index of 1 represents linear variation. It is found that for a muffler with 11 side-branches, the index for minimum transmission is about 1.5, but that for maximum particle kinetic energy is around 1.38. In term of noise attenuation spectrum, the muffler with index 1 and 3 give very strong attenuation at particular frequencies, while that with index 1.5 gives a more uniform attenuation within the operation frequency range.

[Link to paper]
High-speed optical imaging and spatio-temporal analysis of sound sources of edge tone phenomena

Risako Tanigawa¹, Kohei Yatabe², Yasuhiro Oikawa²

¹Panasonic Corporation, 1006, Oaza Kadoma, Kadoma-shi, Japan, ²Department of Intermedia Art and Science, Waseda University, 3-4-1 Ohkubo, Shinjuku-ku, Japan

Aerodynamic sounds are one of the noises of high-speed trains, automobiles, and wind turbines. To understand the characteristics of those noises, measuring sound sources is important. In general, microphones are used for measuring aerodynamic sounds. However, measuring the sound fields inside flow fields is difficult for microphones because they disturb flows. Thus, optical measurement methods have been applied to visualize aerodynamic sounds. The optical method can measure the sound fields without installing devices inside measurement fields. Therefore, it can capture the sound around sources. In this paper, we performed visualization and spatio-temporal analysis of sound sources of edge tones using parallel phase-shifting interferometry (PPSI). We experimentally confirmed the difference in pressure fluctuations near the sound source depending on the frequency of the edge tones.

Link to paper
Experimental and numerical modal analysis of the Turkish traditional instrument ‘bendir’

Uğur Tatlıer¹, Sinem Oztürk¹, Nursaş Oner¹, Sevinc Aycan Yetim¹
²Istanbul Technical University, Istanbul, Turkey

This study carried out an experimental and numerical modal analysis of the Turkish traditional instrument ‘Bendir’ by an acoustical excitation source. In experimental modal analysis, Bendir was excited acoustically for specified frequencies and elastic deformations of different areas of Bendir due to the excitation were observed with a laser vibrometer. Using the Fourier series handled gained data, modal analysis was done. The first six natural frequencies obtained experimentally and numerically were compared. In addition, other hits in Bendir, symbolizing three fundamental voices such as ‘dum’, ‘te’, ‘ke’ were used to excite the instrument. As a result, time dependent deformation & velocity data were determined and different responses of Bendir were compared.
Quantification of coin falling sound quality of coin processing machine

Motoki Terada¹
¹Osaka Institute Of Technology, #501 Westpoint 1-7-16 Akagawa Asahi-ku, Osaka-shi, Osaka-fu, Japan

Quietness is essential for living comfortably but various noise exist at around our living place. Coins falling sound of the coin processing machine is one the noise around us. This noise disturbs our conversations, and it causes tired feeling occasionally. The coin falling sound is unsteady sound and have various frequency characteristic during very short time. Hence, not only the sound pressure level but also the quality is considered to be important for the improvement. In this study, we focused on the sound quality of the coin processing machine and investigated the impression through subjective evaluation test. In order to quantify the impressions, various coin falling sounds were prepared and the participants evaluated the “loudness,” “pitch,” “discomfort,” and “tired feeling.” In the sound quality analysis, multiple regression analysis was applied to understand which sound factor affects largely to the discomfort and tired feeling. As a result, both “discomfort” and “tired feeling” were observed to be affected by “loudness” and “pitch.” Especially, tired feeling was found to be affected more by the pitch of the sound than that of discomfort. From these results, the noise at high frequency band was clarified to be necessary to improve the sound quality.

Link to paper
Construction of motional phase maps for granular dampers

Furkan Terzioglu¹, Jem A. Rongong¹, Charles E. Lord¹
¹The University of Sheffield, Department of Mechanical Engineering, Sheffield, United Kingdom

Harmonically vibrated granular media exhibit a variety of motional behaviours depending on amplitude, frequency, and vibration-to-gravity directional orientation. Motional behaviour defines the physical interactions of particles in the granular media and therefore the energy dissipation performance. A “phase map” that describes motional behaviour over broad ranges of frequency and amplitude is therefore a very useful tool in damper design. However, at present, identification of the operating motional conditions within the granular media has only been conducted by visual observation of the particles following a particle-level simulation or a specifically designed experiment. Because of this, design optimisation over a broad range of amplitude and frequency becomes costly. This paper aims to help reduce this cost through the development of approximate phase maps based on expected dissipative interactions of particles. Three-dimensional discrete element method simulations are conducted over a wide range of excitation intensities under two different vibration-to-gravity directional orientations (i.e., perpendicular, and parallel to the standard gravity direction) to allow the observation of as many motional phases as possible. The effect of particle size, volume filling ratio and particle shape on granular energy dissipation sources are also investigated.
The WHO Environmental Noise Guidelines and noise policy in Denmark

Jens Schultz Thers

1Danish Environmental Protection Agency, Odense, Denmark

The WHO Environmental Noise Guidelines and noise policy in Denmark
Studies from Denmark - and a background article from the WHO report on Environmental Noise Guidelines from 2018- supports the Danish noise limit on Lden = 58 dB for ordinary roads for 10 % highly annoyed. Other studies however shows that motorways are more annoying – close to WHO guidelines at 53 dB.

A Danish investigations point to Lden = 52 dB for 10 % highly annoyed for motorways. A Swiss study suggests Lden 51 dB for 10% highly annoyed for motorways.

According to the studies the Danish EPA has made an investigation of the consequences for new motorways and urban planning - if the guidelines would be changed from 58 dB to 53 dB. It shows the difficulties for urban planners if the noise limit would be changed - but also that it is fact possible to lower the limits technically – through speed limits, noise barriers etc.

The study also shows that new projects for new housing economically would be difficult outside larger cities – because of increasing cost.

This paper shows what policy implications this entails in Denmark ?.
Developing a holistic tranquillity assessment method from a soundscape design approach

Adam Thomas\textsuperscript{1}, David Owen\textsuperscript{1}, Sarah Drysdale\textsuperscript{1}
\textsuperscript{2}Arup, London, United Kingdom

The assessment of tranquillity considered in Environmental Impact Assessments does not currently benefit from a single ‘industry accepted’ multidisciplinary approach. Current assessments rely mainly on objective measurements of imagery, sound, and investigator expert opinion. These approaches do not fully consider the context of the site, the interaction between different environmental disciplines or the perceptual aspects of Tranquillity. Standardised soundscape methodologies (ISO12913-2:2018) are now used to measure perception of acoustic environments in context. This study explores a soundscape approach to tranquillity assessment of heritage assets.

Is it possible to develop a holistic assessment method based upon the data collection methods of soundscape principals of ISO 12913-2:2018 that is robust, scalable and applicable to the methods of assessment used within the built environment?

Existing research on attention restorative theory is used to identify a set of attributes for use in a Soundwalk questionnaire. The methodology is tested by the authors conducting a Soundwalk at a set of heritage locations located within the Knowledge Quarter of London.

The findings are supportive with recommendations for further development of the method that could involve different stakeholders that have local expertise and governance.
The influence of model assumptions in a hybrid prediction tool for railway induced vibration

David Thompson¹, Evangelos Ntotsios¹, Pascal Bouvet², Brice Nélain², Andreas Nuber³, Bernd Fröhling³, Fakhraddin Seyfaddini⁴, Geertrui Herremans⁴, Pieter Reumers⁴, Geert Lombaert⁴, Geert Degrande⁴

¹ISVR, University Of Southampton, Southampton, United Kingdom, ²Vibratec, Ecully, France, ³Wölfel Engineering, Höchberg, Germany, ⁴KU Leuven, Department of Civil Engineering, Leuven, Belgium

Within the SILVARSTAR project, a user-friendly frequency-based hybrid prediction tool is developed to assess the environmental impact of railway induced vibration. This will be implemented in the existing noise mapping software IMMI. The vibration level in a building in each frequency band is expressed as the product of source, propagation and receiver terms. A hybrid approach is used that combines experimental data with numerical predictions, providing increased flexibility and applicability.

The train and track properties can be selected from a database or as numerical values. The user can select soil impedance and transfer functions from a database, pre-computed for a wide range of parameters with the MOTIV and TRAFFIC models. An experimental database of force densities, transfer functions, free field vibration and input parameters is also integrated into the new tool. The building response is estimated by means of empirical correction factors.

Assumptions within the modelling approach can influence the prediction accuracy and the present paper aims to quantify these. We focus on the influence of train speed and soil properties on the compliance of the track-soil system, the dynamic axle loads, and the free field response, as well as on the load transfer between track and soil.

[Link to paper]
Study on railway curve squeal using a rigid-flexible coupling model of vehicle and track

Qiuyong Tian¹, Yichang Zhou¹, Thilo Hanisch¹, Markus Hecht¹
¹Technische Universität Berlin, Chair of Rail Vehicles, Berlin, Germany

Squeal noise occurring in narrow curves is one of the most annoying noise issues for people living by the railway track. When vehicles pass through those curves, squeal noise is mainly generated due to the large, high-frequency, lateral sliding friction force. To investigate generation mechanism of curve squeal, a three-dimensional (3D) vehicle-track interaction model with a flexible wheelset and a flexible curved track is built in a multi-body simulation tool in this paper. Compared to conventional rigid models, this model allows to obtain the high frequency friction force between wheel and rail. This calculated friction force in the frequency domain is analyzed to identify the major modes. Those modes are compared with the modal properties of the wheelsets and rails in order to determine which of their modes have the main contribution to the friction force and the squeal noise. In addition, a parametric study is performed to study the influence of vehicle speed, curve radius, wheel/rail friction coefficient and further parameters on the dominant modes of friction forces.

Link to paper
Speech enhancement for helicopter headsets with an integrated ANC-system for FPGA-platforms

Johannes Timmermann¹, Florian Ernst¹, Delf Sachau¹
²Helmut-Schmidt-University / University of the Federal Armed Forces Hamburg, Hamburg, Germany

During flights, helicopter pilots are exposed to high noise levels caused by rotor, engine and wind. To protect the health of passengers and crew, noise-dampening headsets are used. Modern active noise control (ANC) headset can further reduce the noise exposure for humans in helicopters. Internal or external voice transmission in the helicopter must be adapted to the noisy environment and speech signals are therefore heavily amplified. To improve the quality of communication in helicopters speech and background noise in the transmitted audio signals should be separated. Subsequently the noise components of the signal are eliminated. One established method for this type of speech enhancement is spectral subtraction. In this study, audio files recorded with an artificial head during a helicopter flight are used to evaluate a speech enhancement system with additional ANC capabilities on a rapid prototyping platform. Since both spectral subtraction and the ANC algorithm are computationally intensive, an FPGA is used. The results show a significant enhancement in the quality of the speech signals, which thus lead to improved communication. Furthermore, the enhanced audio signals can be used for voice recognition algorithms.
ERROR AND UNCERTAINTY IN NEAR-FIELD SOUND POWER ASSESSMENTS OF INDUSTRIAL SOURCES

Jon Tofts¹
¹Environment Agency (England), Taunton, United Kingdom

Near-field sound pressure measurements may be converted into sound power levels (Lw) in order to populate propagation models. Although standards exist such as ISO 3740:2019 which present rigorous methods for the accurate determination of sound power levels, complying with such standards is not always feasible once an industry is operational. In such cases, it is common to see propagation models populated using a sound power estimate from a single field-based measurement.

Alternatively, propagation models can be populated using sound power data that have been provided by equipment manufacturers or that have been presented in other standards such as BS 5228-1:2009+A1:2014.

Previous papers commonly consider the isolated uncertainties associated with laboratory-based sound power assessments. This paper will explore multiple sources of error and uncertainty within near-field sound power estimates from field-based sound pressure levels and will suggest ways to minimise them.
Reduction of transmitted impact sound of dry-type floating floor due to differences in impact force characteristics

Ryuta Tomita

Nihon University, Chiyoda-ku, Japan

In Japan, JIS A 1418-2:2019 specifies the car-tire with impact force characteristics (1) and the rubber ball with impact force characteristics (2) as standard heavy impact sources. In addition, JIS A 1440-2:2007 specifies the measurement method of the reduction of transmitted impact sound by floor coverings on a solid standard floor. It has also been reported that the reduction of transmitted impact sound differs depending on the impact sources of the car-tire and the rubber ball. It has been reported that one of the reasons for different reduction of transmitted impact sound is excessive car-tire impact force, and a tendency for a nonlinear response to impact force for a dry-type floating floor. In this study, an experimental examination is conducted to interconvert the reduction of transmitted impact sound of the car-tire and the rubber ball. This paper discusses the reduction of transmitted impact sound due to the change in impact force by varying the drop height of the car-tire and the rubber ball. The results suggest that the difference in reduction of transmitted impact sound between the car-tire and the rubber ball cannot be explained only by nonlinearity due to the impact force for a dry-type floating floor.
Generation and Analysis of Artificial Warning Sounds for Electric Scooters

Antonio J Torija Martinez¹, Andrew Elliott, Lara Harris, Zuzanna Podwinska, Connor Welham
¹Acoustics Research Centre, University Of Salford, Manchester, United Kingdom

Micro-mobility transportation, including electric scooters and e-bikes, could bring substantial benefits to resolving road congestion, provide an eco-friendly transportation system, offer low-cost personal transportation, and increase accessibility. Another benefit is that electric scooters are very quiet, only producing some minimal rolling noise and high frequency emission due to electric motors. Quietness of the vehicles has led to safety concerns being raised by accessibility groups, such as the Royal National Institute of Blind people (RNIB). For this reason, we have teamed up with the RNIB to explore, well-designed Acoustic Vehicle Alerting Systems (AVAS) as a potential solution to ensure vehicle detection and avoid potential conflict with pedestrians.

This paper presents the key findings of a research project carried out by the University of Salford’s Acoustic Research Centre, in collaboration with Dott Scooters and RNIB. The goal of this project was to develop a stand-alone warning sound system for electric scooters, with the main constraint of ensuring an appropriate balancing between vehicle awareness and noise annoyance. Based on preliminary results, this project concluded that a significant benefit, in terms of vehicle noticeability, is observed with the addition of a warning sound. Funding has been secured to carry out further research to optimise the AVAS for complex urban environments.

[Link to paper]
Evaluating the Specific Sound Level from Plant and Machinery in High Residual Sound Environments

Matt Torjussen

ANV Measurement Systems Ltd, Milton Keynes, United Kingdom

BS 4142 requires the selection of periods within a sound pressure level time-series to calculate the specific sound level from the ambient and residual sound levels. This is usually done in the time-domain by monitoring and/or controlling the specific sound source(s); however, there are instances where it is necessary to evaluate the specific sound level at a remote location without any control over the operation of the specific sound source(s), which may make it difficult to obtain a representative specific sound level where there are high levels of residual sound. BS 4142 directs practitioners to carry out measurements closer to the source and then use a calculation method to estimate the specific sound level at the assessment location(s).

For some types of specific sound sources, it may be possible to increase the accuracy of the specific sound level evaluation using two microphones. This paper presents a method that uses two microphones to acquire ambient sound data simultaneously at the receptor and closer to the source. Coherence is used to identify the components present in the signal measured at the receptor that are also present in the signal measured closer to the source. This approach allows the specific sound level to be evaluated when the difference between the overall A-weighted ambient and residual sound levels is less than 3dB.

Link to paper
“You are on mute”: the impact of indoor soundscape on sexual well-being during the COVID-19 lockdown

Simone Torresin¹,², Eleanor Ratcliffe³, Francesco Aletta⁴, Rossano Albatici¹, Francesco Babich⁵, Tin Oberman⁴, Jian Kang⁴

¹Department of Civil Environmental and Mechanical Engineering, University of Trento, Trento, Italy, ²Institute for Renewable Energy, Eurac Research, Bolzano Bozen, Italy, ³School of Psychology, Faculty of Health and Medical Sciences, University of Surrey, Guildford, UK, ⁴UCL Institute for Environmental Design and Engineering, The Bartlett, University College London, London, UK

Sexual well-being is a fundamental facet of the overall well-being of individuals and implies the ability to have safe and pleasurable sexual experiences, beyond the absence of disease or disturbance. The extent to which people can achieve sexual well-being depends, among other aspects, on whether they live in an environment that promotes and support it. The present study focuses on the unexplored impacts of the perceived acoustic environment (i.e., the soundscape) on human sexual activity carried out in domestic settings. Verbal descriptions have been gathered from open-ended questions included in a survey administered to 848 respondents living in London (UK) and in Italy in January 2021 during the COVID-19 lockdown. Thematic analysis was used to extract a framework detailing the positive and negative impacts of the acoustic environment on sexual activity. The results show the mechanisms by which the acoustic features of the environment can impact on the sexual experience in terms of privacy, distraction, disruption or support, up to trigger coping strategies (e.g., controlling windows, playing music) and behavioural changes (e.g., lowering the volume of the voice) that can in turn limit or enhance the freedom of sexual behaviour, affect or foster sexual well-being.
A recent feedback of wooden multi-storey buildings in France

Thomas Toulemonde¹, Bertrand De Bastiani¹
¹ACOUSTB, Saint Martin d'Hères, France

Wooden structures are becoming quite common in the French architectural landscape, and ACOUSTB has made it a specialty regarding acoustics. Its experience ranges from office buildings to residential buildings, and from small to high-rise constructions. Airborne and impact noise insulation are of first importance. Structural aspects, construction methods and architecture are also discussed. Constructive solutions concern both CLT and traditional wood joists flooring systems, alternatives to floating screeds in office buildings and visible wooden structures in dwellings. Buildings are described, then selected constructive solutions are presented and debated with respect to targeted acoustic performance. Finally, in-situ measurement results are compared with the theory that underlays them, as well with the targeted performance.

[Link to paper]
Sound propagation and audibility of train horns

Martin Toward¹, Mike Lower¹, Marcus Wiseman¹, David Thompson¹, Paul Ferraby²
¹ISVR, Southampton, United Kingdom, ²RSSB, London, United Kingdom

Horn sound levels and sound propagation along the track were investigated to understand the relationship between standardised tests at 25 metres and audibility in practice. Sound levels from a static horn above a test track decayed by 6 dB per doubling of distance (6 dB/dd) up to about 30 or 50 metres, depending on the horn height. At greater distances the level decayed by approximately 12 dB/dd. At 400 metres, the sound level from a horn 2.5 metres above the ground was about 10 dB higher than the level from the horn 0.5 metres above the ground, although the levels at 25 metres were the same. The audibility and the effective range of a horn depends on its height.

At two rural mainline sites, with line speeds of 160 km/h and 200 km/h, the mean attenuation rates beyond 90 metres were 10.7 and 9.2 dB/dd respectively. At the first site, horn sound levels were highly correlated with distance. At the second site, with newer trains, horn levels were poorly correlated, suggesting some variability in horn sound levels at source.

Track workers ratings of the audibility of the horns were compared to horn levels recommended by Dectsound and by ISO 7731.
Why listening matters

David Trevor-jones¹, Peter Rogers²

¹Sustainable Acoustics, Basingstoke, United Kingdom, ²Sustainable Acoustics, Ovington, Alresford, United Kingdom

Sound is the only one of our senses that remains active while we sleep. Through hearing we test our safety at distance and in the dark. It can also condition the way we feel. Noise can affect our health and well-being negatively but sound may do so positively. Acousticians are used to measuring noise but the more positive effects of sound less well understood.

The idea that sound can reduce stress and enhance our sense of wellbeing and even improve our health is a tantalising target for soundscape designs in the future but we need more fully to understand how to achieve it in a scientific way. We know that a tranquil place does not need to be quiet for instance, and that context and non-acoustic factors are important in the perception of tranquillity.

We know that natural sounds: waves breaking, rain, leaves rustling, water babbling, birdsong; and some anthropogenic sounds: a familiar voice, the murmur of conversation, music; can contribute to a positive soundscape.

Some examples and the current understanding of why this is, taking in cues from neuroscience, medicine and psychoacoustics are explored leading to quantification of these benefits for application in soundscape analysis and, ultimately, design.

Link to paper
Protection of art gallery and museum collections from vibration

David Trevor-jones¹, Martin McNulty²

¹Sustainable Acoustics, Basingstoke, United Kingdom, ²Hoare Lea, Manchester, United Kingdom

Awareness that works in museum collections might be at risk of damage from exposure to vibration has existed in the art world at least since the 1970s. The acute risk is greatest when works are being moved. Early attempts at measurement and risk evaluation were focussed on works in transit. The assumption was that works at rest, exhibited or stored in gallery conditions, were no more vulnerable to vibration than the buildings housing them. That may hold true for conventional paintings, whatever their medium, age or even condition. Artefacts may be at greater risk. As practicable methods for monitoring emerged, especially during nearby construction, attention turned to the vulnerability of art objects more widely. Few verifiable cases of damage caused by exposure to vibration have been reported but the perception of risk has nonetheless increased. A necessarily precautionary approach has become ever more cautious, especially encouraged by the hypothesis that all objects are susceptible to accumulated exposure and eventual fatigue failure. Yet there is no numerical or experiential evidence to support that. A summary of a comprehensive literature review leads here to an attempt at numerical analysis of the risk, taking Michaelangelo’s ‘David’ as a case study.
Sensitivity of Input Parameter on CNOSSOS-EU Railway Emission Levels

Jonathan Phillips¹, James Trow¹, Simon Shilton²
¹Noise Consultants Limited, Warrington, United Kingdom, ²Acustica Limited, Manchester, United Kingdom

The United Kingdom Department for Food and Rural Affairs (Defra) commissioned a series of studies investigating the sensitivity of the CNOSSOS-EU noise assessment method. CNOSSOS-EU presents challenges in terms of input data accuracy and availability. For this reason, the studies were commissioned to support data decision making and quantify potential uncertainty in Defra’s national noise model. The quality framework set out in Directive 996/2014 requires uncertainty in rail emission levels at source to correspond to an uncertainty of ±2dB(A). Due to the CNOSSOS-EU rail emission model being of multivariate complexity, and the multitude of possible parameter combinations, a scenario and parametric-based approach was taken to the study. The variation in rail emission levels was presented for each parameter for a set of rail vehicle speeds and rail infrastructure scenarios. The results of the analysis indicated which input parameters the CNOSSOS-EU rail noise emission model is most sensitive to. It was found that emissions are most sensitive to changes in the number of axles on the vehicle (i.e. wheel / rail interaction), the density of track joints (impact noise), the curvature of the track (squeal noise), and the construction of bridges (structural resonances). However, the choice of rail roughness, vehicle transfer function, and track transfer function (except in the case of direct fastenings) were found to have a limited impact on rail emission levels.
Determining and quantifying effects of Favourable Propagation on CNOSSOS-EU Calculated Noise Levels

Davide Vinci¹, Joshua Nunn¹, James Trow¹, Simon Shilton²
¹Noise Consultants Limited, 6 Bankside, United Kingdom, ²Acustica Limited, Manchester, United Kingdom

The United Kingdom Department for Food and Rural Affairs (Defra) commissioned a series of studies investigating the sensitivity of the CNOSSOS-EU noise assessment method. CNOSSOS-EU presents challenges in terms of input data accuracy and availability. For this reason, the studies were commissioned to support data decision making and quantify potential uncertainty in Defra’s national noise model. A study was undertaken to identify approaches to quantifying the effect of favourable propagation (FP) when calculating noise levels using the CNOSSOS-EU noise assessment methodology. Literature reviews allowed the identification of two methodologies for quantifying the occurrence of FP, and their respective data requirements. Data requirements were reviewed against data available from meteorology stations across UK and a method selected. FP was calculated for met sites in England and presented in tables and in the form of meteorological roses. Analysis was then undertaken exploring the effect of including of FP on sound propagation using CNOSSOS-EU using a test model. Comparisons were then made against assuming 100% favourable and 100% homogeneous conditions to identify the importance of calculating the occurrence of FP in noise exposure data.
Impact of Ground Cover Dataset Selection on CNOSSOS-EU Calculated Levels

Chris Youdale¹, Simon Shilton², James Trow¹
¹Noise Consultants Limited, Warrington, United Kingdom, ²Acustica Limited, Manchester, United Kingdom

The United Kingdom Department for Food and Rural Affairs (Defra) commissioned a series of studies investigating the sensitivity of the CNOSSOS-EU noise assessment method. CNOSSOS-EU presents challenges in terms of input data accuracy and availability. For this reason, the studies were commissioned to support data decision making and quantify potential uncertainty in Defra’s national noise model. A study was undertaken to identify how the selection of a ground cover dataset may influence calculated noise levels using the CNOSSOS-EU noise assessment method and computational load. Acoustic test models were developed incorporating prepared ground cover datasets based on CORINE Land Cover 2018, CEH Land Cover Map 2019 and OS Mastermap Topography. Noise calculations in accordance with CNOSSOS-EU were carried out for rural and urban/suburban propagation environments. A statistical analysis of the differences between each selected dataset was then undertaken. The paper discusses the findings of this analysis along with generic rules which were identified with respect to modelling ground effect using CNOSSOS-EU.

[Link to paper]
Sensitivity of Input Parameter on CNOSSOS-EU Road Emission Levels

Jonathan Phillips¹, Simon Shilton², James Trow¹
¹Noise Consultants Limited, Warrington, United Kingdom, ²Acustica Limited, Manchester, United Kingdom

The United Kingdom Department for Food and Rural Affairs (Defra) commissioned a series of studies investigating the sensitivity of the CNOSSOS-EU noise assessment method. CNOSSOS-EU presents challenges in terms of input data accuracy and availability. For this reason, the studies were commissioned to support data decision making and quantify potential uncertainty in Defra’s national noise model. The quality framework set out in Directive 996/2014 requires uncertainty in road emission levels at source to correspond to an uncertainty of ±2dB(A). By calculating emissions across a range of values for input parameter within various scenarios in which all other parameters were kept constant, changes in road traffic noise emissions were observed. This was performed separately for each of the five CNOSSOS-EU vehicle categories as well as for a selection of hypothetical composite road traffic flows. A similar analysis was then performed for a series of road surface types. The results were used to indicate which input parameters road traffic noise emissions were most sensitive to. The results identified that uncertainty in traffic flow speed has a tolerance of ±11 kmh-1 for cars and two-wheelers, and ±24 kmh-1 for HGVs in order to meet the quality framework. Significant variation in emissions were found across surface types, indicating the importance of obtaining representative road surface data. The study found that traffic volumes should be within 60% of their true value. The effect of road gradient was found to be dependent on flow composition and speed. Road traffic noise emissions were found to be insensitive to changes in air temperature. Composite flow analysis using English traffic statistics with various proportions of HGVs showed that these assumptions become more important on lower speed roads, while the proportion of two-wheelers is relatively insignificant with respect to overall noise emissions.
Automation of a National Noise Model

James Trow¹, Magdalena Wilczek², Katarzyna Fedyk², Simon Shilton¹, Hartmut Stapelfeldt⁴, Raymond Wong⁵
¹Noise Consultants Limited, Warrington, United Kingdom, ²Mott MacDonald, Bristol, United Kingdom, ³Acustica Limited, Manchester, United Kingdom, ⁴Stapelfeldt Ingenieurgesellschaft mbH, Dortmund, Germany, ⁵NGIS, Hong Kong, China

The United Kingdom Department for Food and Rural Affairs (Defra) commissioned the design and build of an environmental noise modelling system (NMS). The NMS has been developed to support Defra in developing its environmental noise evidence base by preparing national road and railway noise models. This paper discusses the automation aspects of the NMS with respect to the various elements required for a noise model. This includes the development of sophisticated data processing engines and the techniques utilised to automate the delivery of a 3-dimensional noise propagation environment, and road and railway noise emissions. It highlights several innovative methods which are now possible due to the data landscape in England and how through open data standards the NMS has the potential to improve the fidelity of national noise models.
Simulating Changes in Aircraft Noise at Heathrow Airport during the 2020 Covid-19 Lockdown

James Trow\textsuperscript{1}, Jonathan Phillips\textsuperscript{1}, Davide Vinci\textsuperscript{1}
\textsuperscript{1}Noise Consultants Limited, Warrington, United Kingdom

Global restrictions on domestic and international travel introduced in March 2020 as a result of the Covid-19 pandemic resulted in a significant reduction in air traffic movements around the world. This paper presents the findings of research carried out at London Heathrow Airport exploring the day-by-day changes in aircraft noise exposure and event levels over the period March 2020 to June 2020. The research was carried out using validated modelling of aircraft procedures and noise profiles alongside radar data obtained from the airport. This allowed trends in metrics such as LAeq, N65, and overflight to be considered in the form of contours, and at community locations. This was facilitated using geospatial databases and interactive dynamic reporting toolkits. The research has allowed estimates to be made of the point where aircraft noise at Heathrow Airport reached a minimum. It also provides some helpful insight as to the potential of generating daily noise exposure data and the advantages, and disadvantages of modelling using radar data.

[Link to paper]
Quantifying Carbon in Airspace Noise Management Measures

Pierangelo Di Stefano¹, James Trow¹, Davide Vinci²

¹Noise Consultants Limited, Warrington, United Kingdom

Aviation is subject to increasing environmental scrutiny. This can often be compounded by a poor understanding of environmental and operational interdependencies. Aircraft noise and carbon whilst being environmental emission that the aviation sector is working to reduce, can often be subject to separate policies and regulations. Although carbon emissions are one of the main contributors to environmental impacts at a global level, other environmental impacts, such as noise, result in more localised impacts to the natural environment and communities. This paper presents analysis that quantifying the potential carbon consequences of various airspace noise management measures. This has been possible through processes developed to describe the interrelations between fuel burn, consequential carbon and noise emissions of various noise abatement procedures. Using this process, the overall environmental performance of various noise management measures are considered. This analysis has identified noise management measures which are beneficial with respect to noise and carbon emissions, however others have been identified which could increase carbon.
Measurement of acoustic source data of taxiing aircraft for noise modelling

George Gibbs¹
¹Noise Consultants Limited, Warrington, United Kingdom

Noise from airport ground activities can be a significant contribution to the ambient sound climate in communities close to airports. The shortfall in robust acoustic source data for taxiing aircraft is a limitation to the accuracy of noise modelling supporting impact assessments associated with changes in airport infrastructure and operations. The aim of this project was to develop a robust measurement methodology for the purpose of obtaining acoustic source data of taxiing aircraft. The project addressed two major challenges: the theoretical principle and experimental design for characterizing complex moving sources (i.e. the sound power, spectra and directivity); and the practical problems involved in on-site measurement. The theoretical principle is to consider an aircraft, moving in-line past a microphone, as reciprocally equivalent to a stationary aircraft alongside a line-array of microphones. Increasing the number of microphones in the array is equivalent to increasing the number of angles in the polar distribution plots.
Study on an evaluation method of virus exposure risk by droplets focusing on a sound environment

Sohei Tsujimura¹
²Graduate School of Science and Engineering, Ibaraki University, 4-12-1 Nakanarusawa, Hitachi, 316-8511, Japan

The final goal of our study is to propose a new method to evaluate the risk of virus infection from the aspect of the sound environment. In this study, we attempted to quantitatively grasp the relationship between speech level and number of droplets when talking while eating at a restaurant. A psychoacoustic experiment was conducted in which the subject was made to speak under the condition that the background noise level was varied every 5 dB from 55 dB to 70 dB using a pair of speaker and listener as subject. From the results, the effect of background noise level on speech level was examined, and the relationship between speech level and number of droplets was clarified. Although the speech level tended to increase with increase in the background noise level, in the background noise range of 55 dB to 70 dB, there was no significant difference in the number of droplets with particle sizes larger than 100 μm. Furthermore, we evaluated the risk of virus exposure in droplet infection focusing on the indoor background noise level.

Link to paper
Environmental Noise Monitoring and Assessment of Petrochemical Plants

Scott Tunnah¹
¹Robin Mackenzie Partnership, Edinburgh Napier University, Edinburgh, United Kingdom

This paper will look at the Scottish regulatory guidance for the monitoring and assessment of environmental noise from petrochemical plants. The practical challenges of on-site measurement and long-term monitoring will be discussed. The use of BS 4142 and NANR 45 within this context and the appropriate data analysis to assess noise impact on residential locations.

[Link to paper]
Noise Policy in a More Sustainable Future

Stephen Turner

ST Acoustics, Ashtead, United Kingdom

This paper examines the issues that could arise regarding the implementation of noise policy in the context of the need and desire to deal with the effects of climate change. Is it going to be necessary to compromise the standards used or implied in noise policy in order to enable measures to tackle climate change to be put in place? Based on the author’s extensive experience of developing and implementing noise management policy, this paper will consider how the pressures of tackling climate change could impinge on the outcomes that should be sought through noise management policy. The paper will consider the various types of noise policy that have and do exist and explore the issues that might now have to be addressed in order to secure a more sustainable future.
Mixed Reality Visualization System for the 3D sound intensity using PAGE method and spatial interpolation

Ayame Uchida¹, Yukiko Okawa¹, Yusuke Ikeda¹, Yasuhiro Oikawa²

¹Tokyo Denki University, 5 Senju-Asahi-Cho, Adachi-ku, Japan, ²Waseda University, 3 Okubo, Shinjuku-ku, Japan

In our previous study, we proposed the visualization system of three-dimensional sound intensity measured by handy 4-ch microphones using Mixed Reality. In the previous system, since the sound intensity was estimated by the cross-spectrum method, the error at the higher frequency than the spatial Nyquist frequency becomes larger due to the microphone intervals.

In addition, visibility of sound intensity map was degraded because the microphone array was moved by hands and the intervals of measurement points for sound intensity map are irregular.

In this study, we improve the previous mixed reality system for sound intensity by applying the PAGE method (Phase and Amplitude Gradient Estimation), which can accurately estimate the sound intensity up to higher frequencies. Furthermore, by using spatial interpolation of an irregularly-sampled intensity map, we improve visibility of sound intensity map with mixed reality. The proposed system interpolates sound intensities at equal intervals from the sound intensities measured at irregular intervals. For evaluation, we conducted visualization experiments of sound intensities surrounding single loudspeaker.

Link to paper
Sound source distribution of high-speed trains and reduction of aerodynamic bogie noise

Toki Uda¹, Sound source distribution of high-speed trains and reduction of aerodynamic bogie noise Mariko Akutsu²

¹Railway Technical Research Institute, 2-8-38, Kokubunji-shi, Japan, ²Railway Technical Research Institute, 2-8-38, Kokubunji-shi, Japan

When the Shinkansen train runs at a high speed more than 300 km/h, the contribution ratio of the aerodynamic noise generated from bogies to the total wayside noise is as large as 30%. This is because the aerodynamic noise is proportional to the 6th power of the train velocity.

RTRI has designed and made a large new microphone array with a diameter of 3m easy to install in the wayside of the railway. By applying the latest deconvolution algorithm to improve the spatial resolution of sound sources, it was found that the most prominent noise sources distribute around the train nose, pantographs and bogies. Because Japanese environmental standards impose to evaluate the A-weighted maximum noise level at the point 25m apart from the nearest truck after applying time-weighting, S, the aerodynamic bogie noise needs to be reduced. For this reason, we conducted a wind tunnel test to develop countermeasures to reduce aerodynamic bogie noise. As a result, several measures are found to be effective.
An inter-laboratory study to quantify the repeatability, reproducibility, and bias of sound power measurement methods

Samuel Underwood¹, Lily Wang¹
¹University Of Nebraska - Lincoln, United States

An inter-laboratory study across multiple facilities has been completed to quantify the repeatability, reproducibility, and bias of three different sound power measurement methods used in the heating, ventilation, and air-conditioning industry: free field method, diffuse field method, and intensity method. The sound power levels of a loudspeaker source across one-third octave bands have been measured in each participating laboratory by the test methods preferred in those facilities. Both a broadband signal with decreasing slope of – 5 dB per octave band and the same broadband signal with four discrete tones at 58, 120, 300, and 600 Hz have been measured in this round robin study. Comparisons of measured sound power levels have been made between methods, between laboratories, and between laboratories using the same method. Repeatability, reproducibility, laboratory bias, and test method bias are then quantified in accordance with ISO 5725. [Work supported by the Air-Conditioning, Heating, and Refrigeration Institute]
Development of a reference energy mean emission level traffic noise models for bituminous pavement for mid-sized cities in India.

Saurabh Upadhyay¹, Manoranjan Parida¹, Brind Kumar²

¹Indian Institute of Technology Roorkee, Roorkee, Haridwar, India, ²Indian Institute of Technology (BHU) Varanasi, Varanasi, India

Present study is towards the development of the Reference Energy Mean Emission Level (REMEL) of vehicle types involved in the mixed traffic flow on the bituminous pavements on Indian roads for a mid-sized city. Five locations were identified in Kanpur urban area under free flow traffic and good pavement conditions. A total 10700 data sets for 11 vehicle categories were collected from these locations under a sponsored research project being sponsored by Ministry of Education (MoE) and Ministry of Housing & Urban Affairs (MoUD), Govt. of India, under the flagship programme of IMPRINT India. The REMEL of every vehicle category was measured using Type-1 Sound Level Meter (SLM) and was placed at a distance of 7.5 meters from the centre of the nearby carriageway while measuring the single vehicle passby event for each category. Noise level and spot speed data for bituminous pavement surface were collected for 11 vehicles categories as bus, truck, tractor-trailer, light commercial vehicle (LCV), 3-wheeler (auto, vikram), motorcycle, e-rickshaw, bicycle, tricycle and horse driven vehicle. Regression analysis was performed to obtain the REMEL equations for prediction of Leq. The study provides an interesting insight to noise emission characteristics of vehicle types for mixed traffic under Indian conditions.
Factor analysis of power seat noise using blocked force

Ryohei Usui1, Junji Yoshida, Yasuo Inose
1Osaka Institute of Technology, Osaka, Japan

In recent years, operating noise generated by various devices in cabin has been focused and becomes noise reduction target due to the reduction of vehicle running noise. In this study, we then conducted the noise evaluation and investigated the noise factors of a power seat at the operating condition. At first, the operating noise at around driver’s ear position and vibration of the seat frame were measured using an artificial head microphones and acceleration sensors. As a result, the noise and vibration at 400-500 Hz band was found to be large and the reduction was essential to decrease the noise. Subsequently, Component TPA was applied to understand the main factor of the large vibration of the frame at the target frequency. The result shows the vibration was increased largely due to the resonance between the rotational order input force from the driving motor and the natural frequency of the frame. As an instance of the countermeasure, small weight was added to the resonated part of the frame to avoid the resonance and the vibration and noise was observed to decrease at the target frequency band.
Effect of Pitch Ratio of Tube Banks on Passive Acoustic Properties

Charitha Vaddamani\textsuperscript{1}, Susann Boji\textsuperscript{1}, Hans Boden\textsuperscript{1}, Mikael Karlsson\textsuperscript{1}

\textsuperscript{1}KTH Royal Institute Of Technology, Stockholm, Sweden

Tube banks are common design elements in heat exchangers. The most common tube bank patterns are In-line tube banks and Staggered tube banks. These are characterized by their longitudinal and transverse pitch ratios (pitches to diameters). The tube bank with a pitch ratio of less than 1.25 is considered a compact tube bank and a pitch ratio greater than 2 is considered as widely spaced. In this paper, the attention is focused on the effects of pitch ratio in tube banks on its passive acoustics properties which are experimentally investigated. The flow duct experimentation is performed with and without flow to analyse the passive acoustic properties of tube banks. The Experiment is conducted for both the In-line and Staggered tube banks with pitch ratios from 1.2 to 2.5. Experimental results consist of scattering matrix coefficients and power balance. The results are compared to see the pitch ratio effect.
Sound propagation for a low height impulsive source over an absorbing ground

Frits Van Der Eerden$^1$, Frank Van Den Berg$^1$, Ad Van Heijningen$^1$

$^1$TNO, The Hague, Netherlands

Noise contours around military training areas are calculated by using: a) the measured source strength for the impulsive sources and b) the calculated sound propagation using a representative set of meteorological situations. For high-energy impulsive sounds the source strength is measured at distances beyond 100 meters, where peak levels are below 154 dB. A linear model is used to correct for the sound propagation from the source to the measurement position. In this way a linear source strength is determined that can be used with linear sound propagation models. Previous results showed that the source strengths at higher frequencies (above 250 to 500 Hz) were overestimated when the impulsive source is on the ground. Apparently, the calculated sound propagation over an absorbing ground, used to determine the source strength, is accounting for too much ground effect. Note that the actual meteorology and ground absorption are measured during the measurements. In this paper an impulsive reference source is used at two heights and the sound propagation is measured and calculated at increasing distances. It is shown that the measured ground effect saturates for higher frequencies. Next, an unknown impulsive source was measured and the effect of saturation was demonstrated.
A new approach to generate diffuse sound pressure fields

Cédric Van hoorickx¹, Edwin Reynders¹
¹KU Leuven, Leuven, Belgium

If the acoustic wavelength is small compared to the characteristic size of an enclosed space, the sound field in that space is often modeled as diffuse. A diffuse sound field is conventionally defined as a zero-mean circularly-symmetric complex Gaussian random field. A more recent, generalized definition is that of a sound field having mode shapes that are diffuse in the conventional sense, and eigenfrequencies that conform to the Gaussian Orthogonal Ensemble. Such a generalized diffuse sound field can represent a random ensemble of sound fields that share gross features such as modal density and reverberation time, but otherwise have any possible arrangement of local wave scattering features. In this contribution, realizations of a conventional diffuse sound field or, equivalently, of the mode shapes of a generalized diffuse sound field, are generated in a Monte Carlo framework. As a discrete decomposition is numerically expensive when the sound pressures at many locations are of interest, a fast analytical decomposition based on prolate spheroidal wave functions is developed. The approach is numerically validated by comparison with a detailed room model, where random wave scatterers are explicitly modeled, and good correspondence is observed. Applications involving correlated sound sources and sound-structure interaction are presented.

[Link to paper]
Vibro-acoustic analysis at high frequencies is challenging due to a large sensitivity to spatial variations and short acoustical wavelengths, rendering deterministic methods expensive. At these frequencies, the wave field is usually assumed diffuse. A realization of a diffuse field can be obtained considering that the mode shapes of the system are Gaussian random fields, and that its squared eigenfrequency spacings distribution conforms to the Gaussian orthogonal ensemble (GOE) eigenvalue spacings distribution. These diffuse field properties were for example used to extend statistical energy analysis (SEA) towards energetic variance prediction. However, energetic methods such as SEA lack the propagation of phase information, which means that, e.g., time-domain reconstruction is not possible. In this contribution, instead of total energies, expressions for the ensemble average and the cross-frequency covariance of frequency response functions are presented. These expressions are obtained from the generalized definition of a diffuse field, treating the eigenfrequencies of a diffuse subsystem as a collection of points randomly located on the frequency axis, making the analysis amenable to random point process theory. These expressions are numerically validated by comparison with computationally costly detailed models where random wave scatterers are modeled explicitly.
Energy transition related noise issues and its health consequences

Irene Van Kamp
RIVM, Bilthoven, Netherlands

Climate change leads to architectural adaptations in urban areas, heat islands and increased use of ventilation/cooling systems, expansion of windparks and behavioral changes. Most changes are part of the energy transition and affect noise exposure and related perceptions and health/wellbeing. Against this background the influence of adaptive measures on noise exposure was explored by us since 2011 by means of literature reviews and, secondary analysis of existing survey data. A recent review of the Dutch Health Council confirmed and expanded the importance of earlier detected noise issues related to energy transitions. Four noise issues came forward 1) Insulations and ventilation 2) increased use of electronic appliances 3) increased complexity of electronic appliances 4) cooling and heating systems. In our view, also the expansion of the windpark should be added to this list. Noise characteristics of these sources have an equivalent-, and low frequent component in common. It is remarkable how little progress has been achieved in mapping the health consequences of these “new” sources, since 2011. This paper will give an overview of the evidence and gaps based on recent literature reviews, and a survey on the acceptance of new energy saving measures in relation to annoyance and risk perception.

Link to paper
Annoyance and sleep disturbance due to vibrations from trains in the Netherlands: results from the second study “Living Alongside Railway Tracks”

Elise Van Kempen, Sendrick Simon, Harm van Wijnen, Arnaud Kok, Nick Mabjaia, Irene Van Kamp

National Institute for Public Health and the Environment (RIVM), Antonie Van Leeuwenhoeklaan 9, Bilthoven, The Netherlands

In 2013, RIVM investigated how people, living in the vicinity of railways, experience vibrations due to trains. As a follow-up, and in response to questions from Parliament on the expansion of the Dutch rail network, the Secretary of State of the Ministry of Infrastructure and Water management commissioned a second study and a repeated measurement of the persons who participated in 2013. This abstract focuses on the second study. The most important objective of this study was to derive exposure-response relationships between exposure to vibrations caused by trains and annoyance and sleep disturbance. The results are important for the further development of policy, and possibly also regulations, on railway vibration in The Netherlands. For this second study, 16,000 people living within 300 meters of a railway track were invited to participate. By means of an online questionnaire, that was administered in September 2021, information was gathered about annoyance, sleep disturbance due vibrations and noise from trains and the determinants of those. The participants’ exposure to vibrations from trains was estimated by means of an improved version of the Dutch calculation model for railway vibrations n (OURS). During the conference, the first findings will be presented.
A reduced-order cutFEM approach to model complex moving sound sources

Sjoerd van Ophem1,2, Wim Desmet1,2
1KU Leuven, Leuven, Belgium, 2Flanders Make, Leuven, Belgium

While traditional finite element based vibro-acoustic analysis of structures is done on stationary structures, in many occasions the structure under investigation is actually moving. To perform accurate finite element analysis on the vibro-acoustic performance of such structures requires the evaluation of a time-varying system, leading to several challenges. Of paramount importance are a strategy to update the mesh to the new configuration and an adequate time integration scheme that does not introduce large numerical artifacts. Additionally, the time-varying nature leads to an increase in computational complexity. In this paper a modeling strategy based on cut finite elements (cutFEM) is introduced that aims to tackle these challenges. The cutFEM approach can be seen as a fictitious domain approach in which the source is moving over a static mesh, cutting through elements where the actual source is located, using a level set description. The key advantage of this approach is that no remeshing and/or mesh morphing is required. It is shown how both implicit and explicit time integration schemes can be used to propagate the solution while the source is moving. Additionally, several model order reduction strategies are compared to speed up the online evaluation of the reduced order model.

Link to paper
Turbulent scattering in upwardly refracting atmospheres: towards a practical approach

Timothy Van Renterghem¹, Kirill Horoshenkov
²Ghent University, iGent building, Technologiepark 126, 9052 Zwijnaarde, Belgium

Neglecting turbulent scattering when modelling sound propagation in an upwardly refracting atmosphere leads to unrealistically low levels. Engineering models then typically impose a distance independent constant value for the sound pressure level relative to free field propagation. However, such an approach neglects the strong temporal variability in level one might observe in such an acoustic shadow zone, depending on whether the atmospheric boundary layer is either strongly or weakly scattering. In this work, a modelling framework is presented to account for the effect of such changing scattering contributions, showing that level variations might be as large as 20 dB in such zones. This work contributes to predicting more accurate long-term sound pressure level distributions e.g. near wind turbines.

Link to paper
Urban advanced noise indicator mapping relying on street categorization and measurements

Timothy Van Renterghem\textsuperscript{1}, Wout Van Hauwermeiren, Valentin Le Bescond, Luc Dekoninck, Dick Botteldooren\textsuperscript{2}

\textsuperscript{1}Ghent University, iGent, Technologiepark 126, 9052 Zwijnaarde, Belgium
\textsuperscript{2}Ghent University, iGent, Technologiepark 126, 9052 Zwijnaarde, Belgium

In order to more accurately estimate health outcomes related to environmental noise exposure such as sleep disturbance and noise annoyance, indicators beyond long-term equivalent sound pressure levels might be needed (such as statistical levels, number of events, psycho-acoustical indices etc). In urban noise mapping, predicting these more advanced noise indicators is especially challenging. In the current work, an open source noise mapping code (NoiseModelling) is combined with micro-traffic simulations. However, in most cities, traffic data availability is poor, especially in low traffic streets. To overcome this issue, the noise mapping procedure developed here assumes no access at all to traffic information and fully relies on Open Street Map street categorization. These street categorizations were then assigned sets of plausible traffic compositions, counts and speeds; various scenarios were explicitly simulated. In a next step, these traffic scenarios were weighted to best fit a set of 29 noise indicators on 23 measurement stations deployed in the city of Barcelona, during various periods of the day. It was shown that this procedure leads to adequate assessments of a wide range of noise indicators in a specific city.
Nonlinear dynamical features of vortex-acoustic lock-on in a backward-facing step combustor

Joel Vasanth¹, Satyanarayanan Chakravarthy²
²Indian Institute Of Technology Madras, Chennai, India

Unstable shear layers characteristic of step combustors display strong vortex shedding and play a dominant role in combustion instability. Past non-premixed flame experiments with Reynolds number (Re) as the bifurcation parameter showed that during instability, the frequency of acoustic oscillations locks-on to the natural vortex shedding mode for a range of Re. In the present work, we study the dynamical features of this type of lock-on. We employ a vortex model to bring out the nonlinearity in the flame response to vortical perturbations. This is coupled with a Galerkin model for the acoustic field. Regimes of aperiodic oscillations, low-amplitude lock-on and high-amplitude lock-on are predicted in agreement with experimental trends. Phase portraits show a transition to instability during lock-on via a supercritical Hopf bifurcation with an increase in limit cycle amplitudes. Synchronisation between the acoustic pressure and vortex-driven heat release perturbation is studied using recurrence analysis. The system transitions from asynchronous to phase synchronisation in the low-amplitude lock-on regime, characterised by an increasing degree of phase correlation. In the high-amplitude lock-on regime, a state of generalised synchronisation exists, where in addition to the phase, the amplitudes also show strong correlation.
Experimental and numerical investigation of the narrow-band impact sound insulation of layered floors

Jasper Vastiau¹, Cédric Van hoorickx¹, Edwin Reynders¹

¹Ku Leuven, Kasteelpark Arenberg 40, box 2448, B-3001 Leuven, Belgium

Measurement results of the impact sound insulation of (floating) floors are generally limited to one-third octave bands. As a consequence, detailed information on modal behavior and on the influence of the impact source, are largely lost due to band-integration. To this end, narrow-band measurements are performed on five different layered floors. Various tapping machine locations are considered and the results are averaged over several receiver positions for each tapping machine location in order to reduce the influence of the spatial distribution of the sound pressure in the receiver room. A new prediction model for impact sound transmission, termed the modal TMM, or mTMM, is used to interpret and investigate the measurement results. This prediction method includes a detailed source model and accounts for the finite dimensions of the layered floors. The measurement results of the layered floors clearly indicate the importance of considering all five impact hammer locations of the tapping machine to achieve a high prediction accuracy, especially at low frequencies. The influence of the impact source and the modal behavior of the floor can lead to high peaks in the radiated sound power level.

Link to paper
Effect of Face Masks on Speech Intelligibility

Ruben Vazquez Amos¹, James Green¹, Stephen Dance¹, Jerrin Thomas¹, Havni Gohil¹, Jacob Telford¹, Peter Mapp¹
¹London South Bank University, London, United Kingdom

With the advent of COVID, the wearing of face covering has been obligatory in both medical and everyday life. This paper describes three experiments undertaken to establish the effect of face coverings on speech sound power, speech directivity and speech intelligibility. The experiments used two different approaches acoustic measurements and word scores. The face coverings assessed were a ‘standard blue’ surgical mask, a typical fabric mask, and a plastic transparent visor. The results showed that non-native English speakers had by far the most difficulty in comprehending the English language speech when face coverings were worn in speech intelligibility tests, as measured using phonetically balanced word lists. All the masks were found to noticeably affect speech intelligibility, with the surgical mask having the least detrimental effect. The results are also compared to objective measurements of their physical acoustics characteristics to establish their performance.

[Link to paper]
Emission and propagation of sound waves in porous media with active inner heat sources

Rodolfo Venegas¹, Claude Boutin², Gabriel Núñez¹

¹University Austral of Chile, Institute of Acoustics, Valdivia, Chile, ²ENTPE - Université de Lyon, Vaulx-en-Velin 69518, France

Wave propagation through porous media with active inner heat sources is investigated in this paper. Through the use of the two-scale asymptotic method of homogenisation, it is found that a macroscopic non-homogeneous wave equation describes the emission and propagation of sound waves in such active porous media. The upscaled model is validated numerically for the cases of single and double porosity media, and shows that the general properties of the effective parameters of the porous media are not altered by the inner heat sources. Instead, the inner heat sources contribute to the non-homogeneous term in the upscaled wave equation. The paper also explores the potential of using active inner heat sources for controlling sound waves incident to the porous media in practical scenarios.

Link to paper
Optimizing noise exposure in the Vehicle Routing Problem: A case study of last-mile freight deliveries in Stockholm

Siddharth Venkataraman\textsuperscript{1,2}, Sacha Baclet\textsuperscript{1,2}, Romain Rumpler\textsuperscript{1,2}  
\textsuperscript{1}KTH Royal Institute Of Technology, Stockholm, Sweden, \textsuperscript{2}The Centre for ECO2 Vehicle Design, Stockholm, Sweden

Improvements in noise mapping techniques and smart cities infrastructure have fostered the development of new ways to evaluate traffic noise exposure. An example of one such outcome is the noise exposure sensitivity map, which quantifies the noise exposure potential of a road network as a function of the vehicle type, the prevailing background noise, and the population exposed. The potential for planning vehicle routing that is offered by the above-mentioned map calls for revisiting the Vehicle Routing Problem (VRP) with a focus on accounting for the noise exposure in the optimization process.

A case study is chosen for applying the VRP, and it is taken from last-mile off-peak deliveries performed in Stockholm, Sweden, in the context of the CIVITAS Eccentric project. The VRP is independently solved for the following objectives: distance travelled, driving time, and driving noise exposure potential. Also considered is a heterogeneous objective that is consisting of a combination of these factors.

The impact of the objective function on the resulting routes is presented. A sensitivity analysis is performed to determine the trade-offs between the chosen factors.
Acousto-optic sensing for near-field acoustic holography

Samuel A. Verburg¹, Efren Fernandez-Grance¹, Earl G. Williams²
¹Technical University Of Denmark (DTU), Lyngby, Denmark, ²United States Naval Research Laboratory, Washington, DC, USA

Near-field acoustic holography (NAH) is a very powerful and widely used technique for the study of complex acoustic radiators. NAH enables to quickly understand how a complex source radiates into the medium. The technique is particularly suitable at low frequencies. At high frequencies, a dense transducer interspacing is required, and the measurement microphones can disturb the studied sound field when their size is comparable to the acoustic wavelength. In this study we examine the use of acousto-optic sensing in NAH. Acousto-optic sensing uses light beams as the sensing element, making it possible to acquire remote and non-invasive measurements without introducing extraneous objects in the vicinity of the source. The pressure, particle velocity and intensity fields, as well as the sound power radiated by a complex source, are determined from measurements in the near-field with an optical interferometer. The presented results demonstrate the potential of optical sensing to non-intrusively characterize sound fields, particularly at high frequencies.

[Link to paper]
LOWNOISEPAD: Low-cost noise control by optimized rail pad: Feasibility study on the use of rail pad as noise mitigation measure

Eduard Verhelst¹, Pinar Yilmazer², Jakob Oertli³, Guenter Dinhobl⁴
¹SD&M, La Borderie, 87120 Damps, France, ²SBB, Bern, Switzerland, ³UIC, Paris, France, ⁴ÖBB, Austria

When aiming to minimize track noise, there is a significant conflict of aims that must be considered. Tracks with stiff rail pads are generally less noisy than ones with soft rail pads. Stiff rail pads, however, can decrease the long-term quality of the track. In order to achieve an optimum, beside stiffness also rail pad damping at relevant frequencies must be considered. The International Union of Railways (UIC) works with its members to better understand the noise-generation and rail pad effects. The LOWNOISEPAD project brings together the European railway community in an effort to find an optimal rail pad for both noise and track quality issues and for the different situations encountered in 12 European railway networks.

Besides acoustic rail roughness, the stiffness and damping properties of rail fastening systems such as rail pads have a considerable influence on rail noise. In practice, rail pad design is always a compromise between track engineers’ demand for flexibility and acoustic engineers’ expectations for sufficiently high Track Decay Rate.

The paper describes the measurements undertaken in the project, shows first conclusions as well as a software tool that allows determining noise levels after installing rail pads with given stiffness and damping properties.
Environmental noise and densification of cities – a paradox?

Ivonne Verstappen\textsuperscript{1}, Kjersti Espeland\textsuperscript{2}

\textsuperscript{1}Norconsult AS, Vestfjordgaten 4, 1338 Sandvika, Norway, \textsuperscript{2}Statens vegvesen, Nygårdsgaten 112, 5008 Bergen, Norway

Densification of cities is used because of numerous benefits and fits well with sustainable development. Densification can however lead to disadvantages, especially related to environmental noise.

In this paper, we ask: is it possible to restrict disadvantages by balancing out these with benefits? Access to quiet areas in cities plays an important part here, due to benefits related to well-being and health for inhabitants.

We will give an overview of Norwegian guidelines on environmental noise and how these are implemented. We look at the situation from the Norwegian Public Roads Administration’s viewpoint and include the experiences from a consultant company.

We present projects situated in Norway, a large country with a relatively low population density compared to most other European countries. However, access to quiet areas isn’t optimal in the largest cities, which leads to problems related to environmental noise and densification. Our experience is that it’s crucial to include noise assessment in the early stages of planning.

Together we need to find a balance, where new roads and new dwelling areas can be realised without more negative than positive aspects. The final goal must be, that there is no paradox!

[Link to paper]
Long-term exposure to transportation noise and diabetes mortality: a national cohort study

Danielle Vienneau¹,², Benedikt Wicki¹,², Benjamin Flückiger¹,², Beat Schäffer³, Jean-Marc Wunderli³, Martin Röösli¹,²

¹Swiss Tropical And Public Health Institute, Basel, Switzerland, ²University of Basel, Basel, Switzerland, ³Empa, Swiss Federal Laboratories for Materials Science and Technology, Dübendorf, Switzerland

Long-term exposure to transportation noise is related to cardio-metabolic diseases, including diabetes incidence. This study aimed to evaluate the association between transportation noise exposure and diabetes mortality. Over 4.1 million adults in the Swiss National Cohort were followed from 2001-2015. Accounting for residential history, source-specific noise calculations were performed for residential locations. Over 73000 deaths due to or with diabetes occurred during follow-up. Multipollutant, time-varying Cox regression with age as timescale was applied to evaluate the risk of mortality (hazard ratios, HR and 95% confidence intervals). Models included each noise source, and were incrementally adjusted for individual and area-level covariates and air pollution. HRs stratified by sex and age were also derived. HR in the adjusted model (including PM2.5) were 1.061 (1.051-1.071), 1.021 (1.015-1.030) and 1.004 (0.991-1.018) per 10 dB Lden road traffic, railway and aircraft noise, respectively. Substituting PM2.5 with NO2 did not change the associations. Risk of mortality was higher in males compared to females, and higher in younger compared to older adults. This study provides new evidence that diabetes mortality is associated with exposure to road traffic and railway noise. An updated meta-analysis including these results on mortality will also be presented.

Link to paper
Why noise control must be considered in the context of sustainable development

Monica Waaranperä
Chalmers University of Technology, Gothenburg, Sweden

The United Nations 2030 Agenda for sustainable development comprises 17 Sustainable Development Goals (SDGs) of interlinked social, environmental and economical dimensions. Since noise and noise control are not directly apparent in any of the goals, Eoin King from the NUI Galway, presented an article at the Internoise 2021 conference with the objective of sparking “a debate about how noise might be further considered in the context of sustainable development”. Inspired by King’s article, this paper presents examples from the planning of two new railroad lines in Sweden, where the Swedish Transport Administration has based the goals of the projects on the 2030 Agenda. Different SDGs have been applicable for different aspects of the projects. For traffic noise the SDG nr 3 - Good Health and Well-being, and nr 11 - Sustainable Cities and Communities, are considered the most relevant. The reasoning and the method to integrate the SDGs in the railroad projects are described and discussed in the paper. The author also emphasizes the importance of including noise in the SDGs for infrastructure projects, by expressing why noise control must be considered in the context of sustainable development, especially from the viewpoint of the 10th SDG – Reduced Inequality.

[Link to paper]
Habitats: Managing the Ecological Impacts of Noise on Wildlife Habitats for Sustainable Development

David Waddington¹, Mike Wood¹, Bill Davies¹, Rob Young¹

¹University Of Salford, Salford, MS 4WT, United Kingdom

The objective of the Habitats project is to integrate research in the fields of ecological impacts and of environmental noise to develop management tools and processes to enable sustainable development. Rapid population expansion and economic development against the backdrop of climate and biodiversity crises presents major global challenges. Global society is dependent on ecosystem services, underpinned by biodiversity. In the UK alone, these ecosystem services are valued at £761 billion/year and human noise impacts will significantly degrade that value unless managed appropriately. We can no longer consider nature to be separate from our economy and society, it needs to be part of business, cultural and economic decision making. The Habitats project is leading the development of an international industrial and academic network to research and explore new ways and new technologies to better measure, understand and model the effects of noise on wildlife habitats. However, current noise pollution legislation is focused on humans; despite policy aspirations, there is no systematic approach to assessing, regulating, or mitigating noise impacts on wildlife. This paper will review the scientific evidence available for underpinning environmental noise legislation, regulation, and policy development for managing the ecological impacts of noise on wildlife habitats.
Accelerometer Intensity Vector Sensor (AIVS) network for environmental noise monitoring with source location

Jim Waite

Nanotok LLC, Eastsound, United States

AIVS (Accelerometer-based Intensity Vector Sensors, /āvs/) represent a new way to measure 3-d sound and are designed to integrate into existing noise monitoring solutions. Standard microphones measure sound pressure, which cannot alone deduce the direction of sound propagation. AIVS is based on the measurement of the velocity of a small parcel of air surrounding a triaxial accelerometer, from which a vector-based representation of sound intensity is calculated. AIVS integrates a MEMS triaxial accelerometer with one MEMS microphone and synchronously measures particle velocity and pressure, resulting in a 3-d intensity vector at each AIVS node.

An AIVS network is synchronized to GNSS time and sensors are deployed in groups surrounding and/or within a local measurement site. Low power AIVS nodes are location-aware and estimate azimuth and elevation angles to detected noise sources as a function of frequency. Range to source is computed when noise events are observed from multiple nodes. AIVS nodes are managed by a Raspberry-Pi (RPI) sensor hub in a wired CAN-bus supporting distances up to 100 m, or via the Bluetooth Low Energy (BLE) protocol. More widely separated nodes are joined through WWLAN technologies via the local RPI hub.

[Link to paper]
A Prewhitening Technique for Adaptive Active Noise Control Applications using Polynomial Matrix Spectral Factorization

yiming wang¹, Yongjie Zhuang², Yangfan Liu²
¹Ancersonic, Beijing, China, ²Ray W. Herrick Laboratories, School of Mechanical Engineering, Purdue University, West Lafayette, United States

Least-mean-square (LMS) algorithm has been widely used in the area of active noise control (ANC). One practical concern of LMS-based algorithms is its slow convergence rate in multi-channel broadband noise control applications. To improve the convergence speed of traditional LMS algorithm, preconditioning filters were added to the LMS system in previous studies to remove the correlation between the reference signals and decouple the plant responses. However, the preconditioning filters implemented previously are usually obtained through singular value decomposition of the cross spectral matrix of reference signals and the plant response matrix, which does not lead to causal preconditioning filters and, thus, it can only be applied in spatial audio applications when delay is not an important concern, but cannot be implemented in real-time active noise control applications. In the current work, a method is proposed to obtain a casual multi-channel preconditioning filter for real-time active noise control applications through a numerically robust algorithm to perform a spectral factor decomposition to the reference signal cross spectral matrix and a minimum-phase and all-pass decomposition to the multi-channel secondary path. Simulation results show that, by applying the proposed preconditioning filter, the convergence speed of the LMS algorithm can be significantly improved.

Link to paper
A theoretical study on the interplay of thermoacoustic modes with Helmholtz dampers in a longitudinal combustor

Yichen Wang\textsuperscript{1}, Dong Yang\textsuperscript{2}, Min Zhu\textsuperscript{1}
\textsuperscript{1}Department of Energy and Power Engineering, Tsinghua University, Beijing, China, \textsuperscript{2}Department of Mechanics and Aerospace Engineering, Southern University of Science and Technology, Shenzhen, China

Thermoacoustic instabilities often present in gas turbine combustors, especially in land-based heavy-duty gas turbines. Normally, thermoacoustic modes can be classified into two sets: acoustic mode and intrinsic mode (ITA mode). Low order network models are usually used to study thermoacoustic instabilities and passive control methods such as liners and Helmholtz dampers are often used to suppress these instabilities. The addition of Helmholtz dampers could suppress the original thermoacoustic modes. Meanwhile, it could also introduce a new mode, the eigenfrequency of which is related to the parameters of the Helmholtz damper, including its resonant frequency and neck mean flow Mach number. The damping effects depend on the system parameters and could be different on the two categories of original thermoacoustic modes. Based on a rational design, both original modes can be controlled by one damper. The new mode introduced by the damper could interplay with original modes to form new exceptional points with certain parameters. In that case, the eigenfrequency and mode shape of original modes could be vastly influenced. The theoretical results will be verified by numerical simulations.

\textbf{Link to paper}
Tactics Implemented at the University of Nebraska – Lincoln for Growing Inclusive Excellence in Engineering

Lily Wang¹
²University of Nebraska - Lincoln, Omaha, United States

The percent of women and other underrepresented minorities who receive graduate degrees in engineering within the United States has been steadily increasing over the past 25 years, but it remains under 25%. Many colleges of engineering in the United States are implementing various methods to improve culture towards achieving greater inclusive excellence, helping to support women and underrepresented minorities among their undergraduate, graduate, and faculty populations. In this talk, assorted tactics that have been used at the University of Nebraska – Lincoln will be discussed, many of which could be incorporated into professional society activities. These include offering training on (a) recognizing implicit bias, (b) learning tactics to interrupt implicit bias, (c) growing the number of allies who actively support persons from underrepresented groups in our field, (d) writing diversity statements to include in job applications, and (e) mastering non-violent communication skills. Additionally regular demographic and climate surveys should be conducted to gauge the levels of diversity and inclusivity in our professional societies. Descriptions of the tactics and suggestions on how to deploy them in other organizations are provided.

Link to paper
Relationships between Acoustics, Thermal, Indoor Air Quality, and Lighting Conditions on Student Achievement in K-12 Classrooms

Lily Wang¹
¹University Of Nebraska - Lincoln, Omaha, United States

Data on acoustic, thermal, indoor air quality, and lighting conditions have been collected from 220 classrooms in the midwestern United States. Gathered acoustic data include sound levels logged every 10 seconds and room impulse responses from which reverberation times were extrapolated. K-means clustering was used to group the logged sound data into times when speech was or was not occurring; then acoustic metrics were calculated from the clustered data. When comparing the measured acoustic conditions to ANSI S12.60, 91% of the classrooms did not meet the recommended maximum background noise level for unoccupied conditions, while 15% did not meet the recommended maximum reverberation time. The field measurements also revealed that only 20% of the classrooms met ASHRAE Standard 62.1 ventilation rate requirements, while all classrooms met recommended IES illuminance level for reading and writing. Multivariate linear regression analyses between the environmental conditions and student achievement data, while controlling for student demographics, have identified a number of significant relationships. This presentation summarizes key results, describes how acoustic conditions were correlated to building mechanical systems, and considers how indoor environmental quality may be optimized to benefit occupants in educational settings. [Work supported by the United States Environmental Protection Agency Grant Number R835633.]
Experimental study of the Sound Absorption of Nylon Woven Fabric

Fang Wang¹, Zenong Cai¹, Xianhui Li¹, Xiaoling Gai¹, Tuo Xing¹
²Beijing Key Laboratory of Environment Noise and Vibration, Institute of Urban Safety and Environmental Science, Beijing Academy of Science and Technology, Xicheng District, China

Nylon is the world's earliest synthetic fiber, it has excellent performance and rich raw material resources, so that it has been used until now. The purpose of this research is to investigate the acoustics of thin fabric. Acoustically, it can be seen as a thin layer composed of porous fibrous materials. Therefore, its sound absorption performance is the combination of at least two kinds of sound absorption mechanisms. The main purpose of this paper is to study the relationship between sound absorption properties and structural parameters of thin fabric by means of experiment. The study concerning the transmission and attenuation of acoustic wave in thin fabrics is helpful for the design of thin fabric, and improving its applications in the field of noise control and indoor acoustics.
Monitoring of combustion oscillation by cascade extended state observer

Zhaohui Wang

Tsinghua University, Beijing, China

In modern gas turbines, active control has proved to be a useful tool in the suppression of combustion oscillation. As the basis of early warning and control, signal monitoring will directly affect the performance of the whole system. Traditionally, time series analysis and machine learning methods are often applied to monitor system information. However, there are some drawbacks, such as a large amount of calculation, limited accuracy and insufficient generality, which limit the engineering application. To solve these problems, this paper presents a monitoring method based on extended state observer (ESO), which utilizes the observed derivative information for online monitoring. Due to the difficulty in parameter tuning and sensitivity to noise, conventional high order ESO is modified to cascade low order ESO. Meanwhile, a compensation scheme based on Taylor expansion is proposed to tackle the phase delay caused by the cascade group. Combined with known system information, the structure of ESO can be further updated, which improves monitoring accuracy. Simulation results show that the proposed method can achieve computation simplicity, high monitoring accuracy, and has great robustness and noise immunity.

Link to paper
The use of a parametric array source and nearfield scanning in the characterisation of panel materials for underwater acoustics

Lian Wang, Lian Wang, Victor Humphrey

1 NPL, Teddington, United Kingdom

The properties of the materials used in underwater acoustics are important for applications such as acoustic windows, reflectors and baffles, acoustic barriers or screens, decoupling materials, and anechoic coatings. To characterise the performance of such materials at frequencies above 1 kHz, measurements are typically undertaken on samples of the material in the form of finite sized panels. Such measurements suffer from uncertainty due to the finite size of the panel (leading to contaminating signals from edge diffraction), and the difficulty in simulating the ideal plane-wave insonification. This paper describes work at the UK National Physical Laboratory to minimise these effects by use of: (i) a parametric array as a sound source that provides a directional beam and short broadband pulses; and (ii) nearfield scanning using a hydrophone to sample the complex sound pressure field interacting with the test sample, decomposing the sound field into its plane-wave components. Results are presented of these techniques applied to measurements in laboratory test tanks at frequencies between a few kilohertz and a few hundred kilohertz to determine the reflection and transmission performance of a range of test samples, including panels consisting of homogeneous polymers and materials with regular periodic structure.
Numerical analysis of acoustic noise from an electronic cooling fan at flow disturbed by an external obstacle

Sahan Wasala¹, Lon Stevens², Raye Sosseh³, Tim Persoons¹

¹Trinity College Dublin, Dublin 2, Ireland, ²Seagate Technology, Longmont, USA, ³Seagate Technology, Minneapolis, USA

Axial cooling fans are widely used in data center dense Hard Disk Drive (HDD) storage systems. However, these fans emit high noise levels and degrade HDD performance at certain frequencies. Flow at the fan's inlet can be highly turbulent due to the wake generated by fan components such as struts, finger guards, stators/guide vanes, shrouds, and other external system components such as connectors and mounts, power cables and components, circuits etc. The wake-fan interaction also causes high tonal noise. Therefore a proper understanding of this noise mechanism will help optimize the cooling system in next-generation high-performance HDD enclosure systems.

This paper focuses on studying this phenomenon using numerical simulations of a typical data center cooling fan combined with various simplified strut geometries as the obstacle. The high-fidelity Computational Fluid Dynamic (CFD) method, Large Eddy Simulation (LES), was used to obtain a transient flow field. The Ffowcs-Williams and Hawkings acoustic analogy was used to predict far-field noise.
A Method for Separating Knocking Sounds from Engine Radiation Noise by Deep Learning

Hikaru Watabe¹, Taro Kasahara¹
¹Ono Sokki Co., Ltd., 3-9-3 Shin-yokohama, Kohoku-ku, Yokohama, 222-8507, Japan

Knocking is the abnormal combustion of a gasoline engine, it generates a metallic noise. Engine knocking can damage the engine, so workers detect knocking by listening to the sound. There is a need to develop a way to automate this kind of work.
We developed the deep learning model which separates Knocking sound from engine radiation noise measured by a microphone.
This model obtains the time-frequency mask from the paired data of engine emissions and cylinder pressure. The time-frequency mask enables the separation of knocking sound from engine radiation noise. By training various rotation speeds, the proposed model can separate the knocking sound without training target engine speed.

[Link to paper]
Performance and acceptability of the TfL Urban Bus Sound (AVAS)

Eduardo Manzano¹, Grant Waters¹, Thomasin Stuart¹
¹Anderson Acoustics, London, United Kingdom

Transport for London's quiet-running bus fleet is required to include an Acoustic Vehicle Alerting System (AVAS) compliant with UNECE Regulation 138 and as part of a wider series of safety measures as set out in their Bus Safety Standard towards the London Mayor's 'Vision Zero' objectives. As a public body, TfL must ensure that the Urban Bus Sound AVAS implementation is fit-for-purpose from a safety standpoint, is considerate of driver working conditions and is consistently implemented across a number of vehicle types, manufacturers and fleet operators. Additionally, as quiet-running vehicles increase across the London bus network, it must consider the impact on the urban soundscape. Over the course of two years, Phase 2 of the project addressed practical implementation and quality assurance challenges, bringing together soundscape and acoustic testing, on-street public and key stakeholder surveys, workshops with multiple vehicle manufacturers and operators as well as engagement with bus drivers. The project concludes by providing an optimised AVAS solution with specification and vehicle checks documentation to ensure successful roll-out. The project provides an important view on considerations for how AVAS can be implemented on public transport vehicle fleets, to consider and work with a wide range of public and stakeholder requirements.

Link to paper
Acoustic measures of biodiversity and human disturbance – a study in the UK Yorkshire Dales National Park

Greg Watts

Centre for Sustainable Environments, University of Bradford, Bradford, United Kingdom

The Ingleborough Soundscape Project’s study involved long-term monitoring of sonic environment of an ancient woodland and newly rewilded moorland site in order to contrast biodiversity and human disturbance.

Both sites are located in the Ribble Valley located 6 km north of the village of Horton in Ribblesdale. They lie in the NW area of the Yorkshire Dales national park in the UK. The sites are affected by both road and rail noise and by overflights. The ancient woodland (Colt Park Wood (CPW) lies 380m from the nearest road and South House Moor (SHM) is located over three times that distance (1220m).

The primary aim was to propose a simple, low-cost acoustical metric by which non-experts can measure the success of contrasting wildness interventions. This metric, which uses raw acoustic and ground-truthed data obtained from CPW and SHM, is an updated version of 'Acoustically Enhanced Ecological Richness' (AEER), as initially proposed by Agius. Additionally, human impact was gauged by predicting noise exposure and converting to tranquillity levels using Tranquillity Rating Prediction Tool (TRAPT) and plotting contours across the study sites.
Usage of the 2.5D Boundary Element Method for the Detection of Moving Noise Sources

Holger Waubke¹
²Acoustics Research Institute, Austrian Academy of Sciences, Wohllebengasse 12-14, 1040 Vienna, Austria

The boundary element method in 2.5D allows for the usage of moving sources by a modification in the wave number frequency domain. The 2.5D boundary element method uses a Fourier transformation about time and the axis of movement of the object. The boundary element method is applied to the cross section. To use the method it has to be assumed that the cross section is constant along the direction of movement. An advantage of the method is that reflections in the sound path caused by the ground are taken into account. The inverse form of the method is used for the detection of noise sources on railway trains. Recordings made with a 64-channel microphone array at the high-speed railway line near Vienna will be investigated by this method. A big disadvantage is the fact that only eight positions along the track and eight positions in the cross section were measured. This leads to the fact that the wave number can only be estimated in a rough manner and that the IBEM has much more unknowns than measured positions exist. The second point needs for a regularization. An advantage of the method is that the vibration at the surface is determined.
Scaling of the simulated pass-by measurement based on the vehicle's acoustic centre

Yannik Weber¹, Albert Albers¹

¹Institute of Product Engineering at the Karlsruhe Institute of Technology, Karlsruhe, Deutschland

Preliminary work by the IPEK - Institute of Product Engineering at KIT has shown that the simulated pass-by measurement for exterior noise homologation of vehicles has relevant optimization potential: the measurement can be carried out in smaller halls and with a smaller measurement setup than required by the standard and thus with less building construction cost and measurement effort. A prerequisite for this, however, is the scaling of the entire setup. For the scaling to work correctly, the sound sources of the vehicle must be combined to a single point sound source - the acoustic centre. Therefore, in a preliminary work, the IPEK developed a method, with the help of which the dominant sound sources of a vehicle can be localized and combined to an acoustic centre.

In this work, the method is applied exemplarily on two test vehicles and their acoustic centres are determined. Afterwards, the measurement setups for both vehicles are scaled based on the acoustic centres. Finally, the simulated pass-by measurement with the scaled measurement setup is performed on an acoustic roller test bench and the scaled sound pressure levels are determined. To verify the overall method, the results of the scaled pass-by measurements are compared with the unscaled one and with measurements on the test track.

Link to paper
Optimization of a thermoacoustic system with adjoint-based sensitivity analysis

Jiasen Wei¹, Jan Oscar Pralits¹, Alessandro Bottaro¹
¹University of Genoa, Department Of Civil, Chemical And Environmental Engineering (DICCA), Via Montallegro, 1, 16145 Genoa, Italy

Clean combustion such as hydrogen combustion for the reduction of NOx emission is prone to thermoacoustic instabilities, which may cause structural vibrations and equipment failures. In the present work, an adjoint-based sensitivity analysis is applied to a low-order thermoacoustic model with a non-zero mean flow. The adjoint-based analysis can be a powerful tool to yield information for optimization techniques to eliminate or control such instabilities. With quick and low-cost calculations, structural sensitivity and base-state sensitivity are achieved and the conditions most sensitive to instabilities are identified.

Link to paper
MEMs Based Low-Cost Urban Noise Monitoring: Tests and Case Study

Paola Weitbrecht¹, Carolina Monteiro¹, Leonardo Jacomussi¹, Marcel Borin¹, Cecilia Jardim¹

¹Harmonia, Avenida Mofarej 1200, Brazil

Noise pollution has been one of the main causes of citizens' discomfort in the urban centres in Brazil, an issue enhanced by the Covid pandemic that resulted in an increase of noise complaints, especially those related to noise from construction sites. This context triggered the construction industry to pursue solutions to understand the acoustic reality and minimise the impacts through regulations that require long-term noise measurements. Due to the necessity of a comprehensive evaluation in several locations, class 1 Sound Level Meters measurement systems can hardly be considered because of their high costs. This paper discusses the practical implementation of MEMs in a low-cost monitoring system for urban noise, focusing on construction sites. The prototype, based on a Raspberry Pi (a single-board computer model widely used in IoT projects) and a MEMs microphone with I²S interface for high-fidelity digital audio communication, was compared in a controlled environment to a Sound Level Meter of Class 1 through validation tests, such as calibration, frequency response, and dynamic range. Field measurements were also carried out in typical urban noise-generating sound environments.

Link to paper
Low Frequency Noise – An inventory of literature and of the situation in the Netherlands

Kim White¹, Anja Versteeg¹, Arnaud Kok¹, Ric van Poll¹, Annelike Dusseldorp¹
²RIVM, Antonie van Leeuwenhoeklaan 9, 3721 MA, Bilthoven, Netherlands

Low Frequency Noise (LFN) is an environmental stressor causing annoyance and, potentially, sleep disturbance. It is a topic of increasing social concern. In the Netherlands, an increasing number of complaints about LFN in the home environment is filed each year. A consortium of four ministeries has asked the RIVM to prepare an overview on LFN, including literature, an update on the Dutch situation and advise on how to move forward in the field of LFN. To gain insight in the way that LFN complaints are handled in the Netherlands, a questionnaire was filled in by officials of municipalities and other public authorities, and by audiologists This paper will contain an overview of LFN literature, findings of our questionnaire study and recommendations for future research on LFN.
New Zealand is actively improving school acoustics with government-led initiatives

James Whitlock\(^1\)
\(^2\)Marshall Day Acoustics, Auckland, New Zealand

New Zealand’s Ministry of Education is taking active steps to ensure that the country’s 35,000+ classrooms are fit for purpose. Acoustics is a primary factor in central government's School Property Strategy 2030, which has informed three major initiatives to establish and implement sensible acoustic regulations. All three initiatives are underway.

First is the Designing Quality Learning Spaces (DQLS) – Acoustics document, launched in December 2020. It sets out mandatory requirements for reverberation time (RT), background noise and sound insulation in new and refurbished learning spaces.

Second is the Ngā Iti Kahurangi ‘small and remote schools’ programme. We are measuring RTs in 630 schools, assessing compliance with DQLS and adding absorption where necessary. The plan is to scale this programme up to include many more schools across the country.

Third is the Internal Environmental Monitoring (IEM) programme. Sound levels (and other environmental factors like temperature, humidity and CO\(_2\)) are continuously measured in a range of schools, and reviewed to inform improvements.

These initiatives aim to provide quality learning environments for New Zealand children, and this paper sets out how they have been designed and implemented. Similar initiatives could be adopted by other countries to improve acoustic quality in their classrooms.

[Link to paper]
A novel method for measuring the airborne sound insulation of partitions

Gabriel Whittle¹, Daniel Wong-McSweeney, Joshua Meggitt, Andrew Elliott

¹University of Salford, Salford, United Kingdom

BS EN ISO 10140-2 outlines a method for estimating the airborne sound insulation of a partition using adjacent rooms. In this paper, a new method is presented by which the airborne sound insulation is obtained without the need for a transmission suite. Using a stand-alone partition, a representative blocked pressure field is applied numerically to a measured frequency response function matrix characterising the partition. The incident and transmitted powers are determined from the blocked pressure and velocity field on the source and receiver sides, respectively. Results of several partitions measured using the proposed methodology will be compared against estimates obtained according to BS EN ISO 10140-2.

[Link to paper]
Parameter identification of two coupled oscillator model for pure intrinsic thermoacoustic instability

Roeland Wildemans$^1$, Viktor Kornilov$^1$, Philip de Goey$^1$, Ines Lopez-Arteaga$^{1,2}$

$^1$Eindhoven University Of Technology, Eindhoven, Netherlands, $^2$KTH Royal Institute of Technology, Stockholm, Sweden

Thermo-acoustic instabilities are a well-known problem in combustions systems. In general, the type of these modes can be divided in two categories: (i) modes with an acoustic origin and (ii) modes with an intrinsic thermo-acoustic (ITA) origin. It is an challenging task to observe the ITA modes experimentally. Therefore, a setup with a burner in an acoustic embedding with close to anechoic up- and downstream terminations is required. In previous research we introduced such a setup and conducted an experimental bifurcation analysis on the dominant pure ITA mode. In this bifurcation analysis, we observed that for increasing upstream velocity the flames loose stability through a supercritical Hopf bifurcation and subsequently exhibit limit cycle, quasi-periodic and period-2 limit cycle oscillations. The quasi-periodic oscillations were characterized by low frequency amplitude and frequency modulation. In this research we present a phenomenological model consisting of two coupled oscillators that is able to reproduce all the different experimentally observed regimes. This model consists of a nonlinear Van der Pol oscillator and a linear mass-spring-damper oscillator, which are nonlinearly coupled to each other. Furthermore, we executed a parameter identification of the model and concluded that the model is able to describe the experimental data quantitatively well.
High-resolution vibro-acoustic measurement and analysis of the DLR ISTAR aircraft to assess engine-induced cabin noise

René Winter\textsuperscript{1}
\textsuperscript{2}\textit{DLR - German Aerospace Center, Göttingen, Germany}

Aircraft engines, especially when mounted directly to the fuselage, inject a considerable amount of tonal vibrations into the airframe causing audible and comfort reducing cabin noise. Reducing this noise requires the development of specialised noise reduction systems. This is a time consuming and expensive endeavour. To speed up and ease this process a sufficiently detailed numerical model of the aircraft structure and the force injected by the engines is required. The DLR ISTAR, a Dassault Falcon 2000, was used for an extensive vibration measurement campaign. The goal of this campaign was twofold: Getting spatially dense information about the aircrafts vibro-acoustic behaviour to later update a finite element model for calculations in the mid-frequency range and to analyse the vibration injected by running engines into the fuselage structure. The measurements include the vibrational response to both shaker excitation and engine vibration of the DLR ISTAR at about 1400 positions acquired by a rowing grid of sensors. The results are presented in the form of operational deflection shapes and energy transfer paths calculated using structural intensity analysis.
First ideas for a revision of ISO 9614

Volker Wittstock\textsuperscript{1}, Spyros Brezas, Fabian Heisterkamp

\textsuperscript{1}Physikalisch-technische Bundesanstalt, Braunschweig, Germany

ISO 9614 describes the determination of sound power levels by the two microphone intensity technique. Despite some physical advantages the method is relatively seldom used. To improve this situation, theoretical and experimental investigations were performed, which focused mainly on the adequacy of the currently standardized indicators and criteria. This paper summarizes these results and develops first ideas for a revision of ISO 9614. One main proposal is to perform measurements generally in the one-third octave bands between 50 Hz and 10 kHz with a 12 mm spacer and to apply appropriate corrections in the highest three one-third octave bands. Furthermore, it is proposed to require additional measurements with a larger spacer at lower frequencies, if the dynamic capability of the instrument is insufficient. The A-weighted sound power level is calculated from the one-third octave band levels, which may have different grades of accuracy. Calculating different A-weighted sound power levels from different sets of frequency bands fulfilling criteria for different grades of accuracy then allows for designating a grade of accuracy to the A-weighted sound power level. This is considered to be a major improvement since the A-weighted sound power level is the main descriptor for the sound emission of sources.
Deployment of an IoT System for Adaptive In-Situ Soundscape Augmentation

Trevor Wong¹, Karn N. Watcharasupat¹, Bhan Lam¹, Kenneth Ooi¹, Zhen Ting Ong¹, Furi Andi Karnapi¹, Woon Seng Gan¹, Samuel Yeong², Irene Lee²

¹School of Electrical and Electronic Engineering, Nanyang Technological University, Singapore, Singapore, ²Building & Research Institute, Housing & Development Board, Singapore, Singapore

Soundscape augmentation is an emerging approach for noise mitigation by introducing additional sounds known as “maskers” to increase indices like acoustic comfort. Traditionally, the choice of maskers is often predicated on expert guidance or post-hoc analysis which can be time-consuming and sometimes arbitrary. Moreover, this often results in a static set of maskers that are inflexible to the dynamic nature of real-world acoustic environments. Overcoming the inflexibility of traditional soundscape augmentation is two-fold. First, given a snapshot of a soundscape, the system must be able to select an optimal masker without human supervision. Second, the system must also be able to react to changes in the acoustic environment with near real-time latency. In this work, we harness the combined prowess of cloud computing and internet-of-things (IoT) to allow in-situ listening and playback using microcontrollers while delegating the computationally expensive inference tasks to the cloud. In particular, a serverless cloud architecture was used for inference, ensuring near real-time latency and scalability without the need to provision computing resources. A working prototype of the system is currently being deployed in a public area experiencing high traffic noise, as well as undergoing public evaluation for future improvements.

[Link to paper]
A new voice for noise so it can be better understood.

Sebastian Wschiansky¹
¹FOEN (Swiss Federal Office for the Environment), Worblentalstr 68, 3063 Ittigen, Switzerland

The purpose of the European Outdoor Noise Directive (OND) 2000/14/EC is to provide to the buyer of a machine relevant noise information so an informed buying decision favoring low noise machinery will be made. This in return should incentivize manufacturers over time to produce quieter machinery. However, the results of this strategy have yet to meet the expectations. Multiple issues have been recognized and investigated over the last years. As a result two guides were published, one for manufacturers to provide correct noise information and one for buyers in their purchases. Efforts are made to resolve issues with measurement standards. The actual noise label applied on OND-machines is also one of the identified issues at time of purchase. And for market surveillance it provides no real help. So what could be done to improve the situation? What key parts in the process involving different stakeholders and procedures should be addressed? This paper proposes a technical solution to provide understandable noise information to buyers in an effective way by leveraging mobile communication technology and by taking in account insights about human buying behavior. The solution could also help making market surveillance more effective.

[Link to paper]
Study on regional road network planning based on time and noise integrated resistance function

Zhipeng Wu¹

¹Guangdong University of Technology, Guangzhou, China

To rationally reduce traffic noise emission from road network from the perspective of planning, a regional traffic flow distribution method combining time and noise integrated resistance function is proposed, and the method is applied in a typical region to verify its reasonability and practicability. Firstly, according to Greenshields model, the relationship among three traffic parameters (velocity, density and flow) is described, and combined with a line-source emission model of traffic noise, a univariate noise prediction model based on flow is established. Then, with the establishing of the traffic noise resistance function, an integrated resistance model considering traffic noise impact and travel time impact is proposed, which is used for traffic flow distribution while in the road network planning process. Finally, the network planning is realized utilizing the proposed method considering traffic noise. A network planning case in a typical region shows that the method can effectively reduce the noise emission of the regional network, which has practical value in traffic environment control.

Link to paper
Model test analysis of control effect of building foundation elastic pad on subway environmental vibration

Yubin Wu¹, Ruixiang Song¹, Yanan Wu¹, Lei He¹, Bideng Liu¹, Qiong Wu¹, Dan Wu¹, Jing Zhang¹

¹Institute Of Urban Safety And Environmental Science, Beijing Academy Of Science And Technology, Beijing, China

Building foundation elastic pad is one of the important measures for subway vibration control. In order to understand the subway vibration control effect of elastic pad on superstructure, two identical concrete test blocks were poured on site near a subway line. Taking the real subway vibration load as the input source strength, the vibration isolation effect of elastic pad on upper concrete mass block was compared and analyzed; At the same time, the influence of the backfill around the underground foundation of the building on the vibration isolation effect is simulated and analyzed. The backfill has a non negligible restraint effect on the building, improves the vertical natural frequency of the "building elastic pad" system, and then reduces the vibration isolation effect of the elastic pad. Therefore, it is very necessary to lay the elastic pad on the side wall around the building to reduce the lateral restraint effect of the backfill.

Link to paper
Long-term evolution of noise annoyance depends on the type of transportation noise - what are the main drivers for the observed trends and their differences?

Jean Marc Wunderli¹, Mark Brink
¹Empa, Dübendorf, Switzerland

Transportation noise annoyance has been investigated in a widely standardized way over the last decades, which allows studying the evolution of exposure-response relationships over time. A comparison reveals an increase of high annoyance in recent studies for railway and especially aircraft noise, compared to rather stable relationships for road traffic noise. Yet the reasons for these disparate developments remain only little explored, particularly for railway noise. In this contribution, potential explanations for the observed divergences are discussed, namely changing values and expectations in society, changing semantics of words used in survey instruments, changes in the attitude towards the different types of traffic, and changes in exposure strength and characteristics. On that basis, considerations are made about the suitability of noise annoyance as a noise effect informing noise limits.

[Link to paper]
Design and validation of microperforated panel absorbers using Occam’s razor and causal inference

Ning Xiang¹, Cameron, J. Fackler¹, Michael Hoeft¹
²Rensselaer Polytechnic Institute, 110 8th Street, Troy, New York 12180, United States

Microperforated panel absorbers in forms of micro-poles /-slits (MPP/MSP) can achieve high absorption. However, noise control practice usually requires broadband high absorption. Single- or double-layer MSP/MPP absorbers often cannot meet practical requirements. Multilayers become a natural option. Multiple layers of MSP/MPP absorbers inherently complicates the design process upon a given design scheme. This work applies a Bayesian framework using a potentially multilayered prediction model. The Bayesian design involves two-levels of probabilistic inference to design a parsimonious number of layers using the model-selection solution, a quantitative implementation of Occam’s razor, while the parameter estimation is used to estimate MPP/MSP parameters given the selected number of multilayers. This probabilistic design process rapidly hones in on the MPP/MSP parameters of each individual layer so that the overall composite meets the design goal. When experimentally validating the designed prediction upon the design scheme, manufacture inaccuracies may lead to deviations. In analyzing reasons of the deviations, this work further applies causal inference to analyze the cause-effect relationship. To this end a causal model has also been established. Using both parametric prediction model for the absorption performance and the causal model for causal inference of the deviation causes, the Bayesian multilayer design can be satisfactorily validated.

Link to paper
An experimental study of the spanwise coherence generated by porous coated cylinders in uniform flow

Zilun Xiang¹, Elias Arcondoulis¹, Reza Maryami¹, Yu Liu¹
²Department of Mechanics and Aerospace Engineering, Southern University of Science and Technology, Shenzhen,, People’s Republic of China

A porous coated cylinder (PCC) generates weaker vortex shedding noise than a smooth cylinder placed in uniform flow. A key understanding of how the porous media relates to vortex shedding reduction is linked to the spanwise coherence length of the PCC at the near-wall region. To date, few studies estimate the PCC spanwise coherence to be five-to-six outer diameters in length, yet a more comprehensive study is needed. This paper presents an experimental investigation conducted in an anechoic wind tunnel using a set of polyurethane PCCs tested with varying porosity, thickness and at several Reynolds numbers. Spanwise coherence is estimated at various circumferential angles using (1) flush-mounted microphones distributed along the bare cylinder span, beneath the porous layer, to record surface pressure fluctuations, and (2) two hot-wire anemometry probes in the near-wall flow field, where one probe remains in place and the other is shifted along the span. A transfer function of the porous layer is estimated based on the surface pressure and velocity fluctuations. The results presented here give some new visions of the spatial structure of vortex shedding caused by porous materials, noise generating mechanisms and a fitting formula of spanwise coherence length of PCCs.

Link to paper
Sound environment of bedrooms in typical long-term care facilities in China

Mingxuan Xie¹, Zhixiao Deng¹

¹Kunming University Of Science And Technology, Kunming, China

Evidence shows that older individuals would be more sensitive to noise, whereas sound environment of healthcare facilities for seniors in China is largely ignored. In this study, acoustic measurements were carried out over 24 hours in twelve bedrooms in five typical long-term care facilities, including two nursing homes and three adult homes in Kunming, China. Sound perception and preference of elder and nursing staff were also investigated through questionnaire surveys. The results showed that the noise levels of the measured bedrooms reached 47.4~59.3 dBA during the daytime and 39.1~49.3 dBA during the nighttime. The nursing homes were measured higher noise levels than the adult homes due to nursing care activities. Meanwhile, results showed a more significant gap between the bedrooms facing the streets and those not facing the streets. In terms of subjective evaluation, 'traffic noise' was the most common and unwanted noise source considered by both recipients and staff. Recipients from nursing homes indicated that noise has more significant impact on their 'sleep,' 'health' and 'relaxation' than those from adult homes. The indoor soundscape could be improved by introducing some natural sounds such as 'stream,' 'birds,' 'wind' and 'rain' which were considered as the wanted sounds by most participants.

Link to paper
Acoustical design of large stadium buildings

Wei Xiong

South China University of Technology, Guangzhou, China

Taking the architectural acoustic design of a stadium and gymnasium in a sports center as an example, the acoustic parameters of large stadiums under different working conditions were explored. In order to improve the reliability of acoustic design of large stadiums, the acoustical environment of stadiums is simulated and matched with the design standard value by using the sound absorbing materials arranged in limited positions.

Link to paper
FDTD-Based Simulation and Analysis of Noise Reduction Effects in Hospital Wards

Yiquan Xu¹, Yiquan Xu¹

¹School of Architecture, Southeast University China, Nanjing, 中国

The impact of domestic hospital acoustic environment on the health of patients and healthcare workers is attracting more and more attention. This paper investigated and analyzed the noise situation of typical double wards in hospital, and designed noise reduction schemes according to its noise sources; based on finite difference time domain method (FDTD), sound fields in wards were simulated before and after noise reduction treatments, and noise reduction results were compared and analyzed. Results show that FDTD can be used to effectively model sound field of wards with complex boundary conditions; meanwhile, the noise mitigation processes have significant effects on improvement of reverberation time and speech intelligibility in wards.

Link to paper
Analysis of Spatial and Temporal Variation of Noise Level at Intersections of a Mid-Sized City in India

Adarsh Yadav¹, Manoranjan Parida², Brind Kumar³

¹Indian Institute of Technology Roorkee, India, ²Indian Institute of Technology Roorkee, India, ³Indian Institute of Technology (BHU), Varanasi, India

This study aims to determine spatial and temporal noise variation and acoustical climate at intersections. Data monitoring comprises measurement of peak and off-peak hour variations at 19 intersections between February 2020 to September 2021 in Kanpur, India. Kanpur was proposed as a smart city in 2015 under National Smart Cities Mission. This work has been part of a National Level Project “IMPRINT” to document ambient noise levels for a Tier 2 city with highly heterogeneous traffic. Noise variations are primarily influenced by traffic flow, geometric characteristics, classified volume, and honking events. Frequent stoppage of vehicles for boarding and alighting of passengers also significantly affect noise levels. The results suggest that spatial variation of noise is larger (more than 15 dBA) than temporal variation (less than 5 dBA). Noise risk zones are identified based on noise level alongside intersections. Zones are classified as safe, tolerable, low risk, moderate risk, high risk, and extremely high risk zones. Noise level crosses tolerable limit at most study locations, and some locations fall in high-risk zones. The study has highlighted influence of different parameters on spatial and temporal noise variation at intersections and remedial action plans for traffic noise abatement.

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Masking effect of sounds during treatment on dental drill sound

Tomomi Yamada¹, Kazunori Nozaki², Sonoko Kuwano¹, Mikako Hayashi¹
¹Osaka University, Osaka, Japan, ²Osaka University Dental Hospital, Osaka, Japan

A dental drill has influence on acoustic environment in a dental clinic. Sounds of dental drills are temporary varying and have several prominent frequency components in a wide frequency range. Many patients experienced unpleasant feeling with the sound of a dental drill. In Japan, the use of dental aerosol suction devices, of which loudness level are high, during dental treatment has increased dramatically compared with their use before the COVID-19 pandemic. In this study, the sounds emitted by dental drills and sound related to dental aerosol suction devices were prepared and psychoacoustic evaluation of the stimuli combined the both noise was conducted. The results may help to improve the discomfort feeling in the dental sound environment.

Link to paper
Viewing the changes in community annoyance due to aircraft noise over the times

Ichiro Yamada¹
²RION CO. Ltd., Tokyo, Japan

More than 60 years have passed since the introduction of jet aircraft to civil aviation, and technological innovations have made aircraft much quieter. Nevertheless, people still complain that they experience serious suffering from aircraft noise. This paper overviews and considers the changes over the times both in the aircraft sound exposure level and in the community annoyance caused by aircraft noise. It will also discuss the issue of recent noise complaints associated with the introduction of performance-based flight navigation as well as view the impact of pandemics over the past two years.
Appropriate usage of multi-layered OTPA to identify intensive measuring part among sequential parts

Ryusei Yanagita, Junji Yoshida

*Osaka Institute of Technology, Scheme-16-1 Omiya, Asahi Ward, Japan*

Conducting effective countermeasure to the vehicle interior noise is important for compatible with the other vehicle performances such as light weight. Operational transfer path analysis (OTPA) was proposed to identify high contributing parts (OTPA reference model) and vibration behaviors (OTPA principal component model) to the interior noise with small man-hours. By using this method, we can determine which parts should be measured intensively. In case we apply the method to a vehicle body panel, the method tells us suitable measuring part of the body panel at the target frequency band. However, if the body panel is excited by a forced vibration from the suspension, we had better to apply countermeasure to the suspension. Then in this study, we applied the OTPA several times to identify which sequential parts from frame, body to interior noise makes the large noise using a simple plate model. In the analysis, both OTPA models (reference model and principal component model) were applied at various part and considered appropriate procedure of OTPA to obtain useful information for finding out the modification target part accurately. Through the verification test, the effectiveness of the proposed procedure was confirmed.
A prediction model of speech transmission index based on reverberation time in non-native linguistic context

Da Yang, Qi Meng, Fangfang Liu, Yue Wu

Harbin Institute Of Technology, 66 No. 66 West Dazhi Street, Nan Gang District, Harbin, China, China

High speech intelligibility is an essential requirement for classrooms, especially in relation to non-native students. Speech transmission index (STI) was proved as the most relevant acoustic parameter to assess speech intelligibility. In this paper, twenty-seven classrooms for non-native teaching purposes were selected for investigation. Physical acoustic measurements were conducted in these classrooms and numerical simulation verification was determined by ODEON version 16. The relationships between STI values and RT values were fitted based on non-linear curve fitting regression models. In this paper, three primary forms of non-linear curve fitting regression models were employed for predicting curves. A logarithmic function was selected as the basic regression equation to describe the effects of RT values on STI values. The results showed that STI values increase with the decrease of RT values for all age groups. From the verified results, it was possible to propose the predictive equation that presents the best accuracy in predicting the experimental data for non-native teaching purposes. The impact of different age groups and linguistic environment on STI were discussed. The prediction model is expected to estimate STI values by using RT values during the early design stage in a non-native linguistic context.
Study on the optimal strategy of Campus Concert Hall—Take the Concert Hall of Sun Yat-sen University as an example

Chenxi Yang

South China university of tecnology, Fuzhou, China

With the increasing functional demand of universities, the construction of campus concert halls is become more common. In addition to being a venue for bands to perform, university concert halls are often used as conference halls, in particular. They not only require good music sound effects, but also have certain requirements for speech intelligibility. Using the ODEON software to simulate the design plan of the concert hall of the Zhuhai campus of Sun Yat-Sen University, it is found that the acoustic parameters in the balcony area are unsatisfactory such as uneven sound pressure level, low bass ratio and so on. In response to the shortcomings, the body shape was changed by adjusting the ceiling and adding floating cloud reflectors, so as to vary the distribution of sound field. This strategy can make the above-mentioned acoustic parameter values more evenly distributed in the concert hall and keep the speech intelligibility in the auditorium at a medium level. The above design methods can effectively guide the sound quality design of university concert halls.

[Link to paper]
A Study on the Noise Optimization through the Analysis of Electric Vehicle Noise Paths

Yoon-Sang Yang¹, Seung Lee¹
²Daehan Solution Co., Ltd., Namdong-gu, South Korea

Since an internal combustion engine is not required for electric vehicle, the electric vehicle's noise is much lower than that of conventional internal combustion engine based vehicle. However, a road noise and wind noise that used to be masked by engine noise became the critical noise factors. Moreover, the electric vehicle generates a specific current conversion noise and motor high frequency noise that provides an unpleasant sound environment for drivers and passengers. In this study, therefore, the noise path of the electric vehicle was identified through Power Based Noise Reduction (PBNR) and Acoustic Transfer Function (ATF) tests. As a result of analyzing the noise path, it was confirmed that the rear side of vehicle was weak in terms of noise. As a countermeasure against this, it was confirmed that interior noise level could be improved by reinforcing the luggage side.

Link to paper
Influence of Structural Form on the Acoustic Black Hole Array Coupled with Damping Layers

Zhengcheng Yao¹, Xiandong Liu¹, Yue Bao¹, Haoming Liang¹, Yingchun Shan¹, Tian He¹
¹Beihang University, Beijing, China

Because of the characteristics of manipulating bending wave, acoustic black hole (ABH) structures can efficiently concentrate vibration energy in the center. Other than single ABH structures, the ABH array or damping layers can be used to have a better performance in vibration reduction and noise control, which have great engineering application prospects of plate parts.

In order to explore the influences of ABH array on vibration and noise reduction, finite element models of two-dimensional ABH array coupled with damping layers were established in this paper to study the effects of arrangements and number of ABH cells on dynamic characteristics. Firstly, this paper analyses the influences of array embedded with three ABH cells on the modal loss factor and vibration characteristics of the structures as well as the effects of different arrangements. Secondly, the array with different number of ABH cells were established to study the effects of the number of elements on the vibration response of the plate. Finally, the structure-sound coupling models were established to study the acoustic radiation characteristics and explain the noise response of the array plate.

This study provides a reference for the design and application of the plates embedded with ABH array.

[Link to paper]
Wave-based numerical investigation on diffraction correction for a low-height barrier in energy-based sound propagation model for road traffic noise

Yosuke Yasuda¹, Yu Kamiya¹, Makoto Morinaga¹
¹Kanagawa University, Yokohama, Japan

In energy-based noise propagation prediction methods, such as CNOSSOS-EU in Europe and ASJ RTN-Model in Japan, sound propagation is calculated by using the equation of sound attenuation by the geometrical divergence of the sound power from a sound source and adding various attenuation corrections such as diffraction effect and ground effect. In the ASJ RTN-Model, the insertion loss due to a semi-infinite barrier to a free field is generally used for the diffraction correction for a single barrier, the top of which is regarded as a knife wedge, whereas the diffraction correction for a low-height barrier is different from that for a general single barrier. It is given as the insertion loss due to a low-height barrier to a semi-infinite barrier, the top height of which is at the ground surface level, in a free field: the diffraction correction is zero when the low-height barrier is 0 m high. However, its range of application is not clear. In this paper, the diffraction correction for a low-height barrier is discussed by comparing the results of three-dimensional wave-based numerical analysis and propagation calculations using the ASJ RTN-Model.

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Relationship between the shape of amplitude envelope and the hearing sensation of fluctuation on the simulated exhaust sound of motorbikes

Nozomiko Yasui¹
²Saitama University, 255 Shimo-Okubo, Sakura-ku, Saitama City, Japan

Previous study showed that procedure for estimating Fluctuation Strength (FS) observing both constant fluctuation and deviation for time and amplitude approximately estimated the hearing sensation of fluctuation from tremolo played on the mandolin. Moreover, another one presented another procedure for estimating FS from exhaust sound of various motorbikes by proposing new indexes about the shape of amplitude envelope. However, the procedure was targeted only the recorded exhaust sound of those motorbikes, wasn’t clarified the relationship between the shape and sensation hearing of fluctuation yet. Here, this paper explores acoustic characteristics represent the shape of amplitude envelope and investigates relationship between those characteristics and sensation hearing of fluctuation. Investigations were carried out by using amplitude-fluctuated white noise which were designed to have various acoustic characteristics for the shape. Those white noise have characteristics of amplitude fluctuations in motorbikes. Then, the hearing sensation of fluctuation on those sounds were assessed, investigated relationship between those characteristics and sensation hearing of fluctuation. Concretely, multiple regression analysis was conducted using subjective evaluation results and those characteristics, where slope for rising and falling, duration for rising and falling were calculated. Results showed that those characteristics, especially slope for rising, influences the hearing sensation of fluctuation.
Noise generated by a drum brake at various operating conditions

Akash Yella¹, Aditya Chaudhary¹, Ajay Bharinikala Yuva Venkat¹, Sriram Sundar¹

¹Indian Institute of Technology Tirupati, Tirupati, India

Drum brakes are frequently found at the rear side of heavy vehicles and budget two-wheelers. The noise radiated from these brakes during typical operation plays a critical role in the passenger ergonomics. The acoustic behavior of an automotive drum brake during braking depends significantly on vehicle speed and actuation force as they change frequently. This work attempts to experimentally estimate the effect of these two braking conditions on the noise generated by a two-wheeler drum brake. A sub-scaled experimental setup (with instrumentation) of a drum brake has been developed for this purpose. The radiated sound pressure signals are captured as a result of varying these operating conditions. The acoustic effect of each condition is quantified using the sound pressure data. It is envisioned that the experimental analyses presented in this work will be helpful in better understanding the dependence of acoustic characteristics on the braking conditions, further leading to improvements in the design of brakes.

[Link to paper]
Measurement of vibro-acoustic noise of drum brake under various contact conditions

Bharinikala Yuva Venkat Ajay, Aditya Chaudhary, Akash Yella, Sriram Sundar

1 Indian Institute of Technology Tirupati, Tirupati, India

Drum brakes are vital safety components, widely used in automobiles due to their greater availability and quick replaceability compared to disc brakes. Since automobiles are used in all weather conditions, the braking performance also changes accordingly. Penetration of water, oil, and dust between the brake lining and the drum directly affects the contact parameters. These critical contact parameters (such as friction coefficient, contact damping, and stiffness) in turn affect the dynamic and acoustic responses of the nonlinear system. In this paper, the variation in the vibro-acoustic characteristics of a drum brake due to the presence of water, oil, and dust on the brake lining is studied experimentally by measuring the radiated acoustic signals and the system response. The braking performance under different conditions is quantified based on the system response while the acoustic behaviour of the system is studied using the acoustic measurements. This study would help in determining the safety of the automobile even under such abnormal braking conditions. Further, the acoustic measurements can be used to assess the contact condition of the braking system. It is envisaged to develop an improved health monitoring system for drum brakes.

Link to paper

This paper has the same title as the previous paper but a different sequence of authors.
Polynomial Chaos-Based Procedural Generation of Synthetic Training Data in Machine Learning for Automated Acoustic Monitoring

Ömer Yildiz, Sören Keuchel, Olgierd Zaleski, Peter Gross, Julian Storch, Matthias Weigold

In additive manufacturing such as powder bed fusion the acoustic monitoring taking care of timely process termination in case of failure is commonly achieved by ear and therefore highly susceptible to human bias. Solutions based on machine learning algorithms need large datasets for training purposes which are not readily available. Additionally, capturing high-quality audio samples and providing respective material parts are expensive both in terms of time and cost. To overcome this problem, this work proposes a method by which the required synthetic datasets are obtained by way of procedural generation. Here, synthetic data implies the substitution of measured audio data by equivalent virtual and artificial samples from 3D acoustic simulations. In order to cover process variations as well as consider the variability of multiple input parameters, a design-of-experiments based on the theory of generalized polynomial chaos is conducted. Additionally, the polynomial chaos method is extended through use of a decision tree so that the prevalence of specific critical events may be accounted for.
A virtual reality tool to aid in soundscapes in the built environment (SiBE) through machine learning

Semiha Yilmazer¹, Patricia Davies¹, Cengiz Yilmazer²

¹Purdue University, Ray W Herrick Lab 177s Russell Street West Lafayette, United States, ²CSY R&D Architecture and Engineering, Cyberpark, Bilkent, Ankara, Turkey

Regarding the function and context of the space, virtual reality (VR) can be used for soundscapes design if the user behavior is predictable. This study enables the acoustic characterization of VR development tools to measure auditory perception based on user behavior. The research question is whether soundscapes can be modeled according to the variable acoustic environments defined by the existing architectural features (e.g., prismatic, courtyard, vault, arched, mezzanine). A sound simulation algorithm in MATLAB was developed to extract room impulse response (RIR) of the test environment in a virtual environment and to compare it with the real environment (RE). In the developed program, image source model (ISM) and ray trace were used to be performed the real-time acoustic source generation and real-time signal recording, image functions, data processing, metric calculation operations (e.g., tonality and spectrogram). B&K 4292 omni-power loudspeaker, B&K 2716 power amplifier, and B&K 2250 hand-held analyzer were used to measure RIR in the RE. In addition to RIR and RT30, psychoacoustic metrics (e.g., loudness, sharpness, roughness, and fluctuation strength) were measured in both environments. The results showed that sound simulation, based on ISM, demonstrates the validity and can be used for the acoustic characterization of VR development environments.

[Link to paper]
Principle dimensions of perceptual attributes in indoor public spaces

Semiha Yilmazer¹, Volkan Acun², Donya Dalirnaghadeh², Ela Fasliija², Zekiye Şahin², Elif Mercan²

¹Purdue University, Ray W Herrick Lab, 177s Russell Street, West Lafayette,, United States, ²Bilkent University, Department of Interior Architecture and Environmental Design, Ankara, Turkey

This study aims to analyze the principal dimensions of perceptual attributes in indoor public spaces. Healthcare, working, cultural, educational, leisure, worship, and transportation spaces (e.g., bus, train, metro stations, and airports) were chosen as public spaces. Three members of the research team independently listened to all 70 binaural recordings, taken from indoor spaces, and for each recording identified whether human-generated sounds (e.g., conversation, laughter, footsteps, and coughing), technology-related sounds (e.g., mechanical and electronic sounds) and/or environmental sounds dominated. University students (n=120) performed a listening test to assess 70 binaural recordings of indoor soundscapes on users’ attribute scale. Principal component analysis shows that there are two prominent groups: pleasantness and eventfulness. Perceived sound environments dominated by technology-related sounds were found to be unpleasant, while the acoustic environments dominated by human-generated sounds were eventful.

[Link to paper]
A Qualitative Approach to Explore Audio-Visual Interaction in a Hospital Environment

Semiha Yilmazer¹, Zeynep Uğurlu²

¹Purdue University, Ray W Herrick Lab 177s Russell Street, United States, ²Bilkent University, Department of Interior Architecture and Environmental Design Ankara, Turkey

This study presents the findings of audio and visual evaluations of a hospital environment. The research focused on the waiting area of an oncology polyclinic. The study aimed to get subjective responses of the oncology patients via Grounded Theory and create a conceptual framework with the patients' answers. The polyclinic's acoustic and visual environments were identified, and LAeq levels were measured. Grounded Theory revealed patients' perception of the acoustic and visual environments of the polyclinic. Semi-structured interviews were conducted with 20 voluntary patients in three of the polyclinic's most crowded areas (e.g., reception, courtyard, and corridor). The conceptual framework showed that patients were affected by both audio and visual characteristics of the polyclinic. Patients explained the polyclinic with its existing condition and preferred condition. The results revealed that patients want to hear additional relaxing sound sources such as music and nature sound rather than silence or noise, and they want to see natural elements such as water and greenery rather than plain walls.

[Link to paper]
Suppression of quasiperiodic thermoacoustic oscillations via genetic programming

Bo Yin\textsuperscript{1}, Yu Guan\textsuperscript{1}, Stephane Redonnet\textsuperscript{1}, Vikrant Gupta\textsuperscript{2}, Larry K.B. Li\textsuperscript{1}

\textsuperscript{1}The Hong Kong University of Science and Technology, Sai Kung, Hong Kong, \textsuperscript{2}Southern University of Science and Technology, Shenzhen, China

We use genetic programming (GP) to discover data-driven control laws for the suppression of quasiperiodic oscillations in a prototypical thermoacoustic system. We rank the control laws based on a predefined cost function that accounts for the pressure amplitude and the actuation effort. We then breed subsequent generations of control laws via a tournament process. We find that GP closed-loop control is more effective than GP open-loop control and conventional periodic forcing, producing a similarly high degree of amplitude suppression but with the lowest actuation effort. We also find that GP closed-loop control can identify unforeseen actuation mechanisms, providing new insight into the physical coupling between the heat release rate and pressure fields.

[Link to paper]
Low-order network modelling of the effect of Helmholtz resonators on nonlinear thermoacoustic modes in annular combustors

Liming Yin¹, Dong Yang¹
¹Southern University of Science and Technology, Shenzhen, China

Modern aero-engines and land-based gas turbines often use annular combustors where many burners are installed in the circumferential direction. These combustors are often operated under lean-premixed pre-vaporized (LPP) conditions in which the flames are more susceptible to acoustic perturbations than traditional combustion systems. The resulted thermoacoustic instabilities may involve mode patterns varying in both longitudinal and circumferential directions. When nonlinear flame models are considered, our previous work proved that a 2-D low-order network model can capture limit cycle oscillations involving uncoupled and nonlinearly coupled modes, including longitudinal, circumferentially spinning/standing, and slanted modes. This kind of low-order network modelling tool has been recognised as a computationally efficient way of analysing thermoacoustic instabilities in annular combustors.

Helmholtz resonators (HRs) are widely used to damp acoustic oscillations. For thermoacoustic instabilities in annular combustors, the presence of the HRs causes modal coupling and mode shape change. For nonlinearly coupled thermoacoustic modes, it is difficult to predict the change of modality accurately. In this paper, HRs are incorporated into the aforementioned low-order network model. The effect of HRs on different nonlinear thermoacoustic mode patterns are studied in detail. This provides a powerful low-order network modelling tool for studying the damping performance of HRs on nonlinear thermoacoustic modes in annular combustors.

Link to paper
Relationship between exposure and listening disturbance response due to transportation noise in Japan

Shigenori Yokoshima¹, Makoto Morinaga², Sohei Tsujimura³, M.S. Koji Shimoyama⁴, Takashi Morihara⁵, Takashi Yano⁶

¹Kanagawa Environmental Research Center, Hiratsuka, Japan, ²Kanagawa University, Yokohama, Japan, ³Ibaraki University, Hitachi, Japan, ⁴Organization of Airport Facilitation, Minato, Japan, ⁵National Institute of Technology, Ishikawa College, Tsubata, Japan, ⁶Kumamoto University, Kumamoto, Japan

In the previous study, we performed a secondary analysis using micro-data and established the Japanese relationships between sound pressure level from night-time (Lnight) and the percentage of highly sleep disturbed people (%HSD) for the following transportation noises: road traffic, conventional railway and Shinkansen railway noises. Adding the datasets associated with civil and military aircraft noises, we successively established the Japanese representative relationships between day-evening-night sound pressure level (Lden) and the prevalence of highly annoyed people (%HA) due to transportation noise in Japan. This paper newly focuses on listening disturbance, which is one of psychological effects of noise. Thirty-five datasets, which were provided by Socio-Acoustic Survey Data Archive and derived from the other recent surveys conducted in Japan, were accumulated for the analysis. All the datasets include the following micro-data: demographic factors, exposure, and reaction to disturbance in listening to telephone, television, or radio. This paper defines the percentage of highly listening disturbed people (%HLD) using a 72% cut-off point. Based on the discussion about the difference in %HLD depending on the question wording, the number of scale points, demographic factor, and housing type, we establish the relationship between Lden and %HLD by transportation noise.
Study on the ground attenuation of engine run-up and APU noise for developing the airport noise model in Japan

Takatoshi Yokota¹, Koichi Makino¹, Toshiyasu Nakazawa², Masayuki Sugawara², Naoaki Shinohara², Kazuyuki Hanaka³

¹Kobayasi Institute of Physical Research, Tokyo, Japan, ²Aviation Environment Research Center, Organization of Airport Facilitation, Tokyo, Japan, ³Narita International Airport Promotion Foundation, Chiba, Japan

The correction for ground effect around airports is modeled based on the results of numerical analysis in order to make it possible to estimate the propagation of noise caused by ground operations in airports such as engine run-ups and APU to the vicinity of airports. The excess attenuation due to ground effects on sound caused by engine run-ups and APU is calculated using a PE method for typical jet aircraft and propeller aircraft, respectively. On the assumption that the ground around an airport consists of asphalt-paved surface and grass-covered surface in a certain ratio, the excess attenuation for the mixed impedance ground is calculated with the Fresnel-zone method using the results of PE calculation. The composition ratio of ground surface is assumed based on the composition ratio of asphalt-paved surface and grass-covered surface along the propagation path from the engine run-up spot to the airport site boundary of six major airports in Japan. In this paper, we introduce the excess attenuation calculated with the PE method and the correction model for ground effects on noise of engine run-ups and APU is discussed to implement it in the airport noise prediction model used in Japan.

[Link to paper]
Occupational noise legislation in Asia-Pacific region

Sakae Yokoyama¹, Tomohiro Kobayashi¹
¹Kobayasi Institute of Physical Research, Kokubunji, Japan

To prevent hearing loss for workers exposed to intense workplace noise, occupational noise laws have been enacted in many countries. However, for the legislations on occupational safety and health in Europe and the Americas, it seems that "permissible exposure limit (PEL: 8-hour average)", "exchange rate (ER)", "upper limit of impact noise", and other requirements for occupational noise exposure are not unified at present. On the other hand, few reports have been published in English on laws and regulations related to occupational noise in the Asia-Pacific region. Therefore, in this paper, the outlines of PEL, ER, "upper limit of impact noise", "wearing personal protective equipment", "audiometric test request", "penalties", etc. for occupational noise in the Asia-Pacific region were summarized. As in Europe and the Americas, many countries of the investigated Asia-Pacific region use 85dBA or 90dBA PELs, 3dB or 5dB ERs and upper limit of 140 dB(C) for impact noise.

Link to paper
Subjective evaluation of wind turbine noise using 3-dimensional audio-visual reproduction system

Miki Yonemura¹, Hyojin Lee², Shinichi Sakamoto³

¹The University of Tokyo, Komaba, Meguro-ku, Japan, ²Seoul National University, Gwanak-gu, South Korea, ³The University of Tokyo, Komaba, Meguro-ku, Japan

In recent years, the installation of new wind turbines has been promoted in Japan. Since wind turbines are often installed in quiet countryside, it is necessary to properly evaluate the noise impact of wind turbine installation. Since wind turbines are thought to have visual as well as auditory effects, we conducted a subjective evaluation experiment on the loudness and annoyance of wind turbine noise (WTN) and road traffic noise (RTN) by magnitude estimation method, using a three-dimensional audio-visual reproduction system consisting of 6 channels of loudspeakers installed around the sound receiving point and a dome screen. As a result, the loudness and annoyance of WTN tended to be evaluated higher than that of RTN. These results were considered to be influenced by the amplitude modulation called “swish sound” and the low-frequency dominant frequency characteristics, which are characteristics of WTN. In addition, when comparing the differences in loudness and annoyance with and without visual information, the two attributes tended to be lower when visual information was present.

[Link to paper]
A study on the new PET composite sound-absorbing material applicable to automotive interior materials

Sukjun Yong¹, JangSeok Park¹
²Daehan Solution, Incheon city, South Korea

Various types of sound-absorbing materials are used in vehicles according to external noise and conditions. As sound-absorbing materials for automobiles, there are fiber-type materials such as PET fiber or glass fiber, and foam-type materials such as polyurethane. Among them, PET fiber materials have excellent advantages in terms of weight reduction and recycling, but urethane foam is applied due to their low NVH performance and compressive stress. Recently, as interest in eco-friendly vehicles increases, development of sound absorbing materials using PET fiber is required. To improve this problem, in this study, research was conducted on improving sound absorption performance and compression performance by changing the composition ratio of PET fibers constituting the sound absorption material. The acoustic properties were measured by ALPHA-CABIN and BUCK tests.

Link to paper
Synergetic Effect of Vehicle Interior Sound and Design on Comfortability in Cabin

Junji Yoshida¹, Kanta Imamori¹
¹Osaka Institute of Technology, 5-16-1 Omiya, Asahi-ku, Osaka-shi, Japan

Vehicle interior noise have been quiet by the development of noise and vibration reduction technique. This noise will become quieter by the engine rest in electric vehicle. Hence, vehicle occupants may expect much more comfort in cabin as if they are in living room. In addition, not only the auditory stimulus but also visual stimulus is considered to have important role for the comfortability in cabin. In this study, we then focused on the comfortability in cabin and investigated influence of vehicle interior sound and design on comfortability using VR system. In the test, various virtual interior design and interior sound recorded binaurally at cruising condition were presented in the VR system and the sound, design and total comfortability was assessed through subjective evaluation test. As the result, both sound and design comfort were observed to be essential to increase the total comfortability and synergetic effect between them was found. This indicates that the influence of sound comfort to total comfortability changes according to the design comfort. Furthermore, soft-smooth interior sound and dark-solid interior design were clarified to improve the total comfort.

Link to paper
Psychophysiological responses to traffic noises in urban green spaces

Boya Yu¹, Yuying Chai

¹Beijing Jiaotong University, Beijing, China

The present study aims to explore the psychophysiological impact of different traffic sounds in urban green spaces. In the experiment, 30 subjects were recruited and exposed to different traffic sounds in the virtual reality (VR) scene. The road traffic sound and three railway sounds (conventional train, high-speed train, and tram) with three sound levels (45, 55, and 65 dB) were used as the acoustic stimuli. Physiological responses, electrodermal activity (EDA) and heart rate (HR) were monitored throughout the experiment. Psychological evaluations under each acoustic stimuli were also measured using scales within the VR system. The results showed that both the psychological and the physiological responses were significantly affected by the traffic sounds. As for psychological responses, considerable adverse effects of traffic sounds were observed, which constantly increased with the increase of the sound level. The peak sound level was found to have a better performance than the equivalent sound level in the assessment of the psychological impact of traffic sounds. As for the physiological responses, significant effects of both the acoustic factors (sound type and sound level) and the non-acoustic factors (gender and exposure time) were observed. The physiological effect of high-speed train noise was significantly different from those of the other three traffic noises. The relationship between sound level and physiological parameters varied among different sound groups. The variation of sound level could hardly affect the participants’ HR and EDA when exposed to the road traffic noise. On the contrary, the physiological responses were significantly affected by the sound level of rail traffic noise. By a correlation analysis, no linear correlation between the psychological evaluations and HR was found.

Link to paper

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Numerical Analysis of the Flow-induced Whistling Noise of Ventilation Wall Based on Fluid-structure Coupling Method

Qingqing Yu¹, Fei Xue
¹School of Mechanical Engineering, Southeast University, Nanjing City, P.R. China, ²Nanjing Research Institute of Electronics Technology, Nanjing City, P.R. China

As a widely used device in the field of air cooling and heat dissipation of electronic equipment, ventilation walls often have the problem of whistling caused by airflow. This paper presents a numerical study on the flow-induced whistling noise of a ventilation wall. Firstly, the interior flow field of the ventilation wall under typical working conditions was calculated. Secondly, the structure wet mode of the ventilation wall was calculated considering the airflow influence on the structural vibration. Thirdly, taking the fluid pressure fluctuation at the surfaces of the ventilation wall as excitation source, the structural vibration and radiation noise of ventilation wall was simulated, respectively. Finally, the structure of the ventilation wall was optimized to reduce the whistling noise. The results show that the high velocity airflow causes strong fluid-structure coupling of the ventilation wall. Besides, the peak frequency band of whistling noise ranges from 112Hz to 125Hz, and the maximum sound pressure level (SPL) reaches 87.3dB. Moreover, by improving the structure of ventilation wall, the maximum SPL of whistling noise deceases about 10.5dB, which significantly reduces the flow-induced noise. In conclusion, this paper could provide a method for reducing the flow-induced noise of ventilation walls.
Dynamic Layout Optimization of Stiffeners in Plate Structures Based on Power Flow Response

Huan Yu¹, Xiaoyan Teng¹, Xudong Jiang²
¹Harbin Engineering University, Harbin, China, ²Harbin University of Science and Technology, Harbin, China

By minimizing power flow response, a method of moving asymptotes was adopted to optimize the power flow model by adding and deleting corresponding elements and changing the material setting position in the configuration. To improve the dynamic performance of the whole structure under the premise of slightly increasing the mass of the whole structure, the Rayleigh damping model under the combined action of the environment and the characteristics of the material is established, and the SIMP (Solid Isotropic Material With Penalization) model of the coupling structure is used to calculate the power flow response of the plate-reinforced coupling structure, so that the vibration response of the structure is more accurate. By solving the sensitivity of power flow response, it is concluded that the essence of stiffened layout optimization is to optimize the position of coupling beam on the substrate. Through numerical example analysis, the optimal configuration and power flow response results under different boundary conditions, different shapes and different loading frequencies are compared, which is of great significance for the optimization design of stiffened plate structure layout.

Link to paper
Acoustic monitoring to evaluate the effect of anthropogenic noise within a park

Giovanni Zambon¹, Andrea Potenza¹, Alessandro Bisceglie¹, Chiara Confalonieri, Claudia Canedoli¹, Emilio Padoa Schioppa¹, Roberto Benocci¹

¹Department of Earth and Environmental Sciences, University of Milano Bicocca, Piazza della Scienza 1, Milano, Italy

The aim of this paper is to propose the use of passive acoustic monitoring (PAM) as a non-invasive method to investigate the state of communities and ecosystems. PAM operates through the study and characterization of the soundscape of an area. One of the three components of the soundscape (beside geophony and biophony) is anthrophony, which is the collection of sounds produced by human activities. This kind of sounds can have effects on natural environments and natural population. In this study, recording instruments and sampling techniques have been used to acquire and collect sound data for long periods (two weeks) in a natural terrestrial ecosystem (Ticino Park) which is affected by road and rail traffic noise. The analysis conducted studied the trends of the eco-acoustic indices belonging to three measurement sites to detect the presence of characteristic trends and to evaluate the influence of the two anthropogenic noise sources at different distances.

[Link to paper]
Deriving parameters for characterisation of the track quality in relation to environmental vibration

Hielke Zandberg¹, Agnes van Uitert, Arnold Koopman
²Prorail, Utrecht, Netherlands

Irregularities in track geometry; like insulated joints, switches and crossings, etc. and track stiffness variations in transitions zones near bridges or culverts play a role in the dynamic forces in the wheel-rail interface of train and track. These are important sources for ground-borne vibrations. In the Netherlands the track is monitored to facilitate maintenance management using a track recording coach (TRC). Data of these TRC measuring campaigns are stored and available for stakeholders working in field of rail maintenance or railway engineering.

A database was built using historical data of the TRC measurements back to 2013 together with meta data of track components such as insulated joints, switches, crossings, culverts, etc. The track geometry data (height and shift) have been post processed towards two newly designed spectral parameters, both of them were expected to correlate with ground borne vibration at a distance from the track. One characterises discontinuities, the other continuous track.

The paper will show how these parameters can be used to compare track quality and quality of track components with regard to vibrations. The study analyses differences in track quality near transition zones in relation to vibration levels.
Identification and Reduction of Interactional Noise of a Quadcopter in Hover and Forward Flight Conditions

Nikolas Zawodny¹, Nicole Pettingill¹, Christopher Thurman¹
¹NASA Langley Research Center, Hampton, United States

Advanced Air Mobility is a vision for a safe, accessible, and sustainable aviation system to transport people and packages between places not served by traditional aviation. With this emerging transportation industry, there is motivation to characterize the noise of vehicles to determine their potential impacts on the community. An experimental testing campaign was conducted on a small unmanned aerial vehicle in the NASA Langley Low Speed Aeroacoustic Wind Tunnel as a continuation of a previous testing campaign. The goals of the current test are to identify sources of interactional noise as well as to test custom designed rotors and noise reduction devices. The tested noise reduction methods involve increasing the vertical distances between the rotors and the vehicle airframe as well as between the forward and aft rotor disk planes. These methods are intended to reduce rotor-airframe interaction noise in hover and fore-aft rotor wake ingestion noise in forward flight. A phased microphone array is also utilized to identify the locations of prominent noise generation for the different vehicle configurations in forward flight. Elevation of the rotors from the vehicle airframe yielded up to an 8 dBA noise reduction in forward flight, while yielding only modest noise reductions in hover.

Link to paper
Sell and Buy Quiet - life cycle score estimation using online searches for impact wrenches

Edward Zechmann$^1$
$^2$NIOSH, Cincinnati, United States

Can Sell and Buy Quiet be generalized to consider all the factors influencing a purchasing decision and be implemented through web searches of product data? A simple web search of the “best impact wrenches of 2022” yielded a list of impact wrenches given various classification schemes. These classifications were based on length, overall physical size, versatility, energy system (cordless), affordability, manufacturer, and other attributes of impact wrenches. A list of the best impact wrench for each classification was made from the search results. An additional web search identified the best shopping websites for impact wrenches. These shopping websites had well organized product filters which clearly identified the factors that consumers consider important when purchasing an impact wrench. The important impact wrench attribute data were amassed from user manuals and web searches. The life cycle scores were estimated using the Safety Procurement Standard SAE AS6228 for each of the classification schemes. The weighting of each of the factors was based on the importance given by the classification schemes. For each classification scheme, the impact wrenches were then sorted by descending life cycle scores. For a particular classification scheme, higher life cycle scores indicate a better overall balance of the safety, health, and cost effectiveness.

[Link to paper]
Experimental acoustic testing of alternative ventilation ducts

Suzana Zekic\textsuperscript{1}, Luis Gomez-Agustina\textsuperscript{2}, Haydar Aygun\textsuperscript{2}, Issa Chaer\textsuperscript{2}  
\textsuperscript{1}Imtech Engineering Services, Twenty, Kingston Road, UK, \textsuperscript{2}London South Bank University, 103 Borough Road, UK, \textsuperscript{3}Imtech / London South Bank University, Twenty, Kingston Road / 103 Borough Road, UK

Ducts of alternative materials to galvanised steel, are widely employed in residential buildings’ mechanical ventilation systems in a bid to comply with the conservation of energy regulations in circumstances that prevent the use of natural ventilation. The noise transfer predictions of systems with alternative ducts are still being based on data for galvanised steel due to the lack of the acoustic performance data of alternative ventilation ducts tested in controlled conditions. To close this knowledge gap, alternative ventilation ducts and associated 90° bend samples were acoustically tested in controlled laboratory conditions utilising the substitution principle as outlined in BS EN ISO 7235 (2009) as well as applying a novel “zero substitution” approach. Static and dynamic tests were undertaken and sound attenuation (per meter) as a function of frequency was obtained. Preliminary results revealed the different acoustic characteristics of alternative ventilation ducts when compared to published galvanised steel ducts. The “zero substitution” approach showed good agreement with results obtained from the standardised substitution method when tested in straight duct sections. It is expected that the new acoustics knowledge on alternative ventilation ducts will influence the current design approaches and enhance confidence in noise transfer predictions resulting in cost and energy savings.

[Link to paper]
Comparison of Pure Tone Audiometry and Otoacoustic Emission based Hearing Assessment for Classical Music Students

Georgia Zepidou, Steve Dance
1London South Bank University, London, United Kingdom, 2AECOM Limited, London, United Kingdom

Since the enforcement of the Control of Noise at Work Regulations research has been undertaken in collaboration with the Royal Academy of Music investigating the hearing acuity of more than 5000 students between 2007 and 2021. Standard pure tone audiometric screening methods were employed for both entry and exit testing of undergraduate and postgraduate students. The results of these investigations have informed a pilot study, ran in September 2021, comparing two hearing health surveillance methodologies: pure tone audiometry and otoacoustics emissions involving 256 classical music students. This comparison was necessary as music students had been found to be able to game the Bekesy test procedure as a result of their acute listening ability. The results showed that otoacoustic emissions were able to identify, at an early stage, hearing damage in an additional 3.8% of students. The test procedure itself was found to be quicker, more convenient and offered greater objectivity without learning bias. This provides reassurance that otoacoustic emissions can be an excellent tool for assessing the hearing health of classical music students and identifying hearing damage at an early stage.

Link to paper
Numerical investigation of power flow input into a fuselage due to wing vibrations based on jet engine vibration loads

Sebastian Zettel¹, René Winter¹, Marco Norambuena¹, Marc Böswald¹

¹DLR - German Aerospace Center, Göttingen, Germany

The wings of passenger aircrafts are constantly vibrating due to various loads. There are transient low-frequency vibrations caused by gust loads. But there are also higher-frequency vibrations caused by the vibration load of the jet engines. The higher-frequency stationary vibrations of the wing are partially introduced as a power flow into the fuselage and radiated there as sound, which is then perceived as noise. In this work, which is part of the EU CleanSky2 framework, this chain of effects is being investigated in more detail aiming for the quantification of the vibrational power flow input into the fuselage by utilizing structural intensity. In this paper, numerical investigations are carried out on FEM models of an Airbus A320 wing generated with a parametric model generator. First, the structural components mainly responsible for the power transmission are identified, and second, the magnitude of the power input into the fuselage is determined in dependence of the pylon position along the wing. The engine vibrations are approximated by a custom-developed model. In the further course of the project, these numerical results will be validated by a test campaign. For this purpose, a real wing of an A320 is available as a test structure.

Link to paper
Vibration and acoustic radiation control of a panel with piezoelectric oscillators.

Yongyuan Zhang

The Institute Of Acoustics Of The Chinese Academy Of Sciences, Beijing, China

In this paper, the vibration of a thin plate system with piezoelectric sheets attached and its acoustic radiation are modeled theoretically. Then the results are compared with those of finite element simulation, and the results are relatively consistent. Finally, sound absorption and isolation experiments at non-intrinsic frequencies of the composite plate are conducted in a standing wave tube. Based on the principle of minimum potential energy, the variation equation of a thin plate with a piezoelectric sheet attached are listed, and the impedance matrix of the acoustic radiation of the plate coupled with each order of the cavity modal is calculated. After the modal displacement response of the plate is obtained, the absorption coefficient and sound insulation volume of the composite plate can be calculated. Through theoretical calculations and finite element simulations, it is found that the plate has a modal reorganization phenomenon at the peak of sound insulation, and the modal response of each order increases at the peak of sound absorption. After that, the sound absorption and isolation experiments were conducted in the standing wave tube, and the control effect of the piezoelectric shunt oscillator at the non-intrinsic frequency of the plate was improved by adding negative capacitance.

Link to paper
Programmable time-serial resonances for broadband spectrum matching

Yumin Zhang\textsuperscript{1}, Keming Wu\textsuperscript{2}, Lixi Huang\textsuperscript{2}
\textsuperscript{1}Foshan University, Nanhai District, Foshan, China, \textsuperscript{2}The University of Hong Kong, Hong Kong, China

Spatially parallel and cascading acoustic liners are commonly used to treat duct noise. Their performance depends on the spectral match with source characteristics. Such liners rely on subtle geometrical and mechanical designs which are not difficult to adapt to different noise sources in a passive device. Here, we propose a temporal analogy, which is a shunted electromechanical diaphragm (SEMD) having different resonant frequencies in different time segments, namely, a time-serial resonator. Its sound absorption spectrum can be easily adapted by a program and yet the device functions passively. The acoustic impedance of the SEMD is determined by the shunt circuit, hence its resonant frequency and absorption peak. A multiple set of branch circuits are used to shunt the diaphragm. A MOSFET, which is a voltage-controlled ultrafast electronic switch, is introduced to cascade and switch each circuit branch. By activating circuit branches in a pre-defined time sequence, we obtain a series of resonance and the absorption which are effective for specific frequency bands at different time segments. When viewed over a long period, the averaged effective sound absorption spectrum is broadened and can be easily shaped by the working duty cycle of each circuit branch. Note that the switching voltage changes the circuit states without supplying power to the SEMD. Both numerical results and experimental demonstrations are presented. This study would open the new era of temporal design of acoustic liners.

[Link to paper]
Active control of interior road noise using the remote microphone technique

Zhe Zhang¹, ChenLu Shi¹, Xiao Lv¹, ZiHong Ling¹
²Catarc, Tianjin, China

A multichannel feedforward headrest system for the active control of interior road noise in a vehicle cabin is built. The remote microphone technique is applied, which enables the estimation of the sound pressure responses at the passenger’s ear positions without direct deployment of error microphones there. The optimal observation filter for the remote microphone technique is formulated in a so-called training stage using signals measured at two error microphones on the passenger’s ears and an array of four to five monitoring microphones on the headrest, passenger seat and vehicle ceiling. The estimation accuracy of the observation filter is investigated through simulations and road test. Regarding the causality error encountered in a certain test case where the passenger leans forward, thus making the noise signals arrive at the monitoring microphones prior to the error ones, a delay factor is added into the original remote microphone technique to correctly compensate for the time delay. The noise attenuation performance of the active headrest system is then experimentally and subjectively determined, indicating a larger noise abatement in a wider spatial environment by applying the remote microphone technique.

Link to paper
Research on indoor noise evaluation and renovation design of university library—taking the library of Wushan campus of South China University of Technology as an example

Yang Zhang¹, Hongwei Wang¹
¹South China University Of Technology, Guangzhou, China, ²State Key Laboratory of Subtropical Building Science, Guangzhou, China

Due to the special use requirements of university libraries, the requirements for indoor acoustic environment quality are relatively high. By investigating the layout and structural design of the library on the Wushan campus of South China University of Technology, distributing questionnaires to users and conducting on-site monitoring, finally found out the problems of the library, such as the sound of the upper and lower floors being connected, noise of friction with the ground when walking, keyboard tapping, moving seats, flipping and rummaging books, air conditioning and ventilation equipments and the low voice of speech had a greater impact on users, moreover, near the toilet and the elevator was noisy, the actual measurement of the sound level meter showed that the intermittent noise exceeded 55dB (GB 37488-2019 Hygienic indicators and limits for public places stipulates that the noise limit of the library is 55dB). Based on the above problems, the corresponding renovation measures are put forward, in order to provide technical references for the design and transformation of the acoustic environment of other domestic university libraries.

Link to paper
Acoustic analysis of coupled loudspeakers for low frequency duct noise reflection

Shang Li¹, Xiaochen Zhao¹, Xinyu Zhang¹

¹Harbin Engineering University, Harbin, China

The passive control of low-frequency duct noise remains a technical challenge. Inspired by the research of Wang and Huang [Investigation of a broadband duct noise control system inspired by the middle ear mechanism, Mech. Syst. Signal Process. 31 (2012) 284–297.], an electro-mechanical coupling approach is introduced to solve this problem. The device consists of the main duct segment and multiple sets of connected loudspeakers, which functions as a side-by tube in traditional Herschel-Quincke (HQ) tube. The acoustic waves imposed on the upstream loudspeaker can be transmitted to the other loudspeaker via the connecting circuit immediately, which represents a fast track when compared with the wave transmission via the fluid medium in the main duct. A periodic silencer array is developed to broaden the bandwidth and increase the magnitude of noise attenuation. Transfer matrix method is adopted to investigate its acoustic performance. If proper parameters are selected, the proposed silencer can function effectively as wave reflector in low frequency range. The TL spectrum exhibits multiple peaks, which are mainly contributed by the HQ-tube-like resonance and mechanical resonance of the loudspeaker itself.
Low frequency sound insulation of membrane-type acoustic metamaterials with negative pressure cavity

Tuo Xing, Xianhui Li, junjuan Zhao, Xiaoling Gai, Fang Wang, Xiwen Guan

Institute Of Urban Safety And Environmental Science, Beijing Academy Of Science And Technology, Beijing, China

The membrane-type acoustic metamaterial with negative pressure cavity (MAM-NPC) is designed to achieve low frequency sound insulation and tunable frequency on the duct side wall. A one-dimensional analytical method was used to discuss the sound insulation effect of MAM-NPC on the sidewall of the duct. As the negative pressure increases, the first valley of sound insulation moves to high frequency. High sound insulation can be achieved in the low frequency range. The theoretical and finite element method results are compared. The one-dimensional analysis method basically agrees with the finite element results in the low frequency band. Because only plane waves are considered in the one-dimensional analytical method.
Acoustic performance of micro-cracked slit absorber

Congshuang Jiang, Xianhui Li, Weimin Xiao, Hongbin Su
1 Institute Of Urban Safety And Environmental Science, Beijing Academy Of Science And Technology, Beijing, China

Microperforated plate absorbs sound by resonating with sound waves to dissipate acoustic energy, which usually require a combination of micro-holes, thin plates and high perforation rates. It has always been a challenging task to achieve a broadband, efficient, and practical single-layer microperforated plate absorber. This paper proposes a micro-cracked slit absorber using fracture processing technique. The internal acoustic impedance of the spatial complicated cracks, the end effects at the geometrical discontinuities, and the influence of membrane vibration were investigated. The equivalent acoustic impedance model of the cracked membrane was established. This work provides solid foundations for designing a novel absorber with broadband sound absorption, good mechanical bearing, and convenient processing simultaneously.
Dynamic analysis of negative stiffness noise absorber with magnet

Min Yang¹, Weiming Xiao¹, Erjing Han¹, Junjuan Zhao¹, Wenjiang Wang¹, Yunan Liu¹

¹Institute Of Urban Safety And Environmental Science, Beijing Academy Of Science And Technology, Beijing, China

In the paper, the negative stiffness membrane absorber with magnet has been taken as a nonlinear noise absorber. The dynamic characteristics of the nonlinear noise absorber have been studied by nonlinear dynamics theory and numerical simulation. The dynamic equations of the system were established under harmonic excitation. The slow flow equations of the system are derived by using complexification averaging method, and the nonlinear equations which describe the steady-state response are obtained. Bifurcation diagram, amplitude frequency diagram and phase diagram are used to study the nonlinear response of structures under different excitation conditions. The effects of excitation amplitude, excitation frequency, nonlinear term and structural parameters on the nonlinear dynamic characteristics and sound absorption characteristics of the structure are studied. The resulting equations are verified by comparing the results which respectively obtained from complexification-averaging method and Runge-Kutta method. It is helpful to optimize the structural parameters and further improve the sound absorption performance to study the variation of the sound absorption performance of magnet negative stiffness membrane absorber system with its structural parameters.

Link to paper
Tunable acoustic analysis and prediction of membrane sound absorber with magnet

Junjuan Zhao, Yueyue Wang, Wenjiang Wang, Liying Zhu, Xianhui Li, Min Yang

Institute Of Urban Safety And Environmental Science, Beijing Academy Of Science And Technology, Beijing, China

This paper presents a membrane sound absorber (MSA) with tunable properties for low-frequency sound absorption. A simple method to predict the resonance frequency is proposed; the resonate frequencies predicted show good agreements with the experimental ones. The analysis indicate that the iron-platelet-magnet resonance mechanism introduced by the tuned magnetic field is the main factor leads to the appearance and shift of absorption peaks in low-frequency region, which are almost independent of the back cavity. This demonstrates that the structure has strong potential to achieve an extremely thin and low-frequency tunable-sound-absorption design which can be easily adapted to the noise source variation.
The response of a conical flame to a dual-frequency excitation

jianyi Zheng¹, Lei Li², Guoqing Wang³, Liangliang Xu¹, Sirui Wang¹, Xi Xia¹, Fei Qi¹
¹Shanghai Jiao Tong University, Shanghai, China, ²Beihang University, Beijing, China, ³King Abdullah University of Science and Technology, Thuwal, Saudi Arabia

This work investigates the response of a conical premixed flame to a dual-frequency excitation, based on the integrated CH* signal collected from a photomultiplier tube (PMT), the upstream velocity disturbance measured by a hotwire, and the chemiluminescence signal captured by high-speed imaging. The results show that, in addition to the excitation frequencies, a notable flame response can also be observed at the difference frequency, where the corresponding velocity fluctuation is relatively small. This result means that, at the difference frequency, the velocity fluctuation contributes little to the flame response. Such interacted response generally occurs at intermediate excitation frequencies but tends to disappear as either excitation frequency is below the cut-off frequency. And it increases linearly with the excitation amplitude, with nearly zero dependence on the phase difference. Furthermore, the flame front is extracted based on the chemiluminescence images to analyze the flame area fluctuation. The resultant phase response implies that the fluctuation of the difference frequency propagates downstream convectively, similar to that of the excitation frequencies. Interestingly, the flame area fluctuation at the difference frequency shows significant response and a low-pass characteristic, whereas the CH* fluctuation approaches zero at those low frequencies.

Link to paper
Broadband noise attenuation in the flow duct using metamaterial-based acoustic liners

Jingwen Guo¹, Renhao Qu¹, Yi Fang¹, Siyang Zhong¹, Xin Zhang¹
¹The Hong Kong University of Science and Technology, Hong Kong, China

An acoustic liner design based on metamaterial is proposed for broadband duct noise reduction. The material is constructed by four periodically arranged partitions-embedded units covered by a perforated plate, forming a linear reflected phase-shifting within 0 to 2π in a wide target frequency range. The sound absorption performance under normal incident waves is firstly examined by both numerical simulation and impedance tube measurement, leading to close agreement to the target design. Then, the meta-liner is installed in a flow tube to assess its capability of reducing broadband noise in a duct with aerodynamic flows. The experiments investigations are performed in an advanced grazing flow tube developed at the Hong Kong University of Science and Technology. The effect of sound levels (ranging from 120dB to 140dB), flow speeds with the Mach number up to 0.3, and the position of sound source (at upstream and downstream sides of meta-liner) are investigated. Results show that a nearly flat transmission loss is achieved in the target frequency range by the metamaterial-based acoustic liner in various conditions, showing its potential for practical industrial applications.

Link to paper
Pulsed and Continuous Signal Enhancement Based on Improved Noise Power Spectrum Density Estimation in the Passive Underwater Acoustic Data

Yun Zhong¹, Qisong Wu¹
¹Key Laboratory Of Underwater Acoustic Signal Processing Of Ministry Of Education Southeast University, NanJing, China

The pulsed and continuous narrow-band signal enhancement is quite important for the target detection and recognition in a passive sonar system. In this paper, a novel signal enhancement approach is proposed for both pulsed and continuous narrow-band components in the passive underwater acoustic data. The short time Fourier transform (STFT) method is firstly used in the time-domain radiated noise data, and then an improved noise power spectrum density (PSD) estimation is proposed to obtain the accurate noise power by using a two-dimension (2-D) sliding window. Finally, the improved PSD is utilized to enhance both pulsed and continuous narrow-band components. The proposed method has the capability of enhancing pulsed and continuous narrow-band components with avoiding the annoying tuning of the window length. Both simulation and experimental results verify the effectiveness and robustness of the proposed method.
Three-dimensional nonlinear thermoacoustic instability analysis based on Green’s function approach

Weipeng Zhou

Beihang University, Beijing, China

In this work, nonlinear thermoacoustic instability analysis is made in a hard-walled box to investigate the limit cycle of thermoacoustic oscillation and the interplay of two modes. We model the flame as an acoustically compact source described by a generic Flame Describing Function, i.e. an amplitude-dependent Flame Transfer Function. The acoustic field in the hard-wall box could be described by an integral equation using a Green’s function tailored to a three-dimensional (3-D) rectangular box with hard-wall boundary conditions. The integral equation is solved by two methods. Firstly, an iteration method, stepping forward in time, is used to give the time history of the acoustic velocity. The other method is done in the frequency domain to determine the thermoacoustic eigenfrequency and growth rate of thermoacoustic modes. We could observe the phenomenon of modes “jump” after two different time windows of the time history operated with the Fourier transformation. This result reveals that there are two modes in the system, the interference between modes will occur. In the early stage, the two modes work together. After reaching the limit cycle oscillation, the role of one mode is dominant and the other mode basically disappears.

Link to paper
Time delay estimation via average magnitude differences among multiple microphone signals

Zhen Zhu, Hongsen He, Jingdong Chen

Time delay estimation (TDE) plays a significant role in hands-free speech communication systems for localizing and tracking speakers. To boost the robustness of time delay estimators in room acoustic environments, a novel TDE approach is proposed in this paper. This method first exploits the reciprocals of average magnitude difference functions of sound signals captured at a microphone array, instead of cross correlation coefficients, to construct the entries of the parameterized correlation coefficient matrix in the multichannel cross-correlation coefficient algorithm. A multichannel average magnitude difference coefficient is then defined to establish the time delay estimator. Simulation results demonstrate that the proposed TDE strategy can yield better performance as compared to the multichannel cross-correlation coefficient method in noisy and reverberant environment.
3D printed sound-absorbing materials with double porosity

Tomasz G. Zielinski¹, Nicolas Dauchez², Thomas Boutin², Mikel Leturia², Alexandre Wilkinson², Fabien Chevillotte³, François-Xavier Bécot³, Rodolfo Venegas⁴

¹Institute of Fundamental Technological Research, Polish Academy of Sciences, Warsaw, Poland, ²Université de technologie de Compiègne, Compiègne, France, ³MATELYS Research Lab, Vaulx-en-Velin, France, ⁴University Austral of Chile, Valdivia, Chile

The paper shows that acoustic materials with double porosity can be 3D printed with the appropriate design of the main pore network and the contrasted micro-porous skeleton. The microporous structure is obtained through the use of appropriate additive manufacturing (AM) technology, raw material, and process parameters. The essential properties of the microporous material obtained in this way are investigated experimentally. Two AM technologies are used to 3D print acoustic samples with the same periodic network of main pores: one provides a microporous skeleton leading to double porosity, while the other provides single-porosity material. The sound absorption for each acoustic material is determined both experimentally using impedance tube measurements and numerically using a multiscale model. The model combines finite element calculations (on periodic representative elementary volumes) with scaling functions and analytical expressions resulting from homogenization. The obtained double-porosity material is shown to exhibit a strong permeability contrast resulting in a pressure diffusion effect, which fundamentally changes the nature of the sound absorption compared to its single-porosity counterpart with an impermeable skelton. This work opens up interesting perspectives for the use of popular, low-cost AM technologies to produce efficient sound absorbing materials.
Reducing destructive interferences when synthesizing sound fields in the free field

Franz Zotter¹, Matthias Frank, Gregor-Johannes Müller, Julia Pinkas, Oliver Bayer
¹University Of Music And Performing Arts Graz, Graz, Austria

Sounds to appear in directions between the loudspeakers will typically activate neighboring loudspeakers with the same signal when spatially rendered. The resulting interference causes frequency- and position-dependent cancellation in the superimposed sound field. While keeping the number of active loudspeakers uniformly small is often enough to have the few acoustic reflections of a studio environment conceal the unwanted cancellations, they will remain a problem when synthesizing sound fields in the anechoic chamber or free field. Our contribution investigates short filters for amplitude decorrelation to reduce this problem. The filters supply neighboring loudspeakers via frequency responses that are mutually exclusive and hereby avoid cancellation in the superimposed soundfield. This only works at the expense of requiring a minimum spread to ensure a spectrally balanced synthesis, i.e., by avoiding to activate single filtered loudspeaker, alone. We present a listening experiment investigating in how far the proposed filter strategy is able to improve the spectral stability within a reasonable range of motion for a seated listener, in the anechoic chamber. Other thinkable approaches are investigated for comparison.

Link to paper
Influence of soundscape on visiting time in zoos

Jason Nengsong Zou¹, wanghongwei hongwei wang

¹ 华南理工大学, 广州, China

The soundscape is very important for the environmental quality and animal welfare of zoos. This paper explores the relationship between the soundscape and visiting time, for the case of Guangzhou Zoo in China. In this research, we measured the sound indicators in the zoo along with the visiting time of visitors. This included the cases of with or without animal soundscape around the exhibition area, recorded by video equipment. It was found that there was a positive correlation between visiting time and the consistency of animal sound scene vision. The visiting time of tourists will increase significantly When there is animal sound scene in the exhibition area. The visiting time of tourists is significantly increased when the animal sound is consistent with the animals seen by tourists. Within a certain range, the visiting time is not affected by the sound pressure level. The results of this research are expected to guide the soundscape design, construction and management of zoos.

Link to paper